THE WORLD OF SCIENCE WITHOUT BORDERS

PROCEEDINGS
12th INTERNATIONAL SCIENTIFIC AND PRACTICAL CONFERENCE FOR YOUNG RESEARCHERS

April 2, 2025
Tambov

МИР НАУКИ БЕЗ ГРАНИЦ

МАТЕРИАЛЫ
12-й МЕЖДУНАРОДНОЙ НАУЧНО-ПРАКТИЧЕСКОЙ КОНФЕРЕНЦИИ МОЛОДЫХ УЧЕНЫХ

2 апреля 2025 года
Тамбов

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Издательский центр ФГБОУ ВО «ТГТУ»
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«Тамбовский государственный технический университет»**

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The 12th International Scientific and Practical Conference for Young Researchers hosted by Tambov State Technical University on April 2, 2025 focused on the problems related to the development of education, industry and research. Major topics included problems of humanities, social, and technical sciences in the modern world. The volume is a collection of paperssubmitted to the conference.

Издание представляет собой сборник материалов 12-й Международной научно-практической конференции молодых ученых, организованной ФГБОУ ВО «Тамбовский государственный технический университет» и проведенной 2 апреля 2025 г. Проблематика обсуждаемых вопросов касалась тенденций развития образования, производства и исследовательской деятельности, а также эффективных решений исследовательских задач гуманитарных, социальных и технических наук в современном мире.

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FOREWORD

This volume compiles the papers presented at the 12th International Conference of Young Researchers, titled “The World of Science without Borders”, which took place at Tambov State Technical University on April 2, 2025. Established in 2011, this annual conference serves as a platform for graduate and postgraduate students to participate and share their research. Such conferences are particularly valuable as they address research challenges across various fields.

The mission of the conference is to eliminate barriers to the dissemination of innovative projects among young scientists. The primary language of the publications is English, aimed at facilitating academic communication and firmly establishing Russian science on the global stage.

This volume includes over 100 papers that reflect the diverse research interests of students from Tambov State Technical University and its partner institutions, including contributions from young international scholars. This selection will be of interest to anyone keen on engaging with the scientific endeavors of young researchers in Russia. The latest research findings presented here have the potential to inspire new ideas and further advancements in various fields.

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PhD in Linguistics,
Head of Department of Foreign
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Communication, TSTU

УДК 628.852.2

Modeling of microclimate in a heated room from various heating systems

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Abstract
The article presents the results of a numerical study of the influence of various heating systems on the formation of comfortable indoor climate parameters. The purpose of the work is to model microclimate systems with different heating systems using numerical methods. The relevance lies in the fact that the use of standard calculation methods leads to increased energy consumption of buildings. Numerical methods will allow us to find the optimal design solution.
Keywords: modeling; microclimate parameters; heating system.

The averaged values of design quantities taken into account for steady-state modes form the basis of the applicable methods of heat engineering calculations and heating system design. The analysis does not include local and immediate values of microclimate parameters. The specified design features are one of the reasons for the increased energy consumption of buildings, as well as the discrepancy between the formed microclimate parameters and the comfort conditions.

As a result, maintaining the necessary microclimate characteristics on the property is an important and pertinent practical activity. Numerical experiments are the most effective way to study the issues of microclimate development and sustaining the necessary temperature regime. Numerical modeling enables one to consider the characteristics of a certain assignment and identify the best design solution that offers the necessary microclimatic conditions. A heated residential space (apartment) located on the middle floor of a multi-apartment residential building was chosen as the modeling object. The external walls of the space are made of brick with a thickness of 700 mm, the internal load-bearing walls are made of lightweight concrete blocks with a thickness of 400 mm, and the partitions are made of plasterboard with putty with a total thickness of 100 mm.

The most widely used techniques for heat engineering calculations and heating system design rely solely on average design quantity values for steady-state modes. Typically, the study does not take into account local and instantaneous microclimate characteristics. These design elements are among the causes of buildings' rising energy usage and, of course, the developed microclimate parameters' departure from the bounds of comfortable circumstances.

Based on the aforementioned, it is a pertinent and significant practical duty to create and maintain the necessary microclimate conditions within the interior space of the premises. The application of a numerical experimental approach is the most successful technique known for researching issues of this kind. By employing numerical modeling

techniques, it is feasible to consider the distinct characteristics of a particular issue and identify the best design option for achieving the necessary microclimate conditions.

The subject of the research is residential property, namely an apartment. It is situated in an apartment building on the middle floor. The building's 700 mm thick brick exterior walls, 400 mm thick lightweight concrete blocks for the load-bearing interior walls, and 100 mm thick plasterboard and putty partitions between the rooms make up the building's partitions.

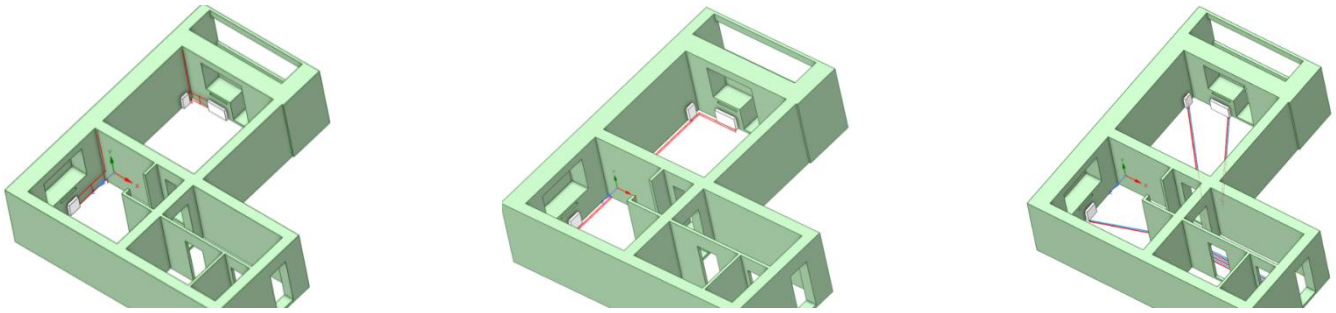
The heat balance of the building, as determined by the conventional approach, is used to determine the heat loads of heating equipment [1]. We use Tambov's climate data in accordance with SP 131.13330.2020 "Building climatology" to determine the heat losses of buildings. Table 1 displays the heat loss computation's findings.

Table 1 - Heat loss in rooms

№	Name of the room	Main heat loss, W	Additional heat loss, W	Total heat loss, W
1	Kitchen	669.7	167.4	837.1
2	Living room	1208.0	664.4	1872.4
			Total	2709.5

Numerical modeling was performed using Ansys engineering analysis and numerical modeling software [2].

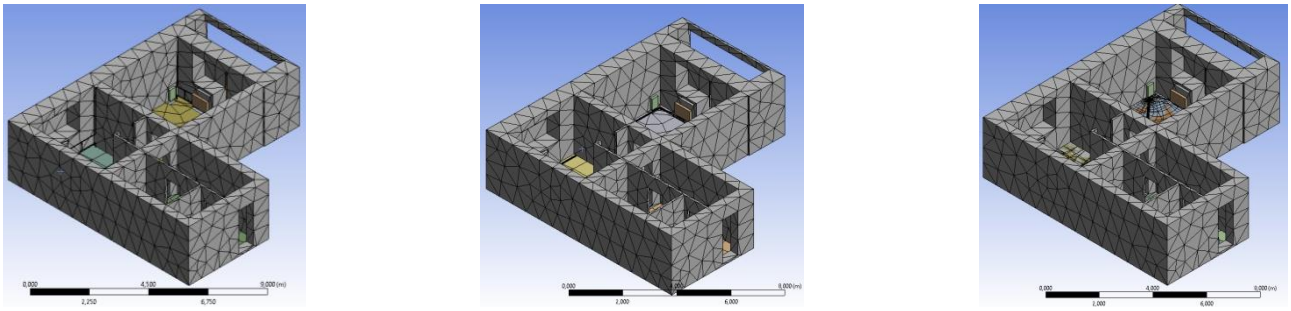
Figure 1 shows a geometric model of the modeling object created in the ANSYS SpaceClaim system.



a) b) c)

Figure 1 - Geometric models of a heated room with different heating systems: a) with a single-pipe vertical; b) with a two-pipe horizontal perimeter; c) with a two-pipe radial.

To solve the problem, the computational domain of geometric models is discretized using the Ansys Meshing subroutine (Fig. 2).

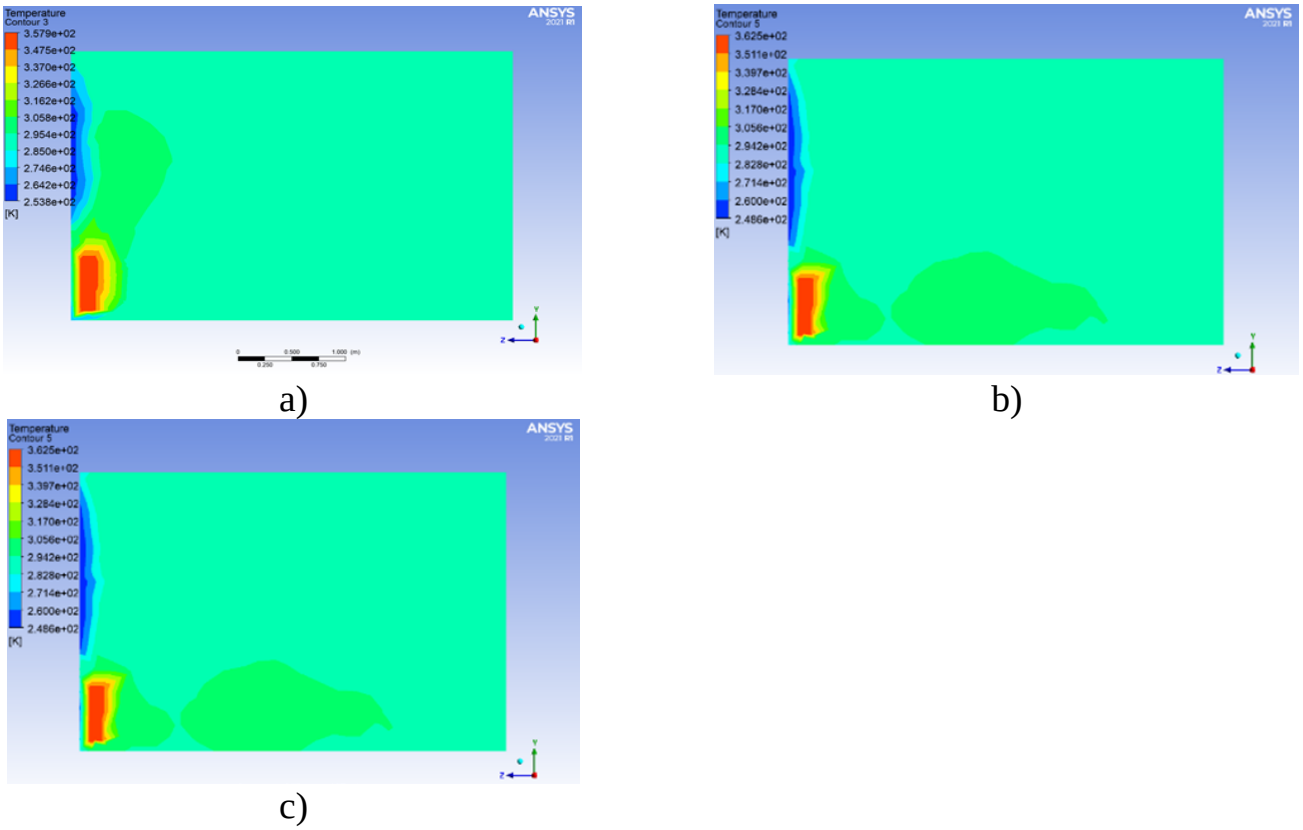


a) b) c)

Figure 2 - Grid models of a heated room with different heating systems: a) with a single-pipe vertical; b) with a two-pipe horizontal perimeter; c) with a two-pipe radial

Calculation models were developed for each of the heating systems under consideration by choosing the parameters of heat distribution processes, material properties, solver settings, and boundary conditions based on the grid models generated in the Ansys Fluent subprogram.

Calculations were made for the kitchen and living room to ascertain how the kind of heating system affected the distribution of microclimate factors. Figures 3 and 4 display the findings of the kitchen's computations. A vertical segment that runs through the window and the room's air environment is the calculation area.



a) b)

c)

Figure 3 - Temperature fields formed in the kitchen by different heating systems: a) vertical single-pipe; b) horizontal perimeter double-pipe; c) double-pipe radial

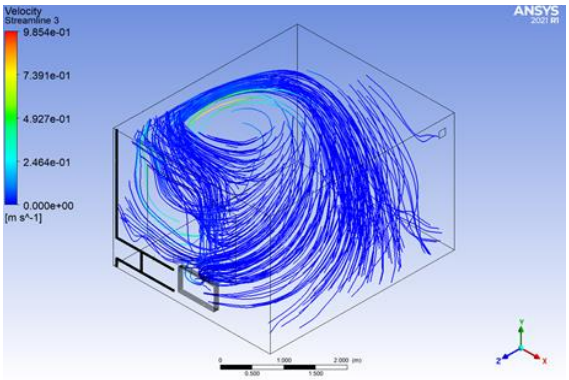
Based on the findings shown in Figures 3 and 4, it has been determined that air moves

inside the room when they are close to chilled surfaces of exterior enclosures and heated surfaces (such as pipelines and heating devices). There is an uneven distribution of temperature and air mobility due to the air flows in the room's volume.

When the same heating equipment is used in several heating systems, the temperature and air velocity distributions vary in kind. When different horizontal heating systems are used, similar temperature field images are shown, but the numerical values of the parameters at the same coordinates vary.

Clause 6.2.13 of SP 60.13330.2020 "Heating, ventilation and air conditioning" stipulates that the heat flow of the heating device should be taken 15% higher than the required one obtained by calculation so that the end user can choose comfortable thermal conditions. This is why the room temperature (Fig. 3) is higher than the standard values. The constructed numerical model does not include thermostatic valves, which are required to select comfortable thermal settings in heating systems.

The internal surfaces of external enclosures (Fig. 3) have average temperatures between 21°C and 24°C. There is no moisture condensation on the inside surface of the walls because the temperature of the interior surface is more than 3°C higher than the dew point temperature (t = 11.5°C).



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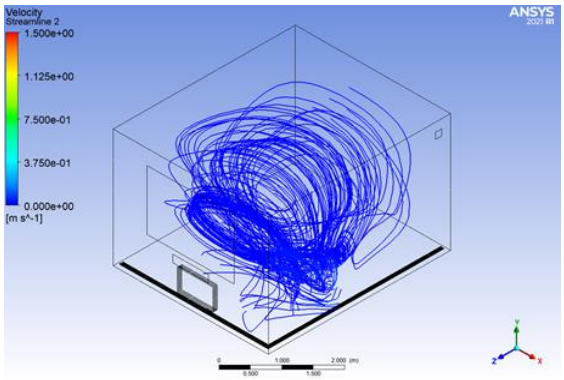

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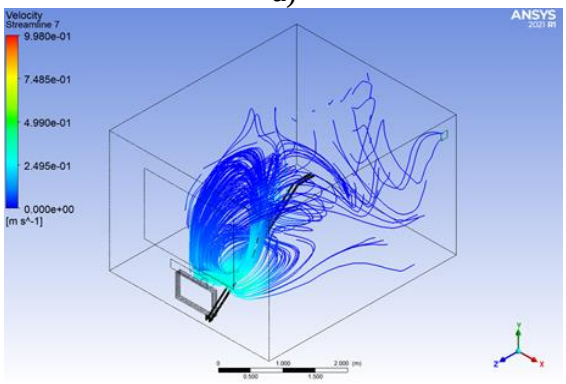

c)

Figure 4 - Air flow velocity lines formed in the kitchen by different heating systems: a) vertical single-pipe; b) horizontal perimeter double-pipe; c) double-pipe radial.

The air flow speed in the heated room must not exceed 0.2 m/s in compliance with GOST 30494-2011 "Residential and public buildings. Microclimate parameters for indoor enclosures" to provide acceptable thermal conditions and the absence of high noise levels.

Nevertheless, as shown in Fig. 4, the air flow speed in the used numerical model fluctuates between 0.33 and 0.4 m/s, exceeding the allowable limit. This is because the air temperature readings that were acquired within the rooms were higher than the numerical model's standard values and supply valve settings.

References

1. Balashov A.A. [et al.] Design of heating and ventilation systems of building. Tambov, FGBOU VPO "TSTU", 2014, 132 p. (Rus)
2. Ziganshin A.M. Computational fluid dynamics. Formulation and solution of problems in the Fluent processor: a methodological manual. Kazan, Publishing house of Kazan. state. architecture and civil engineering university, 2013, 79 p. (Rus)
3. GOST 30494-2011. Residential and public buildings. Available from: https://internet-law.ru/gosts/gost/52219. (Accessed 17 November 2024)

Моделирование микроклимата в отапливаемом помещении от различных систем отопления

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Аннотация. Представлены результаты численного исследования влияния различных систем отопления на формирование комфортных параметров микроклимата в помещении. Цель работы - моделирование систем микроклимата при разных системах отопления с помощью численных методов. Актуальность заключается в том, что использование стандартных методов расчетов приводит к повышенному энергопотреблению зданий. Численные методы позволят найти оптимальное проектное решение

Ключевые слова: моделирование; параметры микроклимата; система отопления.

УДК 620.181.5

Application and methods of controlling metasurfaces for creating flat multi-frequency antenna arrays

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Abstract
This article describes the methods of using metasurfaces in the design of antenna arrays. The use of controlled metasurfaces allows us to find and create the most effective and promising design of a multi-frequency antenna array.
Keywords: metasurface, antenna, antenna array, split ring resonator, structure.

Introduction

New technologies that make use of metasurface structures are currently proliferating. A plane made up of a variety of electrical conductors and dielectric particles that alter electromagnetic waves in various ways is called a metasurface. The unique structure of the receiving or transmitting-receiving device, which is based on a controlled metasurface, is the primary characteristic of multi-frequency metamaterial antenna arrays that sets them apart from all other antenna arrays. Depending on the setup, these antennas can emit up to 95% of the input signal due to their high radiation efficiency.

Metasurface antennas have benefits that go beyond their effectiveness. Because of their small size, devices may be made lighter and smaller, which is especially useful for mobile applications where space is limited. Additionally, these antennas are very adaptable and can be tuned to function in a variety of frequency bands, making them appropriate for a wide range of applications, including medical equipment and telecommunications.

Metasurface antennas are being included into satellite systems and smartphones more frequently in the communication industry to improve performance and connectivity. Their potential is also being investigated in medical technology, where they enable wireless data transfer in a range of medical equipment. Metasurface antennas enhance communication and navigation in autonomous systems, such robots and drones, resulting in more effective operations.

We may anticipate many more advancements in radio engineering and communications as metasurface technology research and development advances. These antennas are positioned as a crucial part of the future of wireless technology due to their special qualities and great efficiency. [1]

Split ring resonators are actively being developed using metasurfaces as the fundamental components of metasurface antennas, whose flexibility and electromagnetic response make them the most useful in a research setting. Microwave lenses hold a distinctive place among information-transmission devices based on metasurface technology (Pic. 1). A spherical lens composed of a metamaterial with a non-uniform density is called a microwave lens.

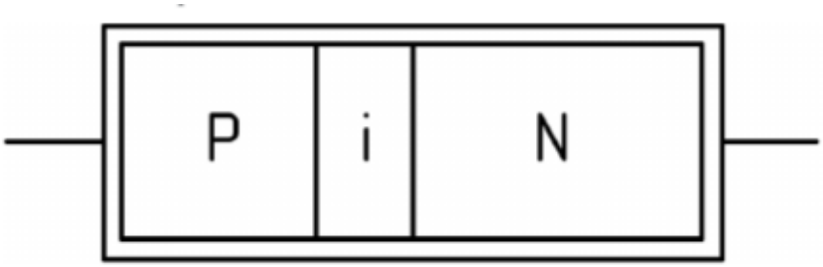

Figure 1 — Operation diagram of a microwave lens

Microwave lenses can be used as a coupler from the emitter to concentrate the reflected signal along the signal's microwave transmission line or from the microstrip line to the transceiver. They can also focus the radiation from a point source to the perimeter. One can utilize such a lens as an input device. The capacity to alter the phase of the propagating signal and to boost the amplitude of damped waves is two characteristics of microwave lenses.

In addition to these characteristics, microwave lenses are essential for improving communication systems' effectiveness. These lenses reduce signal loss and enhance transmission quality by focusing and guiding microwave waves. Their architecture can be modified to suit particular uses, enabling peak performance in a range of settings, including medical imaging, radar systems, and telecommunications.

In addition, the versatility of microwave lenses allows them to be integrated into advanced technologies, such as phased array systems, where precise control of beam direction is important. Because of their versatility, they are extremely useful in contemporary wireless communication, where dependable connections and fast data rates are critical. We may anticipate more developments as microwave optics research progresses, expanding the capabilities and range of applications for microwave lenses and opening the door to more effective and efficient microwave systems. [2]

Special PIN diodes are used to control the metasurface, namely the spatial orientation of the metal conductors and dielectric particles of the metasurface.

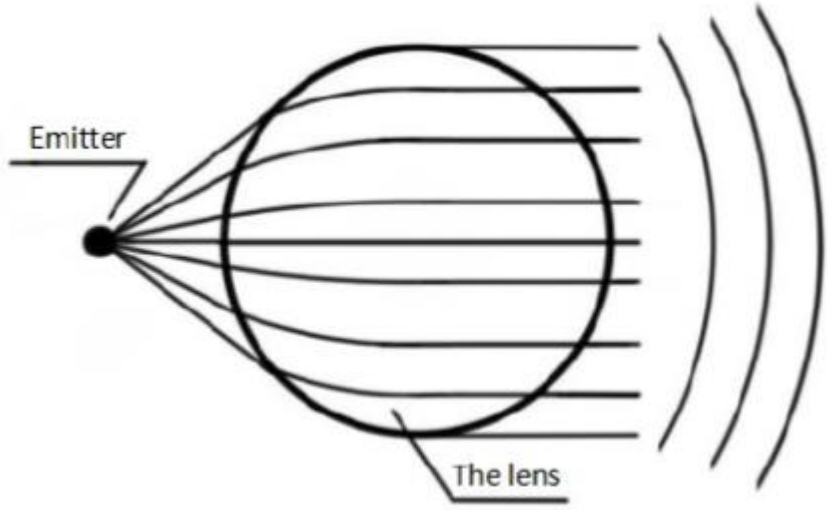

Figure 2 — Structural diagram of a PIN diode

The existence of an unligated zone (i-region) between the electron (n) and hole (p) regions is a defining attribute of a PIN diode. This special structure makes it possible to

precisely manipulate the spatial orientation of each particle within a metasurface by adjusting the voltage supplied, which effectively controls the diode's conductivity. Dynamic reconfiguration of the metasurface can be accomplished by varying the voltage applied to the PIN diodes. This is crucial for a number of applications in cutting-edge imaging and communication systems.

Managing meta-atoms, which can exist in several quantum physical states, is the foundation of all intelligently managed metasurfaces. For applications that need quick and flexible reactions to shifting circumstances, this adaptability is essential. The single-bit encoding technique is the most popular and best option among the different approaches for managing meta-atoms in terms of complexity, production costs, energy efficiency, and economic viability. By assuming that each meta-atom has only two active states, this encoding technique simplifies design and implementation while maintaining a high degree of control over the features of the metasurface.

In addition to improving the metasurface's performance, the ability to efficiently alter these meta-atoms using straightforward binary states aids in the creation of more complex, responsive systems. The use of PIN diodes and single-bit encoding in metasurfaces is expected to result in novel solutions in domains like wireless communication, sensor technologies, and adaptive optics as research advances. [3]

Conclusion

Multi-frequency antenna arrays constructed using metasurfaces represent a significant advancement in wireless communication technology. These antennas possess unique characteristics that allow them to operate effectively in various conditions and scenarios. One of the key advantages of such antennas is their capacity to provide omnidirectional reflection of the incident wave at any angle within the antenna array's working field. This feature makes them particularly suitable in applications where a great degree of adaptation and flexibility is required.

Metasurfaces provide numerous opportunities to change the reflection angle without the need for physical movement of the device. This capability allows antennas to adapt to changing environmental conditions or user requirements in real-time. Furthermore, metasurfaces can be fine-tuned to optimize the operational efficiency of systems, achieved by adjusting the metasurface particles to fully attenuate the incident wave. This leads to significant improvements in communication quality and a reduction in interference levels.

Notwithstanding these benefits, there are a number of obstacles to overcome before metasurface antenna arrays may be widely used in wireless communication systems. The enormous volume of data required for organizing and modeling metasurfaces is one of the primary problems. These systems' intricacy may make them challenging to deploy and maintain, which could prevent their broad use in business applications.

The most common and effective kind of metasurfaces on the market right now are intelligently controlled metasurfaces. These systems provide metasurface-based autonomous control of communication processes, enabling adjustments without the need for human involvement. Wireless communication systems' responsiveness and dependability can be greatly improved by this automation, which makes them better suited for dynamic settings requiring quick modifications.

The most popular method for managing meta-atoms, single-bit programming, does not, however, offer the flexibility and accuracy needed for changes in spite of these developments. Greater control would be possible with multi-bit coding, but for many applications, the high labor and material costs make this method impractical. Consequently, the business is looking for creative ways to get around these restrictions without sacrificing affordability.

Unlocking the full potential of metasurfaces in contemporary communication systems will require addressing these issues. New techniques for effective data management and control of metasurface qualities are probably going to appear as this field of study develops. We anticipate wider use of metasurface antenna arrays after the present challenges are resolved, which will improve wireless communication systems' functionality and performance.

References

1. Slyusar V. Metamaterialy v antennoy tekhnike: istoriya i osnovnye printsipy [Metamaterials in antenna technology: history and basic principles]. ELEKTRONIKA: Nauka, Tekhnologiya, Biznes. 2009. №7, pp. 70-79 (Rus)
2. Larionov M.U., Sobolev A.S., Reznik A.U. Antenna na osnove metamateriala [Antenna based on a metamaterial]. Nanoindustry, 2020, Vol.№ 2, Issue 596, pp 650-652. (Rus)
3. Alekseev U.I., Maliev I.V. Amplitudomoduliruemyj peredatcik na pin-diode [Amplitude-modulated pin-diode transmitter]. Izvestia TTU, 2004, Vol.№ 1, Issue 36, pp 25-26. (Rus)

Применение и способы управления метаповерхностями для создания плоских многочастотных антенных решёток

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Аннотация. Статья посвящена методам использования метаповерхностей при проектировании антенных решёток. Использование управляемых метаповерхностей позволяет находить и создавать наиболее эффективную и перспективную конструкцию многочастотной антенной решётки.

Ключевые слова: метаповерхность, антенна, антенная решётка, разрезной кольцевой резонатор, структура

УДК 004.932.2

System for measuring the thickness of wire enamel

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Abstract
The aim of the work is to develop a system for measuring the thickness of metal wire enamel for the process of enameling metal wire. This article presents and describes the technical support of the system, as well as the software and algorithmic support and the algorithm of its operation. The result of the system is to obtain information about the thickness of the enamel layer on the metal wire.
Keywords: enamelling, measurement system, metal wire, technical vision.

Introduction

Modern enterprises producing high-precision equipment produce enameled metal wire, which is used in the creation of inductors, electromagnets, transformers and other products where dense coils of insulated wire are required. At the moment, many enterprises do not constantly monitor the thickness of the applied enamel layer during the enameling process of metal wire, which entails a loss in product quality due to the unevenness of the applied layer.

The existing methods for controlling the metal wire enameling process have significant disadvantages. The main common disadvantage is the inability to continuously measure the thickness of the applied enamel on the metal wire. Also, existing methods do not allow measuring enameled metal wire with an extremely small size, often not exceeding several microns. Therefore, most thickness measurement methods are not suitable for measuring such a wire [1].

The diameter of the resulting wire often does not exceed several tens of microns. Therefore, most thickness measurement methods are not suitable for measuring such a wire.

Based on the above reasons, technical vision technologies are used in this system. Technical vision technologies make it possible to improve the measurement quality of the enamel layer on the wire several times, this is achieved due to the possibility of processing each pixel that is visible in the image. As a result, it becomes possible to measure extremely small layers of enamel on a wire with an extremely small error [2].

The developed system

The technical support of the developed system includes a Levenhuk M800 PLUS digital camera. This camera is designed for installation on biological, instrumental and stereoscopic microscopes. This camera does not distort the real parameters of the measuring object, has an 8-megapixel matrix and allows you to record videos and create photos with resolution.

The system also includes a Levenhuk 3ST microscope, which is capable of magnifying the image of the measured object. The optics of the microscope are made of high-quality glass and have a special coating for maximum clarity and color correctness of the

transmitted images. The microscope has a variable multiplicity, the range of which is from 20 to 40 times, which helps to increase the image of the wire to sizes that the developed system can clearly recognize. This, in turn, allows you to measure the boundaries of the contour of the object with high accuracy.

The software and algorithmic support of the system is a program code written using the Python language, in the PyCharm development environment, using the OpenCV and NumPy libraries. The developed program code is shown in Figure 1.

```python
import cv2
import numpy as np

path = 'Provoloka.bmp'

img = cv2.imread(path)
mask = np.zeros(img.shape[:2], dtype="uint8")
cv2.circle(mask, (445, 300), 100, 255, -1)
masked = cv2.bitwise_and(img, img, mask=mask)

ret,thresh = cv2.threshold(masked,33,255,cv2.THRESH_BINARY)

kernel = cv2.getStructuringElement(cv2.MORPH_RECT, (7, 7))
closed = cv2.morphologyEx(thresh, cv2.MORPH_CLOSE, kernel)
closed = cv2.cvtColor(closed,cv2.COLOR_BGR2GRAY)

contours = cv2.findContours(closed.copy(), cv2.RETR_EXTERNAL, cv2.CHAIN_APPROX_SIMPLE)[0]

cv2.drawContours(image=img, contours=contours, contourIdx=-1, color=(0, 255, 0), thickness=1, lineType=cv2.LINE_AA)

for contour in contours:

    Area = cv2.contourArea(contour)
    Perimetr = cv2.arcLength(contour, True)
    print("Area contour:", Area)
    print("Perimetr contour:", Perimetr)
    x1, y1 = contour[0, 0]


    a = 1
    b = -0.5*Perimetr
    c = Area

    d = b ** 2 - 4 * a * c

    if d > 0:
        X1 = ((-b + d**0.5) / (2 * a))
        X2 = ((-b - d**0.5) / (2 * a))
        print(f'X1 = {X1:.5f}; X2 = {X2:.5f}')
        l = [X1, X2]
    elif d == 0:
        X = -b / (2 * a)
        print(f'X = {X:.5f}')
        l = X
    else:
        print('Nothing')

Width= min(float(s) for s in l)
print(f'Width = {Width:.5f}')

Diametr = 10.400625 * Width
print(f'D = {Diametr:.1f}')

cv2.putText(img, f'Diametr = {Diametr:.1f}', (x1 + 80, y1 + 325), cv2.FONT_HERSHEY_SIMPLEX, 0.7, (0, 0, 255), 1)


#cv2.imshow("img", img)
#cv2.imshow("mask", mask)
#cv2.imshow("masked", masked)
#cv2.imshow("masked", closed)
cv2.imshow('contours', img)

cv2.waitKey(0)
```

Figure1- Program code

At the beginning, an area in the image is selected in which the program will later search for the contours of the object.;

Next, in the selected area of the image, we find a metal wire with enamel;

After that, the threshold transformation of the image takes place. The essence of this

transformation is as follows: if the pixel value exceeds a certain set (threshold) value, then it is assigned a value corresponding, for example, to white, otherwise to black. This transformation helps to segment the background and object into an image;

After previously performed actions, the system determines and displays the external contour of the wire to be measured.

The resulting wire contour is processed by the system, and then its perimeter and area are calculated.

Next, using basic mathematical formulas, the program compiles a quadratic equation. When solving this equation by the system, two roots are obtained, the smaller of these roots is the thickness of the wire being measured. The resulting value is expressed in pixels, in order to obtain the actual dimensions of the wire in micrometers, a correction is introduced using a coefficient, which is the ratio of one pixel to one micrometer.

At the end, the received information about the size of the wire is displayed in the work console, as well as in a window with an image that is transmitted from the Levenhuk M800 PLUS camera.

Conclusion

Analyzing the data obtained on the operation of the system, the following conclusion can be drawn: the use of technical vision technologies in the developed system for measuring the thickness of wire enamel made it possible to achieve accurate measurement of objects of extremely small sizes, in comparison with other measurement methods. This system can be used in enterprises producing transformers, inductors and other various radio and electrical equipment in which enameled wires are used.

References

1. Smirnov, G.V., Smirnov, D.G., Ekimova, I.A. Tekhnologiya kontrolya i remonta emalirovannih provodov [Technology of control and repair of enameled wires]. Defektoskopiya, 2017, vol. 1, No 3, pp.62-68. (Rus).

2. Lekerova, E.M., Kozlov, M.S. Analiz defektov emalprovoda s pomoshchyu instrumentov TRIZ [Analysis of enamel wire defects using TRIZ tools]. Elektroenergetika glazami molodezhi: materialy XII mezhdunarodnoi nauchno-tekhnicheskoi konferentsii, Nizhnii Novgorod, 2022, pp.265-268. (Rus).

Система измерения толщины эмали проволоки

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Аннотация. Целью работы является разработка системы измерения толщины эмали металлической проволоки для процесса эмалирования металлической проволоки. В данной статье представлено и описано техническое обеспечение системы, а также программно-алгоритмическое обеспечение и алгоритм ее работы. Результатом работы системы является получение информации об толщине слоя эмали на металлической проволоке.

Ключевые слова: металлическая проволока, система измерения, техническое зрение, эмалирование.

УДК 628.87

Comparative analysis of the efficiency of various types of convectors

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Abstract
In today's world, choosing the right heating system can feel like navigating a labyrinth of technical jargon and competing claims. Among the many options available, convectors have emerged as a popular choice, offering a balance of efficiency and versatility. However, with a diverse range of convector types on the market, choosing the optimal solution for a given space can be a daunting task. This study aims to greatly simplify this process by presenting a comparative analysis of the efficiency of different convector designs, helping to clarify why one type of convector is better suited for a given application than another.
Keywords: convectors, heating efficiency, comparative analysis, thermal performance, space optimization, system design, volumetric heat characteristic.

Introduction

Currently, the market for heating appliances (Fig. 1) is characterized by a wide variety of available solutions, a significant proportion of which are represented by convectors of various types. The correct selection of convectors plays a crucial role, as it allows for the creation of a comfortable environment in the heated space and contributes to cost savings [1].

The main objective of this work is to conduct a comparative analysis of the efficiency of different convector types (Table 1). Such an analysis enables rational decision-making regarding the installation of convectors during the design of heating systems, which helps to avoid problems such as insufficient heating or overheating of the room, disruption of the room's aesthetic appearance, and inefficient use of financial resources.

Methods and Results

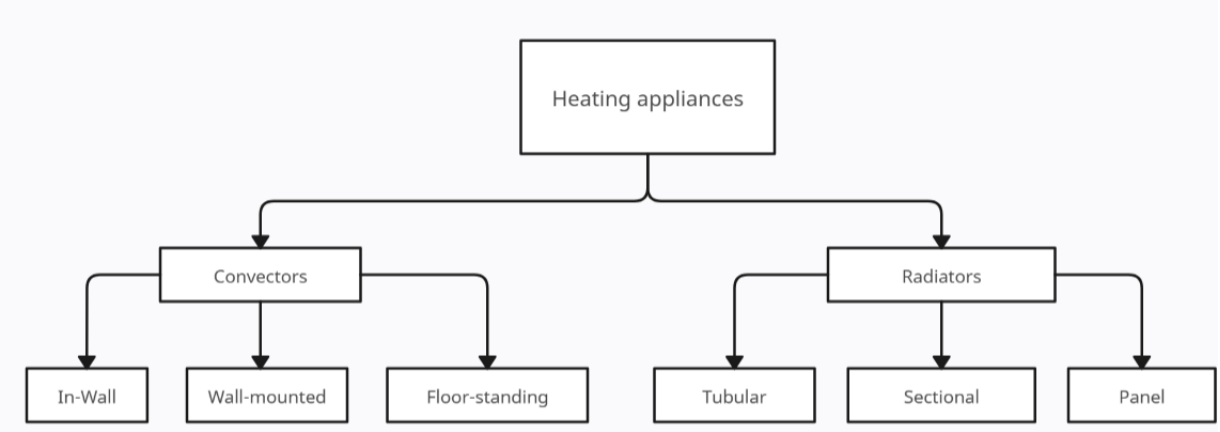

Figure 1 - Main types of heating appliances.

For the analysis, we will use convectors from the SPL brand [2], which comply with the technical requirements according to GOST 31311-2022: Heating appliances. General

specifications [3]. This will allow for more accurate conclusions about the heat performance of convectors, as the efficiency will be considered within one manufacturer.

Table 1. Advantages and disadvantages of different types of convectors

Type	Advantages	Disadvantages	Application Scope
Wall-mounted	Versatile option suitable for most cases, easy installation and operation, wide range of sizes.	Not suitable for rooms with panoramic glazing and low sills, occupies space near the sill, which may interfere with everyday use.	Versatile for all application areas.
Floor-standing	Suitable for rooms with low sills, extremely easy installation.	Inconvenient to use, may cause obstruction in everyday use, limited model range in terms of height.	Rooms with low sills or when wall-mounted convector installation is not possible.
In-wall	Suitable for rooms with panoramic glazing, ease of use, does not take up space in the room.	Complex installation, strict size requirements, the need to purchase a decorative grille separately, can only be installed in a floor screed (false floor).	Rooms with panoramic glazing, apartments with sufficient floor screed height.

As an indicator of convector efficiency, we will use the volumetric heat characteristic, calculated using the following formula:

$$q_v = \frac{Q_{\text{ном}}}{V} \quad (1)$$

where $Q_{\text{ном}}$ - is the nominal heat output of the convector; V - is the volume occupied by the convector.

Since the heat exchanger plays a key role in evaluating the thermal efficiency of convectors, for the sake of fairness in calculations, we will use convectors that are similar in size and have the same type of heat exchanger. In our case, this is a copper heat exchanger with corrugated aluminum fins, designated as 2/1, where '2' represents the number of heat exchanger tubes, and '1' represents the number of tube rows in height [2].

Using formula (1), we will calculate the volumetric heat characteristic for all convector types and summarize the results in Table 2.

Table 2. Calculated characteristics of different types of convectors [3].

Convector Type	Dimensions, L x H x D, m	Occupied Volume V, m³	Heat Exchanger Type	Nominal Heat Output Q_{nom}, W	Volumetric Heat Characteristic q_v, W/m³
Wall-mounted	0,18x0,3x0,081	$4{,}37 \cdot 10^{-3}$	2/1	1295	296339
Floor-standing	0,18x0,09x0,14	$2{,}27 \cdot 10^{-3}$	2/1	1271	559911
In-wall	0,18x0,11x0,2	$3{,}96 \cdot 10^{-3}$	2/1	661	166919

Conclusion

Therefore, it can be concluded that the most efficient convector in terms of the ratio of occupied volume to heat output is the floor-standing convector. It is worth noting that, in

practice, due to the specifics of its installation, the in-wall convector does not occupy any room space. The results of this analysis can be used to select the optimal convector based on individual preferences, considering convenience, aesthetics, and thermal performance. Furthermore, these findings highlight the importance of considering not just raw performance numbers but also the practical implications of installation and space utilization when choosing a heating solution. While the floor-standing model demonstrates superior theoretical efficiency, the in-wall option might be preferable in space-constrained environments or when a minimalist aesthetic is desired. Ultimately, this research provides a valuable framework for making informed decisions about convector selection, ensuring both comfort and optimal use of space.

References

1. Datsyuk, T.A., Ivlev, Yu.P., Pukhkal, V.A. (2013). Rezul'taty modelirovaniya mikroklimata zhilykh pomeshcheniy pri razlichnykh tipakh otopitel'nykh priborov [Results of modelling microclimate of residential premises for linearly arranged types of heating devices]. Inzhenerno-stroitel'nyy zhurnal, 6(41), pp. 12–21. (Rus)
2. Assortimentnyy katalog. Lineyka otopitel'nogo oborudovaniya SPL. (2023) [Product catalogue. SPL heating equipment range. (2023)]. Available from: https://splpro.ru/wp-content/uploads/2023/08/КАТАЛОГ-Конвекторы-SPL_compressed.pdf (Accessed 07.11.2024). (Rus)
3. GOST 31311-2022. Pribory otopitel'nye. Obshchie tekhnicheskie usloviya [Heating appliances. General technical conditions]. – Vved. 2023-02-01. – M.: Rossiyskiy institut standartizatsii, 2022. – 15 s.

Сравнительный анализ эффективности конвекторов различного типа

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Аннотация. В современном мире выбор правильной системы отопления может ощущаться как сложный технический путь между разными производителями и конкурирующими заявлениями. Среди множества доступных вариантов конвекторы стали популярным выбором, предлагая баланс эффективности и универсальности. Однако из-за разнообразия типов конвекторов, представленных на рынке, выбор оптимального решения для данного помещения может оказаться непростой задачей. Это исследование призвано значительно упростить этот процесс, представляя сравнительный анализ эффективности различных конструкций конвекторов, помогая прояснить, почему один тип конвектора лучше подходит для данного применения, чем другой.

Ключевые слова: конвекторы, эффективность отопления, сравнительный анализ, тепловая производительность, оптимизация пространства, проектирование систем, объёмная тепловая характеристика.

УДК 62-5

Disadvantages of 3D scanning and ways to eliminate them

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Abstract
The article touches upon the topic of shortcomings in 3D scanning. Problems related to the accuracy and quality of the resulting data are described. The ways of eliminating these disadvantages are considered. Various approaches to improving the 3D scanning process are analyzed.
Keywords: contrast marks, matting spray, 3D scanning, software.

Introduction

3D scanning offers many advantages over traditional measurement methods. First, they include the speed and completeness of data collection. 3D scanning allows you to save money and time on measurements. Using a 3D scanner, you can get an accurate three-dimensional copy of any object, even with complex geometry. All this makes the 3D scanner a universal and indispensable tool for non-contact measurements. [1].

Disadvantages of 3D scanners

Despite the undeniable advantages of 3D scanners, there are some disadvantages:

1. The availability of special skills and knowledge to work with the software.
2. Long scanning time and human factor.
3. Difficulties when working with shiny, transparent and dark surfaces of the object.
4. The difficulty of scanning bottlenecks and small holes of objects.
5. The difficulty of scanning symmetrical objects.
6. Difficulties in scanning objects without pronounced geometry features.

Ways of eliminating the disadvantages

To eliminate the disadvantages of 3D scanning, you can take the following steps:

1. Special skills and knowledge are required to work with the software. But, there are quite simple 3D scanning programs that do not require deep programming knowledge. For example, Photomodeler Scanner, 3DF Zephyr are very simple and functional software that allows you to create high-precision stl models based on ordinary images taken with a smartphone or tablet cameras. These programs are designed for both professionals and beginners, due to the simple interface and many settings.

2. 3D Scanning objects can take a long time. To get the desired result when scanning in a short time, the following recommendations should be taken into account. The more data there is in each frame, the easier it will be to combine them and the more accurate this mixing will be. It is necessary to start digitizing an object from a position in which all parts of this object are in their normal position. After that, it is necessary to disassemble the object, if necessary, into its component parts and scan each of them separately. The quality of the scan depends on how static the object under study is.

If the size of the object is 2-3 volumes captured by the scanner, you need to start scanning from the center.

If you need to scan several small objects, place them at a short distance from each other. The 3D scanner digitizes a group of elements in one go. After scanning, carefully check the received data for errors. If necessary, re-scan or correct the data.

The influence of the human factor on the scanning quality is reduced when using an automated scanning mode (for example, using a turntable).

3. Reflective light and transparent materials are the most common problems with 3D scanning. Such surfaces create a large amount of glare, so it is recommended to apply a matting spray to the object, which will form a thin homogeneous film on the surface.

Before scanning dark objects, you need to free them from scratches and other defects that can distort the scan results. If necessary, mat the object with a spray and use contrasting labels. It is helpful to use even lighting to minimize shadows and create contrast between the object and its surroundings, but avoid scanning in bright sunlight, as this will greatly complicate the process and reduce accuracy.

4. 3D scanning in hard-to-reach places is particularly difficult: narrow slots and small holes. The light source of the 3D scanner and the reading camera are always at an angle of about 20o, so the scanner cannot look deep into the bottlenecks of the object. And as a result of such a scan, there are gaps in the final polygonal model. In this case, you can take silicone casts of bottlenecks or small holes, do a 3-D scan of these casts and then combine them into a single model with the main 3D scanning. In simple cases, you can "drawing" the missing geometry directly on the 3D scan, without completely reworking the 3D scan into a CAD model.

If none of the above methods gave results, then you can cut the part into parts and scan each part separately, then sew them with a special program.

If the object cannot be destroyed, because, for example, it is in a single copy, then a more expensive 3D video endoscope can be used. The wide field of view and large depth of field allow the 3D video endoscope to take measurements in hard-to-reach places of the object.

5. The easiest way to scan a relatively small symmetrical object is to use additional geometry, that is, add arbitrary asymmetric data to the symmetrical object to help the scanner correctly combine different images. The best example of additional geometry is a crumpled paper (placed under or around an object) or a piece of cloth. To simplify post-processing, you need to place the object on a small platform. Transparent plastic lids and jars are well suited for this purpose. If everything is done correctly, the object will "soar" above the surface, and it will not be difficult to split the scan with additional geometry.[2].

6. We will conduct a 3D scan of the object without pronounced features, for example, dowels. Any 3D scan consists of a large number of small scanned images. Accordingly, to get a 3D model of an object, you need to assemble these images into a single model. The images are very similar to each other, because the change in the curvature of the key is smooth and insignificant. For small objects without geometric features, the presence of contrasting 3D noise will be sufficient (as described in paragraph 5). If the object is large, then use one of the following methods:

A. Texture matching. We apply arbitrary drawings to the object with matting spray and then collect all the fragments according to these drawings. It is fast, but not very accurate.

B. Matching by markers. Before 3D scanning, we glue contrasting labels, the coordinates of which will be determined by the scanner with high accuracy. This is very accurate, but it takes a long time. Since in addition to marking, they will need to be removed not only from the object, but also from the final result of the 3D scan.

Conclusion

In conclusion, it is worth noting that 3D scanning does not stand still, in recent years, three-dimensional scanning technology has made a real breakthrough in its development. Modern compact 3D scanners can produce high-precision digitization of objects of almost any size and level of complexity. There are many scanning devices and technologies on the market. Each has its advantages and disadvantages. The choice is entirely up to the consumer to choose less reliability, but a greater depth of field, or vice versa, different technologies are suitable for each purpose [3].

References

1. Bordachev V. A. 3D Scanirovanie v machinostroenii: technologii i priminenie [3D Scanning in mechanical engineering: technologies and applications]. All-Russian Scientific and Practical Conference, 2023, No. 11, pp. 15-17. (Rus)
2. Kuznetsov A.A. Sovremennye 3D scenery: raspahnutaya dver' v virtual'noe prostranstvo [Modern 3D scanners: an open door to virtual space]. RBC Holding, 2022, pp. 62-77. (Rus)
3. Buyanov S.S. Perspektivy ispol'zovaniya 3D-tekhnologij dlya razvitiya informacionno-analiticheskoj platformy [Prospects of using 3D-technologies for the development of information-analytical platform]. Genesis, 2014, pp. 75-97. (Rus)

Недостатки 3D сканирования и способы их устранения

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Аннотация. В статье затронута тема недостатков при 3D сканировании. Описываются проблемы, связанные с точностью и качеством получаемых данных. Описываются способы устранения этих недостатков. Анализируются различные подходы к улучшению процесса 3D-сканирования.

Ключевые слова: 3D-сканирование, программное обеспечение, матирующий спрей, контрастные метки.

УДК 621.31

Improving the energy efficiency of a multiroom apartment house

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Abstract
The article discusses a way to improve the energy efficiency of an apartment building. The method involves using the energy of wastewater, wastewater disposal systems of a residential building, to generate electric energy. Using the example of a typical panel house, it is shown that the amount of electric energy generated is sufficient to operate most of the equipment that is part of the common property of a residential house.
Keywords: household drains, household needs, turbine, electric energy, energy efficiency.

Since 2023, new rules for calculating fees for general household needs have come into force. If until this moment residents paid for the necessary common building resources in accordance with established standards, now the management company will compare the readings of common building meters with the readings of the apartment meters of the homeowners and distribute the difference to all apartments [1]. This innovation, first of all, takes into account the interests of management companies, which will no longer have to pay for resources spent in excess of standards at their own expense. However, these rules will lead to an increase in the total amount in the housing and communal services receipt for the majority of the population.

To solve this problem, it is proposed to reduce electricity consumption for general household needs from the general network through the installation of microturbines [2, 3]. The turbines will be located on horizontal outlets of sections of the drainage system pipelines located in the basement. It is proposed to use a horizontal-axial turbine in the storm sewer system, and a vertical-axial turbine in the wastewater disposal system due to the presence of solids. These devices will allow you to convert the energy of the waste stream into electrical energy.

The proposed installation must meet the following requirements:

- take into account the nature of wastewater pollution;
-work in generator mode;
- meet the requirements for low wastewater pressure to reach the nominal efficiency;
-have sufficient battery capacity to provide uneven load of consumers, starting from ordinary incandescent lamps and ending with the electric motor of the elevator.

The functional diagram of the installation is shown in Fig. 1. The turbine converts the energy of the water flow into mechanical energy by rotating the shaft, which is converted into electrical energy in the generator. The charge controller is designed to monitor the state of charge of the battery. If the batteries are fully charged, the controller disconnects them from the generator. Rechargeable batteries serve to accumulate electrical energy from turbines and, if necessary, distribute it to the consumer. The inverter converts direct current into alternating

current for subsequent power supply to the consumer electricity.

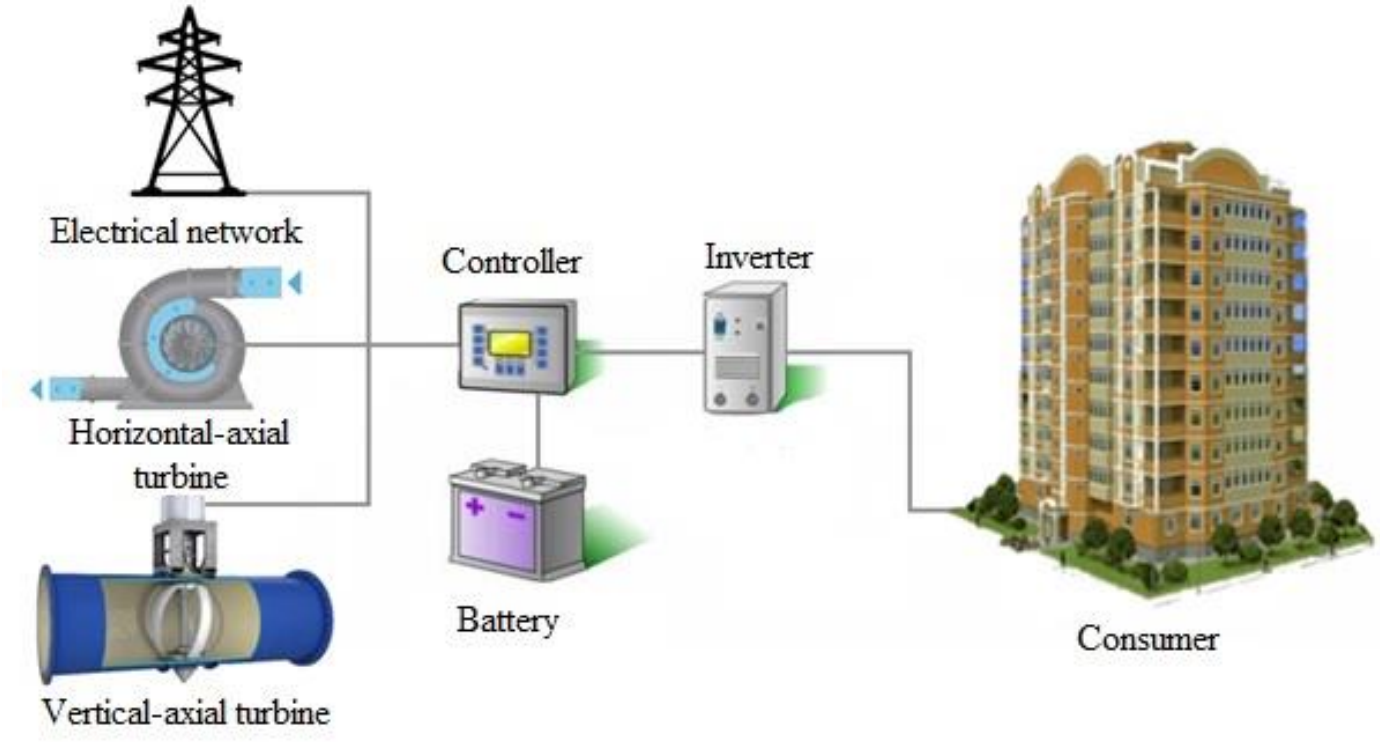

Figure 1 – Block diagram of inclusion of microturbines in the power grid

Using the example of a typical panel house, the potential application of the technology was assessed. A calculation of the amount of electricity consumption for the maintenance of the common property of the apartment building was carried out and a comparison was made with the power of the flow of stormwater and domestic wastewater.

As a result of calculations, it was established that 1382.1 MW is needed to maintain the common property of the apartment building during the year, and the potential power of the water flow of the drainage system will be 1171 MW.

It can be seen from the data obtained that it is impossible to fully cover the need for electricity, however, the stream contains a significant amount of energy, which is enough to partially cover the need for the operation of most systems in a residential building.

References

1. Resolution of the Government of the Russian Federation dated 09/13/2022 No. 1598 "On Amendments to Resolution of the Government of the Russian Federation dated May 23, 2006 No. 306 and Invalidation of Certain Provisions of Certain Acts of the Government of the Russian Federation" // ConsultantPlus: legal reference system. – Moscow, 1997. – Title title. the screen. Author A.A., Author B.B., Author C.C., Author D.D. Title of the book. Place of Publication, Publisher, 2005. 345 p.

2. Patent No. 2526604 Russian Federation IPC F03B 7/00(2006.01), F03B3/12(2006.01), F03D 3/00(2006.01). Hydropower power system and turbine in a pipe: N 2011144173: application 03/24/2010: published 08/27/2014 / SCHLABACH Roderick A., COSBY Mark Rydell, KURT Edward, PALEY Igor, SMITH Greg.; the applicant is Lucid Energy. - 20 p.: ill. – Text: direct.

3. Patent No. 2306452 Russian Federation IPC F03B 3/00(2006.01). Hydroturbine: N 2005133291/06: application 10.28.2005: published 09.20.2007/ Ivanov Vladimir Mikhailovich, Rodivilina Tatyana

Yuryevna, Semkin Boris Vasilyevich, Blinov Alexey Alexandrovich, Ivanova Polina Vladimirovna, Svit Pavel Petrovich, Klein German Orestovich; applicant: Vladimir Mikhailovich Ivanov, Rodivilina Tatyana Yurievna. - 10 p.: ill. - Text: direct.

Повышение энергоэффективности многоквартирного жилого дома

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Аннотация. В статье рассматривается способ повышения энергоэффективности многоквартирного жилого дома. Способ предусматривает использования энергии стоков, систем водоотведения жилого дома, для выработки электрической энергии. На примере, типового панельного дома, показано, что количества вырабатываемой электрической энергии достаточно для работы большинства оборудования, входящего в состав общего имущества жилого дома.
Ключевые слова: бытовые стоки, общедомовые нужды, турбина, электрическая энергия, энергоэффективность.

УДК 621.396.24

Features of application of metasurfaces in designing multi-frequency antenna arrays

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Abstract
This article is devoted to the features of application of metasurfaces in designing multi-frequency antenna arrays. Application of metasurfaces is a more promising technology for creation of multi-frequency antenna arrays due to increased functionality and reduced dimensions of the finished product.
Keywords: metasurface, antenna, antenna array, multi-frequency antenna array, structure.

Introduction

A novel class of materials known as metamaterials has surfaced; these materials have special electromagnetic properties that are absent from naturally occurring compounds. In light of contemporary wireless communication technologies, this invention has important ramifications for antenna technology. The investigation of metamaterials has encouraging opportunities for improving antenna performance as the need for quicker and more effective communication technologies grows.

The idea of metamaterials was first proposed in the early 1800s, when pioneers like Jagadis Chandra Bose carried out the first experiments [1]. The foundation for comprehending the polarization characteristics of structured materials was established by his study. In the latter half of the 20th century, the term "metamaterials" became popular, especially after scientists like Smith et al. (2000) [1] used manufactured structures to demonstrate negative index refraction. This was a watershed in the creation of materials capable of extraordinary electromagnetic wave manipulation.

For metamaterials to be used in antenna design, they must be categorized. Double positive (DPS), single negative (SNG), and double negative (DNG) materials are the three primary categories into which they can be divided according to their electromagnetic characteristics [1]. Each kind has unique benefits for different uses, but DNG materials stand out for their capacity to produce negative refraction and improve antenna efficiency.

The exact engineering of metamaterials has been made easier in recent years by developments in manufacturing techniques, including as 3D printing and nanofabrication [3]. By creating structures with specific electromagnetic characteristics, these techniques make it possible to create antennas that are not only small but also have improved performance metrics, such higher gain and bandwidth. Researchers can now simulate and tune metamaterial structures prior to actual prototyping thanks to the incorporation of computer modeling, which has further expedited the design process [3].

As wireless communication systems evolve, the need for antennas that can operate efficiently across multiple frequency bands has become paramount. Metamaterials offer a solution through the development of electrically small antennas (ESAs), which maintain high efficiency despite their reduced size. This is particularly beneficial for mobile devices

and other compact electronics, where space is at a premium [1].

The investigation of metamaterials in antenna technology includes enhancements in radiation patterns and directivity in addition to size reduction. Engineers can create antennas that perform better than conventional designs in a number of crucial parameters by adjusting the effective permittivity and permeability of metamaterials [2]. This capacity creates new opportunities for satellite systems, radar, and telecommunications applications.

The field of study at the nexus of antenna technology and metamaterials has the potential to completely transform wireless communication. Examining the effects of these materials on upcoming antenna designs and their useful applications in next-generation communication systems is essential as this sector develops.

Methods

A thorough analysis of the body of research on metamaterials and their uses in antenna technology is part of the methodology used in this study. This entails examining numerous publications that go over the classifications of metamaterials, their theoretical underpinnings, and current developments in fabrication methods [3]. The goal is to summarize what is currently known and point out any gaps in the literature that need more research.

The study places a lot of emphasis on the real-world uses of metamaterials in the creation of antennas with improved performance attributes. This entails looking at case studies that demonstrate the effective integration of metamaterials into antenna designs and highlight how they affect performance measures like efficiency, bandwidth, and gain [3]. Various metamaterial kinds, such as DPS, SNG, and DNG materials, and their advantages in antenna applications will be examined.

The study places a lot of emphasis on the real-world uses of metamaterials in the creation of antennas with improved performance attributes. This entails looking at case studies that demonstrate the effective integration of metamaterials into antenna designs and highlight how they affect performance measures like efficiency, bandwidth, and gain [3]. Various metamaterial kinds, such as DPS, SNG, and DNG materials, and their advantages in antenna applications will be examined.

The study also emphasizes the importance of interdisciplinary collaboration in advancing the field of metamaterials and antenna technology. By integrating insights from materials science, electromagnetics, and engineering design, researchers can develop innovative solutions that address the challenges faced by contemporary communication systems [1].

Results

According to the findings of this study, the incorporation of metamaterials into antenna designs can result in notable performance enhancements. For example, research has demonstrated that antennas made of DNG materials can attain greater gain and wider bandwidth than conventional antennas [2], which is especially noticeable in electrically small antennas, where the use of metamaterials enables effective operation despite size limitations.

Additionally, the examination of case studies shows that antennas with exceptional

multi-band capabilities can be produced by combining metamaterials with fractal geometries [3]. By taking advantage of fractals' self-similar characteristics, these designs allow antennas to continue operating across a range of frequency ranges. For contemporary wireless communication systems that use a variety of frequencies, this adaptability is essential.

The idea that metamaterials can successfully improve antenna performance is supported by the computational modeling done for this study. According to simulations, engineers may fine-tune the radiation patterns and gain of antennas to satisfy particular application requirements by varying the effective permittivity and permeability of metamaterials [2]. This ability highlights how metamaterials have the potential to revolutionize antenna technology.

The results also draw attention to the continued difficulties in putting metamaterials into practice in antennas. Widespread use is still significantly hampered by problems such material losses, cost, and fabrication complexity [3]. These issues should soon be resolved, though, thanks to continuous developments in material science and manufacturing methods.

Discussion

The discussion of the findings emphasizes the importance of continued research and development in the domains of metamaterials and antenna technology. A practical solution to meet the growing need for high-performance antennas is the use of metamaterials. The ability to construct tiny and efficient antennas is particularly crucial given the proliferation of wireless devices and the Internet of Things (IoT) [1].

The results also imply that scholars from different disciplines working together can quicken the rate of innovation in this area. Researchers can create innovative metamaterial structures that challenge the conventions of existing antenna designs by integrating knowledge of materials science, engineering, and computer modeling [2].

This research has implications that go beyond conventional uses in telecommunications. Metamaterials' potential to improve antenna performance could have a significant impact on defense technology, medical imaging, and remote sensing [2]. Therefore, investigating the various uses of metamaterials in antenna design is essential to developing technology in these fields.

Conclusion

The search for more effective and adaptable communication systems has advanced significantly with the incorporation of metamaterials into antenna technology. Metamaterials have enormous potential to revolutionize antenna performance and design as research advances, opening the door for next-generation wireless communication systems.

In addition, the study of hybrid metamaterials, which incorporate aspects of synthetic and natural materials, is becoming more popular. These hybrid systems can have special qualities that improve antenna performance and make production more affordable. Researchers are hopeful about creating antennas that not only satisfy present needs but also adjust to upcoming technological problems by utilizing the advantages of both material kinds. Particularly encouraging is the potential for hybrid metamaterials to make

it easier to create multipurpose antennas that can be integrated into a variety of applications, such as driverless cars and smart cities.

Finally, as metamaterials research advances, attention is turning to environmental effect and sustainability. To make sure that technological advancements do not come at the price of the environment, it will be essential to develop environmentally benign materials and production methods for metamaterials. In order to reduce waste and energy usage, researchers are looking into sustainable production techniques and biodegradable substitutes. In addition to improving metamaterials' reputation, this dedication to sustainability will guarantee their continued existence in a world where environmental concerns are becoming more pressing.

References

1. Slyusar. V. Metamateryaly v antennoy tekhnike: istoriya i osnovnye printsipy [Metamaterials in Antenna Technology: History and Main Principles]. ELEKTRONIKA: Nauka, Tekhnologiya, Biznes. 2009. №7, pp. 70-79

2. Efremova A.S., Belousov O.A., Kalashnikov S.N., Kazaryan O.A. Primeneniye fraktal'nykh antenn dlya besprovodnykh shirokopolosnykh setey chetvertogo pokoleniya [Application of fractal antennas for fourth-generation wireless broadband networks]. Problems of Contemporary Science and Practice. Vernadsky University, 2014, Vol.№ 3, Issue 53, pp 56-61 (Rus).

3. Dmitrievtsev A.U., Belousov O.A., Kudryashov M.A., Tetyukhin V.I., Kiryupin M.M. Sintez izluchatelya dlya setey besprovodnogo shirokopolosnogo dostupa na osnove medlennodvizhushchikhsya elektrodinamicheskikh struktur [Synthesis of an emitter for wireless broadband access networks based on slow-wave electrodynamic structures]. Vestnik Izhevskogo gosudarstvennogo tekhnicheskogo universiteta imeni M. T. Kalashnikova [Bulletin of IzhGTU named after M.T. Kalashnikov], 2021, Vol.№ 3, Issue 24, pp 36-45.

Особенности применения метаповерхностей при проектировании многочастотных антенных решёток

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Аннотация. Рассмотрены особенности применения метаповерхностей при проектировании многочастотных антенных решёток. Использование метаповерхностей является более перспективной технологией создания многочастотных антенных решёток за счёт повышения функциональности и уменьшения габаритов готового изделия.

Ключевые слова: метаповерхность, антенна, антенная решётка, многочастотная антенная решётка, структура.

УДК 656.025

Current problems and prospects in the transport system development

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Abstract
The purpose of this study is to analyze the problems and prospects for the development of the transport system. The study will examine the interaction of various types of transport, which consists in the coherence and coordination of operations on different types of transport participating in the general transportation process of goods and passengers. The relevance of the study lies in the fact that despite administrative and economic independence, all types of transport are in a certain dependence on each other and have a significant mutual influence on the process and results of their work. As a result, it is necessary to achieve maximum efficiency of the transport system, it is necessary to continue to develop and improve the interaction of various types of transport, which will reduce costs, reduce transportation time and increase the overall level of transport safety.
Keywords: bulk cargo, freight, transport interaction, railway, transshipment points, transport hub.

Introduction

The transport system is an integral part of the economy and the social sphere of any state. The effective organization of transportation and proper operational arrangement of transport has a huge impact on the development of trade, industry, as well as on ensuring the mobility of the population. This paper examines the problems and prospects for the development of the transport system.

At present day, the bulk of freight and passenger transportation is implemented with two or more types of transport. The freight of 80% which transported by rail is generated and performed on railway roads, i.e. due to industrial transport. The sea freight of about 90% arriving at ports is transferred to rail transport, as well as the river transport freight of about 50% arrives on railways. A large share of oil cargo is transferred from pipelines (through bases) to rail, sea, river and road transport. Therefore, the road transport interacts with almost all modes of transport. The share of road transport in passenger transportation carried out by all other modes of transport is especially high. However, the present conditions for interaction between different transport modes cannot be considered optimal [1].

Problems in the development of the transport system

The problem of transport interaction depends not only on the proper planning and good work organization in transport hubs. Despite that all types of transport which having the same single goal, each of them has its own specifics due to their physical laws of movement, the level and uniqueness of technical equipment, administrative and organizational structure, methods of operation, information exchange system, etc. This specificity determines the processes of transport interaction with historical and natural-geographical factors. Therefore, the problem of transport interaction must be studied from a broad perspective.

The transport system has been created for the mutual agreed planning of cargo transportation in direct rail-water communication. This fairly well-organized system is set out in the Tariff Guide, which includes a list of sea and river ports participating in such transportation. But at the same time a disadvantage of this system is recognized as the situation when the majority of cargo transported by means of different transport types does not fall into the plans of direct mixed communications and result in advance to a long delay at the transshipment points.

The technical and technological aspects of transport interaction

The technical aspect of the interaction problem comes down to the design and power unification of all elements and links (various types of transport) involved in the implementation of transportation in mixed communications. The technical aspect seems to be extremely complex and is subject to further development not only in practical but also in theoretical terms.

The technological aspect of the problem lies in the cargo process in transport hubs in one single procedure without which a quick and efficient transfer of cargo from one type of transport to another is impossible. Here, it is necessary to provide the proper coordination of private technological processes. It should apply to railway stations, motor transport enterprises, ports, access roads of clients and other links concentrated in hubs. The experience of technological interaction between sea, rail, river and automobile transport in many transport hubs is now widely known [2].

The management system has a significant impact on the course and results of operational work in hubs and within the boundaries of larger units of different transport. The effectiveness of this management depends not only on all the above conditions, but also on the personnel, their qualifications, and subjective qualities. The experience shows that positive results are achieved by forming the unified shifts, formed by assigning certain people to the appropriate shifts. The unified shifts allow employees of different "shops" of the hub (stations, ports, enterprises) to study each other, which improves business contacts, promotes increased trust and responsibility between employees of the operational apparatus.

Organization of passenger transportation

The importance of transport interaction is equal to the improvement of passenger

transportation. Many provisions set out specifically for the sphere of freight transportation are addressed in relation to passenger communications. In this case, first of all, the requirements are put forward for clear coordination and implementation of planned movements, volumes of transportation on different types of transport in order to minimize the waiting time of passengers during the "transfer", and also to ensure comfort along the entire route of the passenger's trip, including a convenient transition from one type of transport to another.

The coordination of passenger unit schedules is mostly possible within each individual transport mode. However, the sufficient experience has already been accumulated in coordinating train, ship and airplane schedules, on the one hand, and bus schedules, on the other. In accordance with the airplane arrival schedule, buses are supplied to deliver passengers to the city and other airports.

Direct rail and bus transportation using single passenger tickets is being developed. The bus schedules are linked to the schedules of the corresponding trains at junction points on such routes. The seats are reserved for transit passengers in carriages and buses, respectively. The transfers are usually made at the station square. In case of unforeseen delays, the transit passengers are provided with the possibility of providing a short rest. The direct passenger services are organized with the participation of other types of transport.

Conclusion

The interaction of different modes of transport is an important element of an effective transport system, playing a key role in the process of transporting goods and passengers. Despite significant achievements in this area, the problem of interaction between modes of transport remains relevant. However, in recent decades, various forms of multimodal and intermodal transportation have been actively developing, which contributes to improving the connectivity and efficiency of transport flows.

An important stage in solving this problem is the creation and improvement of transport hubs, which should ensure convenient and fast redistribution of goods and passengers between different types of transport. In this context, the role of effective management, the introduction of modern information technologies and the unification of technological processes play a significant role.

Thus, in order to achieve maximum efficiency of the transport system, it is necessary to develop and improve the interaction of various modes of transport continuously, which will ensure a reduction in costs, a reduction in transport time and an increase in the overall level of transport safety.

References

1. Kostrov V.N., Korshunov D.A. Vzaimodeystvie vidov transporta i multymodalnye perevozky. [Tutorial book], N. Novgorod: Publishing house of FGBOU VO "VSUVT" 2015. 63p.
2. Tokmakova I.V., Kostyuk Zh.S. Problemy formirovaniya yedinoy transportnoq systema Ukrainy [Vesnik economiki transport i promyslovosti №33, 2011]. Available from: https://cyberleninka.ru/article/n/problemy-formirovaniya-edinoy-transportnoy-sistemyukrainy. (Accessed 13.03.2025). (Rus)

Проблемы и перспективы развития транспортной системы в настоящее время

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Аннотация. Целью данного исследования является анализ проблем и перспектив развития транспортной системы. В ходе исследования будет рассмотрено взаимодействие различных видов транспорта, которое заключается в согласованности и координации их работы, как различные виды транспорта, участвуют в общем процессе перевозки грузов и пассажиров. Актуальность исследования заключается в том, что несмотря на административно-хозяйственную самостоятельность, все виды транспорта находятся в определенной зависимости друг от друга и оказывают существенное взаимное влияние на процесс и результаты своей работы. В связи с этим для достижения максимальной эффективности работы транспортной системы необходимо продолжать развивать и совершенствовать взаимодействие различных видов транспорта, что позволит снизить издержки, сократить сроки перевозок и повысить общий уровень безопасности перевозок.

Ключевые слова: навалочный груз, фрахт, транспортное взаимодействие, железная дорога, перевалочные пункты, транспортный узел.

УДК 004.01

Application of computer vision technologies for recording road accidents

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Abstract
The article discusses the use of computer vision algorithms to record and analyze traffic accidents. It focuses on the selection of the YOLOv11 algorithm, which is considered to be the most effective at detecting objects in real-time. The article also describes the process of implementing the system and its potential benefits, such as automating the data collection process for road accidents and enhancing road safety.
Keywords: computer vision, monitoring, YOLOv11 algorithm, traffic accidents

Introduction

Today, more and more cities and transport systems are actively implementing computer vision technologies to automate traffic monitoring and analysis. One of the key areas is the use of computer vision to automatically identify situations such as traffic accidents or traffic violations, which helps to improve safety and reduce the risk of accidents. One of the main factors for the successful implementation of these technologies is the choice of an optimal algorithm that will ensure high accuracy, fast data processing and adaptation to various road scenarios.

Methods of research

When choosing an algorithm to solve the problems described above, the main focus is on the speed of data processing, the ability to work in real time and the accuracy of object recognition. YOLOv11, MediaPipe, and MoveNet algorithms are commonly used among popular approaches.

The YOLOv11 (You Only Look Once) algorithm provides high data processing speed and the ability to identify several objects on a frame at once. Therefore, it is ideal for traffic monitoring, where simultaneous monitoring of multiple vehicles and pedestrians is required. YOLOv11 is also highly accurate, which makes it possible to effectively solve a wide range of tasks in an urban environment. MediaPipe and MoveNet are more focused on tracking human movements, which makes them useful for analyzing the behavior of pedestrians and drivers. MediaPipe allows you to analyze a person's poses, which helps to assess the correctness of the actions of road users. MoveNet provides detailed real-time motion tracking. However, for general traffic monitoring, they are less flexible and scalable compared to YOLOv11. Therefore, the YOLOv11 algorithm was chosen to solve the problem of monitoring the traffic situation and automatically detecting accidents. It provides an optimal balance between speed and accuracy and allows it to be easily integrated with existing video surveillance systems, making it suitable for working in real traffic conditions.

For YOLOv11 to work, it is necessary to use video surveillance cameras on key sections of the road network and ensure the collection of video data from them, on which the model will be trained in the future. The preparation of a training sample of data plays an important role here. The sample may include both real-world scenario data obtained using road video surveillance, and synthetic scenario data created in a specialized simulation environment to simulate various conditions, including emergency situations, which are difficult and dangerous to reproduce. It is also important to ensure the recognition of objects in difficult and unpredictable circumstances, which will increase the stability of the model and its adaptability to real road conditions.

A fragment of the training dataset and its labeling is shown in Fig.1.

Figure 1 - A fragment of the training dataset

After training, the model can be integrated to recognize various objects on the roadway. Later, after validation, the model can be integrated into a decision support system (DDS) focused on accident prevention.

The process of using the trained model is shown in Fig. 2.

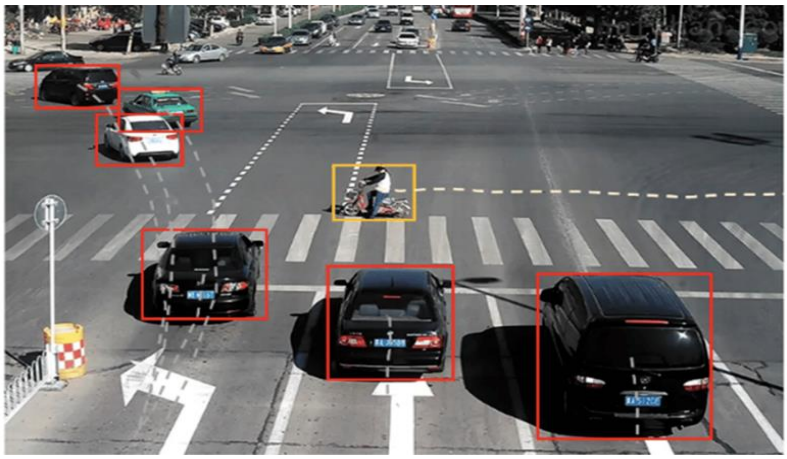

Figure 2 - Using the trained model

Using a DDS based on such a model will allow you to respond to accidents in real time, as well as predict the occurrence, immediately signals the relevant services to take prompt action.

Conclusion

Using the YOLOv11 algorithm for accident monitoring allows you to identify and prevent accidents on the road, which in turn reduces the need for manual monitoring and increases the effectiveness of response services. The use of DSS based on trained models contributes to the creation of a safer and more sustainable transport infrastructure, as well as reducing economic losses.

References

1. Kalinin N.V. Komp'yuternoe zrenie v sel'skokhozyaystvennom proizvodstve [Computer vision in agricultural production]. Tsifrovye tekhnologii v nauke, obrazovanii i proizvodstve, 2022, pp. 34–35. (Rus)
2. Jiang P. A review of YOLOV11 algorithm developments. Procedia Computer Science, 2022, Vol. 199, pp. 1066–1073.
3. Lopukhov S.A., Zubarev F.A. Primenenie mashinnogo obucheniya v komp'yuternom zrenii [Application of machine learning in computer vision]. In: Sostoyanie i perspektivy razvitiya sovremennoy nauki po napravleniyu "Tekhnicheskoe zrenie i raspoznavanie obrazov" [State and prospects of modern science development in the direction of "Technical vision and pattern recognition"], 2021, pp. 211–215. (Rus)

Применение технологий компьютерного зрения для фиксации дорожно-транспортных происшествий

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Аннотация. Статья рассматривает использование алгоритмов компьютерного зрения для фиксации и анализа дорожно-транспортных происшествий. Особое внимание уделяется выбору алгоритма YOLOv11 как наиболее эффективного для детекции объектов в реальном времени. Приведён процесс внедрения системы и ожидаемые результаты её использования для автоматизации процесса сбора данных о ДТП и повышения безопасности дорожного движения.
Ключевые слова: алгоритм YOLOv11, дорожно-транспортные происшествия, компьютерное зрение, мониторинг.

УДК 519.2:656.13

The effects of heterogeneous information in analyzing traffic accidents

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Abstract
Traffic accidents are global issues that result in significant economic costs, injuries, and fatalities. Forecast accuracy and contextual understanding are both enhanced by analyzing traffic incidents using a wide variety of data sources, including past records, weather conditions, road characteristics, traffic patterns, and telemetry data. The present article examines the influence of diverse information on collision analysis, presented its benefits, challenges, and applications. The integration of diverse data sources enhances predictive modelling, improves accident severity assessments, and identifies accident hotspots. However, challenges such as information scarcity, integration complexities, and spatial-temporal heterogeneity necessitate resolution. Future endeavours should concentrate on the integration of diverse data sources to improve the efficacy of prediction and prevention of traffic incidents.
Keywords: crash accidents, data sparsity, heterogeneous information, model fusion, spatio-temporal data, traffic accidents analysis, traffic accidents prediction, traffic accidents preventation.

Introduction

The integration of diverse data sources take part in the growth of traffic accidents analysis, enhancing predictive modelling and risk evaluation. Heterogeneity information pertains to the employment of varied data sources, including historical accident reports, meteorological circumstances, road features, traffic trends, and telematics data, to get a thorough comprehension of accident dynamics. This research investigates the effect of varied information on traffic accident analysis, emphasizing its advantages, obstacles, and applications.

The research problem statement

The increasing complexity of urban transportation and the rising frequency of crashes necessitate improved methods for accident investigation and prevention. Traditional approaches rely on limited data sources, which often fail to include the entire spectrum of impacting factors. The compilation of varied information, encompassing historical incident data, traffic patterns, weather variables, and telematics data, provides an extensive insight into accident dynamics. Combining and analyzing diverse information causes major obstacles, such as data sparsity, format incompatibilities, and spatial-temporal inconsistencies. This work aims to investigate the research question: How does the amalgamation of diverse information enhance crash analysis, and what are the corresponding benefits and obstacles? The results will aid with creating effective traffic safety strategies, predictive models, and policy suggestions for accident mitigation.

The advantages of integration multiple data sources

1-Analysis better predictive accuracy

The consolidation of diverse data has markedly improved the precision of traffic accident prediction algorithms. Researchers have created prediction algorithms capable of accurately forecasting incident hotspots and timings by integrating many data sets, including historical incident records, meteorological factors, and road characteristics. Diverse machine learning strategies, including decision trees, logistic regression, and ensemble techniques such as Random Forest and Gradient Boosting, were employed for model construction. The Ensemble algorithms achieved AUC-ROC scores of 0.89, exceeding those of traditional regression techniques [2].

2-Improving Understanding of Context

Heterogeneous data offers a far more comprehensive contextual understanding of incident risk elements. The integration of traffic flow data, weather conditions, and points of interest has shown an improvement in the actual time prediction of rare accident events [3].

Obstacles in Analyzing Diverse Information

1-Deficient and Absent Information

Data sparsity and missing information present a enormous obstacle to heterogeneous data analysis. Forgetting or incomplete data can make predictions inaccurate on many datasets, especially those that come from cities [4].

2-The fusion of multiple data

The combined collection of different types of data poses an extra challenge in analysis of heterogeneous data. Multiple data often exists across various formats and needs attention preparation to ensure compatibility. This combination requires the resolution of concerns pertaining to information quality, reliability, and spatial-temporal attributes [5].

3-Distinctions in Spatial and temporal data

The spatial and temporal diversity of accident information is an extra challenge. Accidents demonstrate significant diversity across regional and timing situations, hindering the development of models that generalize successfully across different environments [6]. The comparisons and perspectives of data sources as explained by in Table 1

Table1. Exploration of Data Sources and Views

Data Sources	Methods	Key Findings
Telematics, weather, Historical accident reports, road	Machine learning (Random Forest, Gradient Boosting)	AUC-ROC scores reaching 0.89, surpassing conventional models [2].

characteristics		
Temporal characteristics, points of interest, weather, Traffic flow	Deep neural network (DAP)	Enhanced precision in real-time accident forecasting [3].

Applications of Heterogeneous Information in Traffic Accident Analysis

1-Real-Time Accident Prediction

Heterogeneous data has been extensively utilized in real-time accident prediction systems. By utilizing data from diverse sources, including traffic patterns, meteorological conditions, and areas of interest, these systems can forecast the probability of accidents occurring in particular locations. A deep learning algorithm called DAP (Deep Accident Prediction) has been created to forecast accidents in real-time by integrating traffic events, meteorological data, and temporal variables [3].

2-Accident Severity Assessment

Heterogeneous data has been utilized to evaluate the severity of incidents. The researchers have built models that accurately anticipate accident severity by incorporating data on road infrastructure, meteorological patterns and past incidents data. A context-aware nonnegative matrix factorization approach has been proposed to evaluate risk of accidents by simulating interactions among various data sources [7].

3-Identification of Accident Hotspots

The combining of diverse data has been essential in pinpointing accident hotspots. Scholars have discovered locations with heightened accident risks through the examination of data regarding road types, meteorological conditions, and accident statistics. A research carried out in St. Petersburg, Russia, employed accident data, road categories, and climatic conditions to identify risky routes and determine the principal causes of incidents [8].

Conclusion

The combining of diverse information has changed traffic accident analysis, facilitating more precise forecasts, improved contextual comprehension, and economical safety interventions. Notwithstanding the difficulties related to data sparsity, integration, and spatial-temporal heterogeneity, the advantages of heterogeneous data significantly surpass the drawbacks. The application of heterogeneous data has markedly enhanced the capacity to detect accident hotspots, evaluate accident severity, and forecast accidents in real-time. Future studies should persist in investigating novel methodologies to fully leverage heterogeneous data in the analysis of traffic accidents.

References
Zhou Z. et al. RiskOracle: A Minute-Level Citywide Traffic Accident Forecasting Framework // Proceedings of the AAAI Conference on Artificial Intelligence. 2020. Vol. 34, № 01. P. 1258–1265.
1. Mehdi M. Machine learning and multisource data analysis approach towards traffic accident risk prediction // InterConf. Scientific Publishing Center InterConf, 2024. № 50(221). P. 401–406.
2. Moosavi S. et al. Accident Risk Prediction based on Heterogeneous Sparse Data: New Dataset and Insights // Advances in Geographic Information Systems. ACM, 2019. P. 33–42.
3. Mustaquim S.M. et al. Enhancing Accident Risk Prediction with Novel Data and Findings from Heterogeneous Sparse Sources // Journal of Data Mining and Management. 2024. Vol. 9, № 1. P. 1–16.
4. Santos S.R.D., Davis C.A. Junior, Smarzaro R. Analyzing Traffic Accidents based on the Integration of Official and Crowdsourced Data // Journal of Information and Data Management. 2017. Vol. 8, № 1. P. 67. Available from: https://periodicos.ufmg.br/index.php/jidm/article/view/379. (Accessed 15.03.2025).
5. Gao X. et al. SMA-Hyper: Spatiotemporal Multi-View Fusion Hypergraph Learning for Traffic Accident Prediction // arXiv (Cornell University.
6. Chen Q. et al. A Context-Aware Nonnegative matrix Factorization Framework for traffic accident risk estimation via heterogeneous data // 2019 IEEE Conference on Multimedia Information Processing and Retrieval (MIPR). 2018. P. 346–351.
7. Volkov A. et al. Spatio-temporal Data Sources Integration with Ontology for Road Accidents Analysis // Lecture notes in business information processing. 2022. P. 251–262.

Эффекты неоднородной информации при анализе дорожно-транспортных происшествий

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Аннотация. Дорожно-транспортные происшествия являются глобальными проблемами, которые приводят к значительным экономическим затратам, травмам и смертельным случаям. Точность прогнозов и понимание контекста улучшаются за счет анализа дорожных происшествий с использованием широкого спектра источников данных, включая прошлые записи, погодные условия, характеристики дорог, модели движения и телеметрические данные. Настоящая статья рассматривает влияние разнообразной информации на анализ столкновений, представляет ее преимущества, вызовы и применения. Интеграция различных источников данных улучшает предсказательное моделирование, повышает оценку тяжести аварий и выявляет места концентрации аварий. Однако такие проблемы, как нехватка информации, сложности интеграции и пространственно-временная неоднородность, требуют решения. Будущие усилия должны сосредоточиться на интеграции различных источников данных для повышения эффективности прогнозирования и предотвращения дорожных инцидентов.
Ключевые слова: дорожно-транспортные происшествия, разреженность данных, гетерогенная информация, слияние моделей, пространственно-временные данные, анализ дорожно-транспортных происшествий, прогнозирование дорожно-транспортных происшествий, предотвращение дорожно-транспортных происшествий.

УДК 631.316.4

Justification for the development of a new working body for row-by-row potato processing

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Abstract
The article describes various types of weeds in potato plantings, describes the most effective method of controlling them, lists the most common types of working bodies for mechanical weed removal, their disadvantages, and concludes that it is necessary to develop a new working body for row-by-row potato processing.
Keywords: working organ, weeds, depletion method, pruning, potatoes.

Introduction

Potatoes are a valuable food crop for human nutrition in many countries of the world. It serves as a raw material for the production of alcohol, starch, and other products, and is used for animal feed. More than 1,000 species of wild plants can grow on crops of cultivated plants, of which about 400 species are harmful, and 100-120 species are considered consistently harmful weeds. Direct crop losses of agricultural plants from them average 10.3% of the gross harvest, and with severe contamination, they reach 30% or more.

Clearing potato plantings of weeds worsens the conditions for the favorable development of pathogens that serve as reserves for their mass accumulation, including late blight. The destruction of weeds in potato plantings is carried out both before the emergence of seedlings and after the germination of cultivated and weedy plants [1].

Results

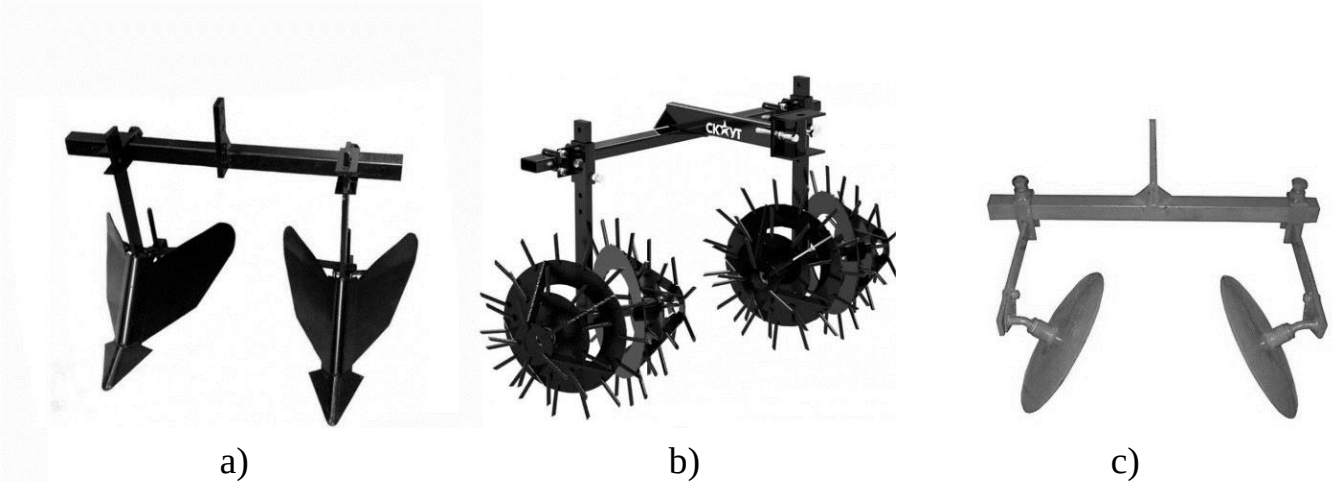
Strong in their competitiveness, weeds such as tenacious bedstraw, highlander species, white marjoram, and spreading quinoa affect not only yields, but also the size of tubers and their marketability, complicate mechanized harvesting, and increase losses. In addition, plants clogged with weeds are less ventilated; they create favorable conditions for potato blight and rhizoctoniosis. Many species of weeds can be intermediate host plants for pests and at the same time reserves of pathogens. For example, shepherd's bag, medium star and violet field — tobacco rattle virus (Tobacco rattle virus), which causes rusting of potato tubers; yellow sweet clover, small-flowered sweet clover, field convolvulus, common datura, common krestovnik, white marjoram, euphorbia, field sowthistle, shepherd's bag, purple jasper — PVY virus (Potato virus Y) [2].

Such root-sprouting and rhizomatous weeds with deep root growth and rhizomes, such as field bindweed, creeping wheatgrass, field aspen, mustard, etc., are especially

effectively removed by the depletion method, the essence of which is as follows: the depletion of the root system of weeds is achieved by systematically pruning shoots that appear on the soil surface. At the same time, the reserves of plastic substances in the root system are spent on the formation of repeated shoots. When these reserves are completely exhausted, the root system with all the underground organs of vegetative reproduction dies off. This treatment reduces the contamination of root-borne weeds by 70% [3].

For potato aisles, such processing with high efficiency can be carried out with flat-cutting paws only before hoeing, after which ridges are formed. The flat-cutting working body is not applicable on the ridge surface of the field, therefore, machines with special working bodies are used for subsequent row-by-row processing. To date, the most common working bodies for row-to-row processing of potatoes after hoeing are: arrow (wedge-shaped), rotary drum-cone and rotary disc.

The arrow working bodies (Fig. 1, a) are designed for hoeing and subsequent processing of row spacing. When the unit is moving, the chisel crushes and feeds the soil layer into two dumps, which throw the soil aside, simultaneously crumbling and mixing it, forming furrows, and during subsequent furrow processing, it cuts the weeds at the bottom of the furrow with a pointed paw, fills the dumps, pulls out and dents the weeds into the soil. The advantage is high reliability and durability due to the simplicity of the design and the preservation of the original geometry of the comb, which improves the growing conditions of tubers. The disadvantage is the inability to completely remove and prune weeds on the walls of the ridge after hoeing due to the lack of structural elements capable of pruning the soil layer on the walls of the ridge. Because of this, when passing through the furrows again, the weeds are removed only from the bottom of the furrow, on the walls of the ridge the weeds can only be pulled out, crushed and sprinkled with soil.



a) b) c)

Figure 1 – Types of working bodies: a – pointed, b – rotary drum-cone, c – rotary disc

Drum-cone rotary working bodies (Fig. 1,b) are located at an angle of 45° in the direction of processing on closed bearings and are designed for cultivating potatoes and other root crops cultivated on ridges. The main advantage is the ability to remove weed roots from the soil by winding and stringing them onto the teeth of harrows, low resistance of the unit due to rotation of the working bodies, good crumbling of the soil on the ridge

wall. The disadvantage is the constructive lack of the possibility of cutting weeds, as a result of which the efficiency of row-by-row processing is reduced. The mismatch of the ridge profile and the profile of the working organ leads either to incomplete removal of the weed roots, or to excessive deepening, which increases the risk of damage to potato tubers.

Disk rotary working bodies (Fig. 1,c) are designed for cutting furrows for planting plants, filling the furrows with a layer of soil after laying seeds and hoeing the soil (loosening the soil in the aisles while simultaneously sinking it from the aisles to the lower parts of the plants). The advantage is the low resistance to movement due to rotating discs, as well as cutting the stems and roots of weeds with the edge of the disc. The disadvantage is that the contour of the disk projection in the longitudinal direction does not match the contour of the furrow, as a result of which the disk cannot remove either some of the weeds, or it gets too deep, increasing the resistance to movement and excessively disrupting the ridge profile.

Conclusion

A common disadvantage of the above types of working bodies is the inability to trim weeds not only at the bottom of the aisle, but also on the walls of the ridge. In addition, in the designs of the working bodies, it is not possible to take into account the shape of the ridge profile and preserve its original shape after the passage of the unit. These disadvantages reduce the effectiveness of control of root and rhizome weeds, lead to a violation of the ridge profile, worsening the growth conditions of tubers, which justifies the introduction of a new type of working organ into agricultural production.

References

1. Redyuk S.I. Zashchita kartofelya ot sornyh rastenij. Vestnik zashchity rastenij [Protection of potatoes from weeds // Bulletin of plant protection] 2(92) - 2017, pp. 54-58

2. Spiglazova S.Yu., Dolmatova N.A. Trudnoiskorenimye sornyaki v posadkah kartofelya bol'she ne problema. Kartofel' i ovoshchi [Difficult-to-eradicate weeds in potato plantings are no longer a problem // Potatoes and vegetables]. – 2014.

3. Bazdyrev, G. I. Sornye rasteniya i mery bor'by s nimi v sovremennom zemledelii [Weeds and measures to control them in modern agriculture]: 1993, p. 242

Обоснование разработки нового рабочего органа для междурядной обработки картофеля

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Аннотация. В статье дано описание различный типов сорных растений на посадках картофеля, описан наиболее эффективный метод борьбы с ними, перечислены наиболее распространенные типы рабочих органов для механического удаления сорных растений, их недостатки, на основе чего сделан вывод о необходимости разработки нового рабочего органа для междурядной обработки картофеля.

Ключевые слова: рабочий орган, сорные растения, метод истощения, подрезание, картофель.

УДК 004.9

Pilot tests of a physical prototype of a seeder for direct sowing of grain crops

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Abstract
The purpose of this study is to evaluate the effectiveness of the seeder developed by the authors based on the pilot tests of its prototype in the fields of the PC "Yeruslan" in the Rostov region when sowing Timiryazevka 150 winter wheat. The quantitative characteristics of the sowing process carried out by the seeder were found using measuring instruments used for testing agricultural machinery. The results of the comparative analysis showed high efficiency of the proposed seeder design, which ensures reduction in its cost due to: simplification of its design, reduction of metal consumption, as well as increased operational efficiency compared to analogues
Keywords: seeder for direct sowing of grain crops; pilot tests.

The Federal Scientific and Technical Program for the Development of Agriculture for 2017-2030 highlights "ensuring stable growth in agricultural production" as the main goal [1]. For its implementation, it is necessary to "provide the branches of the agro-industrial complex with relevant scientific developments and technologies to increase the competitiveness of the domestic agro-industrial complex in accordance with market requirements" [2]. One of the ways to achieve this goal is to introduce sustainable agriculture by including not only profitable crops in crop rotation, but also those that increase soil fertility, implementing a thoughtful approach to choosing means of combating plant diseases and pests, and using multifunctional agricultural machines that perform several operations in one pass [3].

To ensure high productivity of sustainable agriculture, it is necessary to create high-performance machinery.

To solve the problem of creating high-performance agricultural machinery, the authors developed the design of the seeder for direct sowing of grain crops using the scatter method [4-7]. The purpose of this work is to perform a comparative analysis of the seeder's efficiency.

Figure 1 shows a photo of the physical prototype of the seeder. Studies to determine the effect of the speed of movement and the depth of sowing on the value of the specific traction resistance of the seeder developed by the authors were carried out in accordance with the methodology described in [2].

Figure 2 shows the correlations between the value of the specific traction resistance of the developed seeder R and the speed of the seeding machine. The tests were carried out at seeding depth values in the range from 0.01 m to 0.05 m with an interval of 0.02 m only on a stubble background.

Figure 1 - Photo of the physical prototype of the developed seeder

As a result of the approximation of experimental data performed by the least squares method, the following dependences were obtained:

- with a seeding depth equal to 0,05 m $R_C = 0.0152v^2 - 0.0193v + 1.4214$, where R_C - specific traction resistance, kN/m; v – speed of the seeder, m/s. At the same time, the accuracy of the approximation was $R^2 = 0.9865$;
- with a seeding depth equal to 0,03 m $R_C = 0.007v^2 + 0,0301v + 1,0526$, $R^2 = 0.991$;
- with a seeding depth equal to 0,01 m $R_C = 0.009v^2 + 0.0109\,v + 0.9909$, $R^2 = 0.9909$.

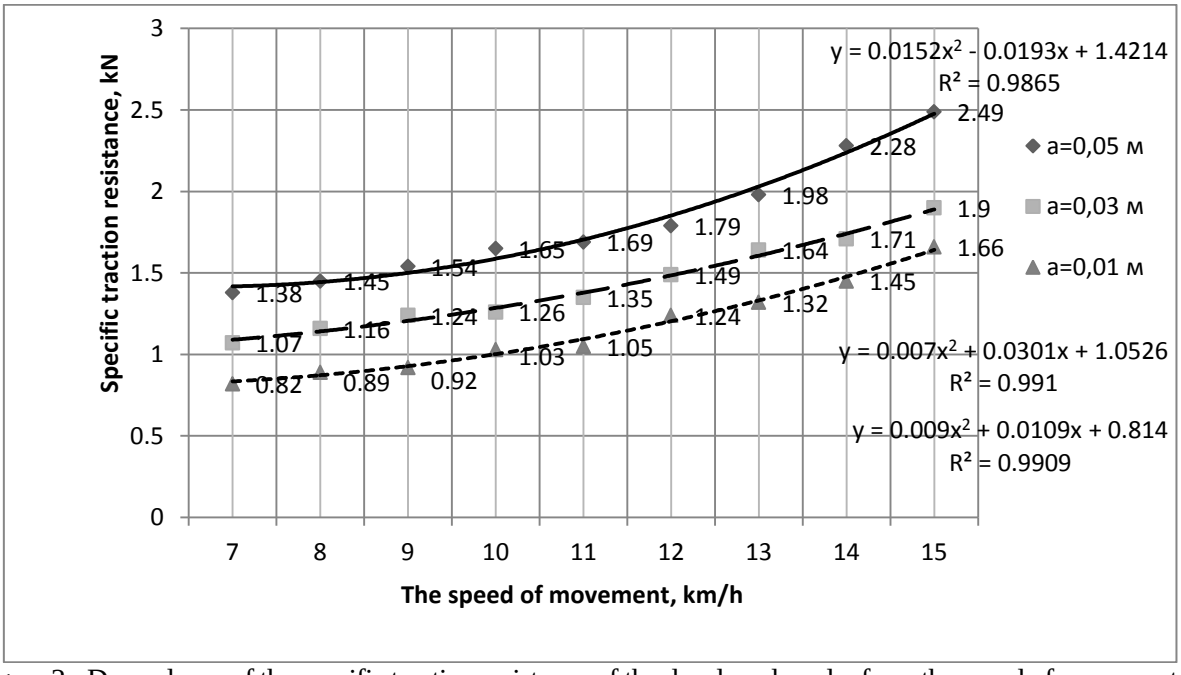

Figure 2 - Dependence of the specific traction resistance of the developed seeder from the speed of movement and the depth of sowing

The type of dependencies obtained above (see Fig. 2) indicates that with an increase in the speed of movement of the developed seeder and the depth of sowing, the value of the specific traction resistance also increases. Thus, the speed of the seeding machine at a seeding depth of

0.03 m is 12 km/h, while the value of the specific traction resistance of the seeder does not exceed 1.5 kN/ m.

Pilot tests have shown high efficiency of the proposed seeder design, which provides a significant reduction in its cost and increased operational efficiency compared to analogues.

References

1. Gaigher R., Berg J., Batáry P., Grass.I. Agroecological farming for insect conservation. In: Routledge Handbook of Insect Conservation, 2024. 14 p. https://doi.org/10.4324/9781003285793
2 Nemtinov V, Zazulya A, Kapustin V, Nemtinova Y. Analysis of decision-making options in complex technical system design. J. Phys.: Conf. Ser. 2019. 1278. DOI: 10.1088/1742-6596/1278/1/012018.
3. Matveykin V., Samarin V., Nemtinov V. [et al.] Design theory of network based smart self-contained self-rescuer with sensor technology. Advances in Intelligent Systems and Computing, 2021, Vol. 1259, pp. 178-186. DOI 10.1007/978-3-030-57453-6_15.
4. Kapustin V., Nemtinov K., Nemtinova Y., Nemtinov V. Decision support system for technological maintenance of seeding machines. E3S Web of Conferences, 2020, 01015. DOI: 10.1051/e3sconf/202019301015.
5. Nemtinov V., Egorov S., Nemtinova Y., Kalach A. Information support for decision-making in emergency situations. Journal of Physics: Conference Series, 2021, 012080. DOI: 10.1088/1742-6596/1902/1/012080.
6. Salih H.S., Egorov S., Nemtinova Y., Nemtinov V. Information system for decision-making support with resources allocation between geographically remote objects within a production association. Journal of Physics: Conference Series : VI International Scientific and Practical Conference "Virtual Simulation, Prototyping and Industrial Design 2019, VSPID-2019", 2020, Vol. 1553, 012001. DOI: 10.1088/1742-6596/1553/1/012001.
7. Eruslanova M.A, Nemtinov K.V, Eruslanov K.A, Nemtinov V.A. Development of a machine for tillage and sowing of grain crops. Tractors and Agricultural Machinery, 2024, Vol. 91, Issue 5, pp. 522-532. DOI: 10.17816/0321-4443-628953

Опытные испытания физического прототипа сеялки прямого посева зерновых культур

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Аннотация. Целью данного исследования является оценка эффективности использования разработанной авторами сеялки на основе выполненных экспериментальных испытаний ее опытного образца на полях ПК «Еруслан» в Ростовской области при посеве озимой пшеницы «Тимирязевка 150». Нахождение количественных характеристик процесса посева, реализуемого сеялкой, осуществлялось с использованием средств измерений, применяемых при испытаниях сельскохозяйственной техники. Результаты сравнительного анализа показали высокую эффективность предложенной конструкции сеялки, обеспечивающей снижение ее стоимости за счет: упрощения ее конструкции, снижения металлоёмкости; а также повышение эффективности эксплуатации по сравнению с аналогами.

Ключевые слова: сеялка прямого посева зерновых культур; полевые испытания.

УДК 004.85

Hyperspectral control of apple surface defects using classification models

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Abstract
This work focuses on the study of the method of hyperspectral control of surface defects of apple tissues using classification models. Two classification models were trained using the Random Forest algorithm, and the basic model was used as a reference model. When creating an optimized model, in order to reduce the number of features, the principal component analysis method was used, then training was performed based on the data obtained using hyperparameter optimization. The resulting model, when compared with the base model, showed better predictive ability.
Keywords: classification, hyperspectral, machine learning, random forest.

Currently, one of the promising ways to control the quality of fruit and vegetable crops in the agroindustry is hyperspectral product control [1]. The key advantage of hyperspectral monitoring is non–invasiveness, which makes it possible not to violate the integrity of the observed object and analyze hidden characteristics [2]. In the context of this work, such characteristics include changes in the tissue structure of fruit and vegetable crops and the presence of hidden defects caused by various diseases or violations of storage and transportation regimes.

The purpose of this work is to study the predictive ability of classification models in the analysis of plant tissue spectrograms in order to detect defects in fruit and vegetable crops.

For the first half of the dataset, the data was taken from the fruits with healthy and defecitve tissue (Fig. 1). The data was obtained from a hyperspectral camera (Specim FX-10) using the linear scanning method.

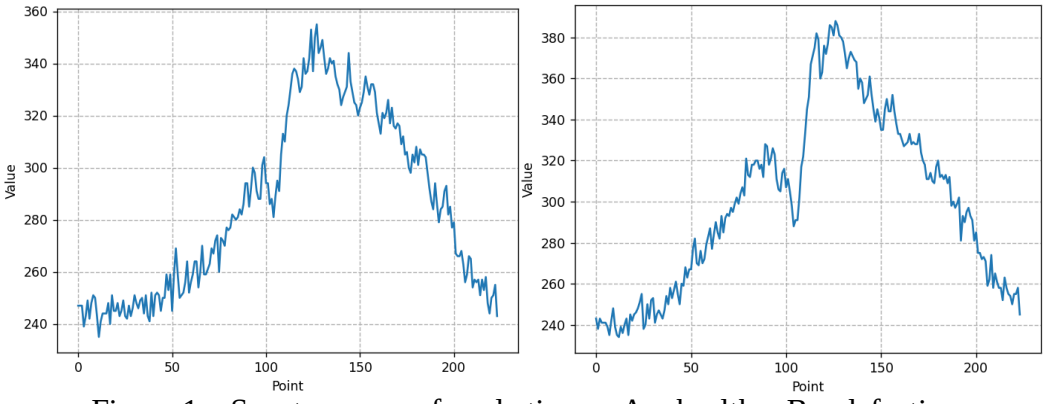

Figure 1 – Spectrograms of apple tissues:A – healthy, B – defective

The Random Forest algorithm was used to classify plant tissues. The resulting matrix of inaccuracies of the basic model is shown in Fig.2.

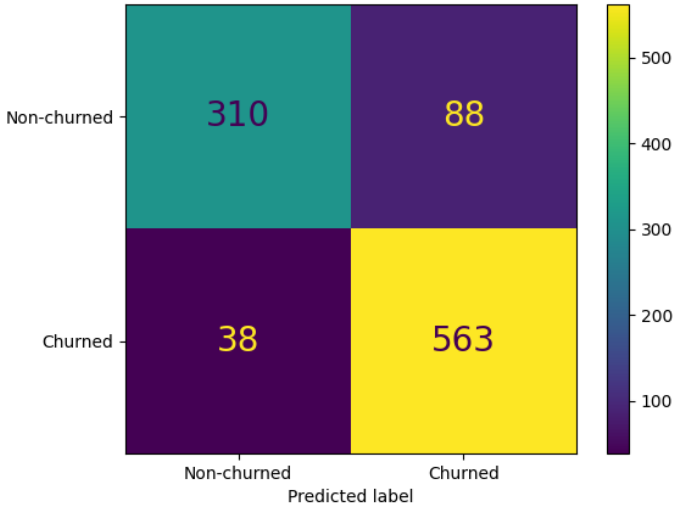

Figure 2 – Matrix of inaccuracies of the basic model

Since minimizing false negative forecasts is a priority, the recall metric was used to evaluate the models, while the value of 93.7% was obtained for the base model. To try to improve this result, it was decided to resort to model optimization.

The volume of calculations is one of the main disadvantages of the Random Forest algorithm, therefore, the Principal Component Analysis (PCA) method was used to optimize the calculations. When using the PCA algorithm, the dimension of the feature space decreases, which can lead to a decrease in the number of features that need to be processed by the RF model.

Sections of the spectrogram were used as components for optimization. After that, a graph of the effect of the number of components on the explained variance was constructed (Fig. 3)

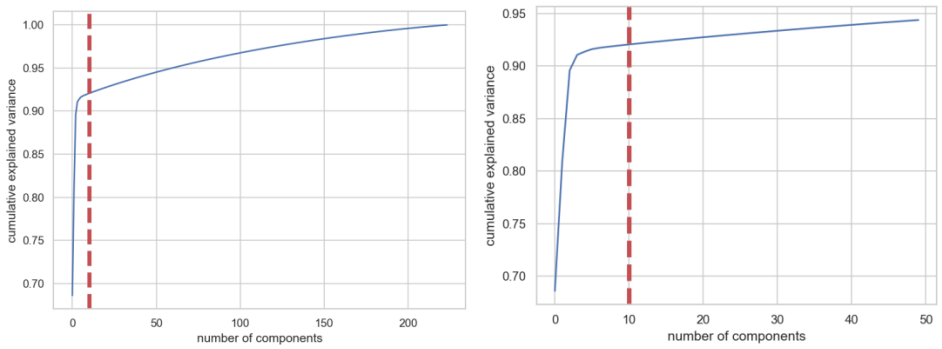

Figure 3 - Dependence of the explained variance on the number of components

From this we can conclude that after the number of components used exceeds 10, an increase in their number does not significantly affect the explained variance. After processing the data using the principal component method, hyperparameters were optimized.

At the first stage, a rough search was performed in a wide range of parameter values (applications of the RandomizedSearchCV algorithm). The results are shown in Fig. 4.

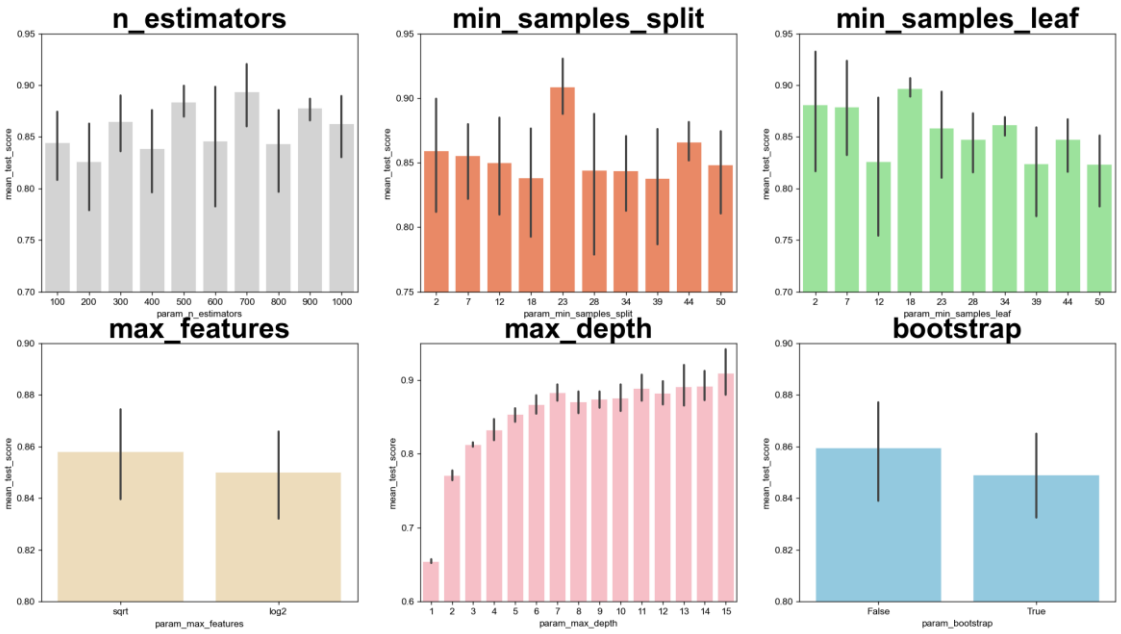

Figure 4 – The effect of various parameters on the explained variance. A – is the number of decision trees, B – is the minimum number of objects required for a tree node to split, C – is the minimum number of objects in the leaves, D – is the number of features to select splitting, E – is the maximum depth of trees, F – is the use of subsampling with return to build trees.

After analyzing the hyperparameter values and narrowing the range of values, a more accurate search was carried out for the best combination of hyperparameters (using the GridSearchCV algorithm). When using the GridSearchCV algorithm, each combination of hyperparameters is examined. This requires much more computational resources than using the RandomizedSearchCV algorithm, when the number of search iterations is set manually. That is why the GridSearchCV algorithm was used after applying RandomizedSearchCV to narrow the ranges of values of the studied parameters.

Based on the data obtained, another model was built. The results of the model evaluation based on the verification data are shown in Fig. 5.

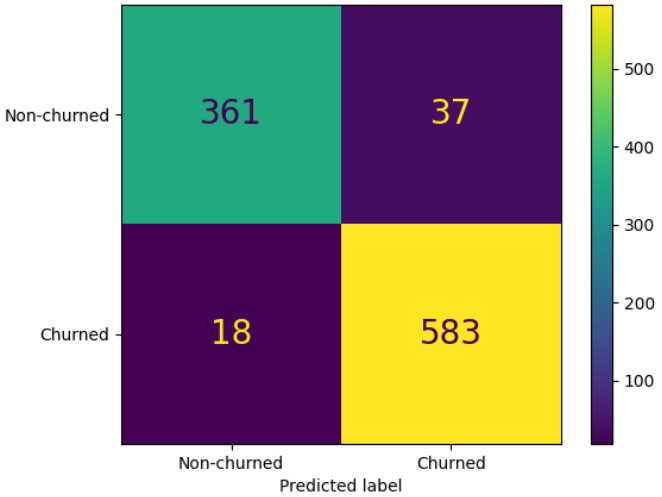

Figure 5 – Model inaccuracy matrix with optimized hyperparameters

The level of the recall metric of the model using the PCA method and hyperparameter optimization was about 97%, which shows that the use of hyperspectral control has very good prospects. To continue the research in order to apply the model in production conditions, it is necessary to assemble a larger dataset, which took into account more gradations of freshness, different types and scales of defects. Also, as a further development of study, we can consider forecasting the shelf life of fruit and vegetable products, as well as evaluating the freshness of products.

References

1. Lu Y. et al. Hyperspectral imaging technology for quality and safety evaluation of horticultural products: A review and celebration of the past 20-year progress. Postharvest Biology and Technology. – 2020. T. 170. pp. 111318.
2. Lu Y., Huang Y., Lu R. Innovative hyperspectral imaging-based techniques for quality evaluation of fruits and vegetables: A review. Applied Sciences. 2017. T. 7. №. 2. pp. 189.

Гиперспектральный контроль поверхностных дефектов яблок с применением классификационных моделей

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Аннотация. Данная работа сосредоточена на исследовании методагиперспектрального контроля поверхностных дефектов тканей яблок при помощи классификационных моделей. С применением алгоритма RandomForest было обучено две классификационные модели, базоваямодель использовалась в качестве референсной. При создании оптимизированной модели в целях уменьшения количества признаков использовался метод анализа главных компонент, затем было произведено обучение на основе полученных данных с применением оптимизации гиперпараметров. Полученная модель при сравнении с базовой показала лучшую прогностическую способность.
Ключевые слова: гиперспектральный анализ, классификация, машинное обучение, случайный лес,

УДК 004.94

Optimization of permaculture systems through digital modeling

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Abstract
In today's world, the problem of environmental sustainability is becoming more and more acute, including agriculture. Permaculture has been proposed to improve the ecological situation. Permaculture is an agricultural system that involves the most rational use of fertile areas. This approach involves building an ecosystem model on a given area but requires the selection of plants with different characteristics that will favorably influence each other. The article explores the possibility of digitalization of permaculture complexes modeling process. For this purpose, it is necessary to consider the characteristics of plants, form models of specific plants and use these models to build a permaculture system model.
Keywords: agriculture, digitalization, digital technologies, modeling, permaculture.

Introduction

In today's world the issue of environmental friendliness of all spheres of life, including agriculture, is quite acute. In this sphere, permaculture was invented to improve the ecological situation.

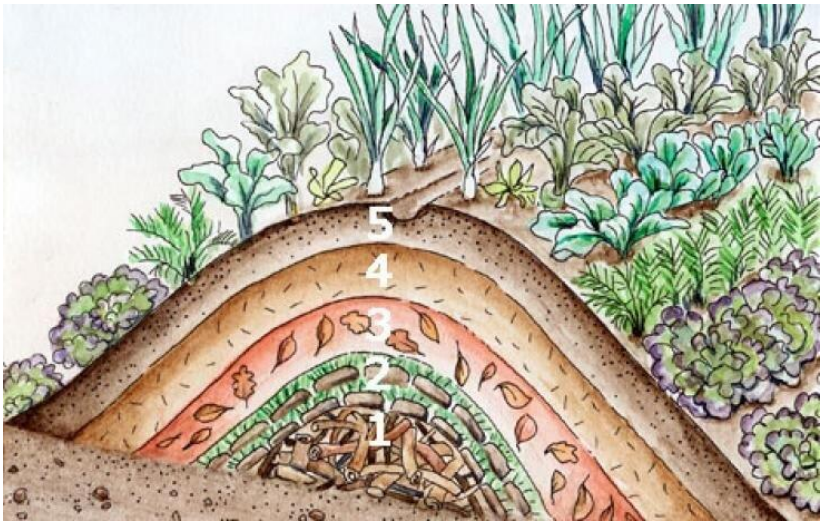

Figure 1 - An example of a permaculture system.

Permaculture is an agricultural system that involves the most rational use of fertile areas. The following principles should be observed:

- interconnectedness - all elements of the system should favorably influence each other, thus increasing the productivity of the whole system;
- functionality - each element of the system should perform a function;
- duplication - a single element of the system should not be used to perform any function;
- multilevel - it is necessary to effectively use the whole volume of the territory where the plantations are located [1].

This implies that permaculture is the result of building a model of an ecosystem on a given

area. But the problem arises that it is necessary to select plants with separate characteristics that will favorably influence each other, and at the same time it is necessary to lay down the infrastructure for the maintenance of plantations. This paper is written with the purpose of researching the possibility of digitalization of permaculture complex modeling process. For this purpose, it is necessary to consider the characteristics of plants, form models of specific plants and use these models to build a model of the permaculture system.

Formation of the permaculture model

It is necessary to consider the basis of any agricultural plantings – the soil. Its characteristics determine which crops can be used within the system, as well as what additional elements are needed to ensure the functioning of this system. Among the main characteristics are the following: soil type, soil moisture, soil nutrients and soil contamination [2].

The soil types include clay, sandy, super-sandy, loamy, calcareous and peaty soils. Different soil types are differently suited for farming and also different types of crops can be grown on these soils [3].

Moisture, organic and mineral content levels can be indicated as percentages of soil content. All of these levels influence which crops can be grown effectively on these soils [2].

The level of soil contamination can be labeled the same as the others, but this level indicates how safe the soil is for plants.

The following components are necessary for plant growth: light, water, soil, temperature, nutrients and biotic factors. Some of the components have been considered when building the soil model, but it is still necessary to specify these parameters in order to check that the necessary conditions are being met.

Light and temperature are defined as a certain indicator of the environment, which can be called illumination and temperature. In the plant itself, it is necessary to specify which range of values is optimal for these plants.

The following factors determine whether it is appropriate to place different plants in close proximity to each other and what additional biological elements are needed to support the growth of different crops.

These factors include:

Biotic factors such as interactions between plants, microorganisms, and animals that affect the growth and development of crops;

Absolute environmental requirements of plants such as temperature, humidity, light and nutrient availability;

Specific plant requirements of soil, such as soil type, acidity, nutrient content and pollution levels;

Interactions between plants and the microclimate that affect crop growth and development.

To effectively model a permaculture system, it is necessary to consider these factors and select a discrete model matrix that will take into account all interactions between plants, soil and environment. However, when building the first models, it is possible to do without the mandate model of interaction between different groups of crops, which will take into account the main interactions between plants and the environment.

A mandate model of interactions between different crop groups can be represented as a matrix, where rows and columns correspond to different crop groups and the elements of the

matrix reflect the type and intensity of interactions between them. For example, if two groups of cultures have positive interaction, the matrix element will be equal to 1, if negative - -1, and if there is no interaction - 0.

Conclusion

Thus, the mandate model of interaction between different groups of crops can help in effective modeling of permaculture system and determining the optimal placement of different plants in close proximity to each other.

The premacultural system model consists of 3 elements. The way in which these models are formed has been described within this article. This method allows simplifying the formation of plantations, but for this method to work effectively it is necessary to work out the models in great detail, which is a difficult task.

References

1. D.Y. Chudosvetova. Potencialpermakul'turydlyarazvitiyasel'skogohozyajstva[The potential of permaculture for the development of agriculture]Ustojchivoerazvitiesel'skihterritorij: vzglyad molodyh uchenyh: materialyVserossijskoj nauchno-prakticheskoj konferencii molody huchenyh (10-12 dekabrya 2020 g.) – Novosib. gos. agrar. un-t. − Novosibirsk, 2020. – 112p.(Rus)

2. Allamyrat Durdymyadov, Nurmukhammet Toylyev, Gur-banberdi Gurbanberdiev Osnovnye harakteristiki tipov pochv v sel'skom hozyajstve [Main characteristics of soil types in agriculture] IN SITU. 2023. No.10.(Rus)

3. R.R. Abdusalamova, Z.M. Balamirzoeva Pochvenye resursy Rossii [Soil resources of Russia] Vestnik SPI. 2020. №1 (33). (Rus)

Оптимизация пермакультурных систем через цифровое моделирование

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Аннотация. В современном мире проблема экологической устойчивости становится все более острой, включая сельское хозяйство. Для улучшения экологической ситуации было предложено использовать пермакультуру. Пермакультура — это сельскохозяйственная система, которая предполагает наиболее рациональное использование плодородных площадей. Этот подход предполагает построение модели экосистемы на заданной площади, но требует подбора растений с разными характеристиками, которые будут благотворно влиять друг на друга. В статье исследуется возможность цифровизации процесса моделирования пермакультурных комплексов. Для этого необходимо рассмотреть характеристики растений, сформировать модели конкретных растений и использовать эти модели для построения модели пермакультурной системы.

Ключевые слова: моделирование, пермакультура, сельское хозяйство, цифровизация, цифровые технологии.

УДК634.8

Innovatives Überwachungssystem für die Lagerung von Trauben: Sicherstellung, Qualität und Haltbarkeit der Ernte

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Zusammenfassung
In diesem Artikel ist die Rolle des Überwachungssystems für die Lagerung von Trauben im modernen Gartenbau untersucht. Das Überwachungssystem ist zu einem integralen Bestandteil der Landwirtschaft geworden.
Schlüsselwörter: Überwachungssystem, Automatikbetrieb, innovatives System, Aufbewahrung.

In der modernen Welt wird bei einem enormen Produktionsmaßstab immer mehr Mengen angebaute Rohstoffe in die Lagerung bis zum Eintreffen zum Endverbraucher geschickt. Die Weintrauben sind im Anbau, in der Montage und in der Unversehrtheit wunderlich, deshalb ist es notwendig, die technologischen Merkmale und mikroklimatischen Parameter zu berücksichtigen und zu analysieren, optimale Bedingungen für seinen Anbau zu bieten, sowie Krankheiten und Schäden vorzubeugen.

Die Lagerung von Trauben insbesondere ist ein schwerer Prozess, bei dem viele Faktoren berücksichtigt werden müssen, wie, zum Beispiel, die Biochemie des Fötus selbst, Temperatur- und Feuchtebedingungen und sowie die Risiken von Pilzinfektionen und bakteriellen Infektionen. Das sind die Hauptfaktoren und Probleme, die angegangen werden müssen, um eine qualitativ hochwertige Lagerung der Trauben zu gewährleisten. Die Weintrauben sind sehr empfindlich zu den Temperaturbedingungen. Die optimale Lagertemperatur liegt im Bereich von -0,5' Grad Celsius bis 1 Grad Celsius je nach Sorte. Sogar geringfügige Abweichungen können zu Qualitätsverlust führen: bei der Temperaturanstieg überreifen die Früchte schnell und verlieren ihre Elastizität, und bei zu niedriger Temperatur frieren sie ein, was den Geschmack und die Textur beeinträchtigt. Die relative Luftfeuchtigkeit sollte etwa 90 bis 95 Prozent betragen, um Austrocknung zu verhindern. Bei niedriger Luftfeuchtigkeit schrumpft die Traube, bei hoher Luftfeuchtigkeit steigt das Risiko von Schimmelbildung an.

Pilzkrankheiten wie Graufäule sowie einige Bakterien und kleine Insekten wie Fruchtfliegen können die Trauben schnell verderben. Die Pilze vermehren sich besonders aktiv bei hoher Luftfeuchtigkeit und Temperaturen über 5 Grad Celsius. Die Niederlage kann mit ein paar Beeren beginnen, aber sich schnell auf die gesamte Charge ausbreiten, wenn keine Maßnahmen ergriffen werden. Die Trauben zeichnen sich durch eine zarte Haut aus, die beim Sammeln, Transportieren und Lagern leicht beschädigt wird. Mechanische Schäden provozieren die Freisetzung von Zellsaft, der auch ein Medium für die Vermehrung von Mikroorganismen wird. Um Schäden zu minimieren, ist es wichtig, die Früchte sorgfältig zu ernten und richtig zu verstauen.

Die Haltbarkeit von Weintrauben ist begrenzt. Bei traditionellen Methoden, solchen wie der Lagerung in kühlen Räumen, behält die Traube ihre Qualitäten für etwa 1 bis 2 Wochen. Für einen längeren Transport oder eine Lagerung von bis zu mehreren Monaten muss die Haltbarkeit jedoch erheblich verlängert werden. Das Überwachungssystem ist eine Reihe von technischen Tools und Software, die zur kontinuierlichen Überwachung und Überwachung der Umwelt in den Lagerräumen von Trauben entwickelt worden sind [1, 2]. Die Hauptaufgabe eines solchen Systems ist die Aufrechterhaltung optimaler Bedingungen für die Produktsicherheit, um ihr Verderben zu verhindern. Die Schlüsselparameter, die vom System gesteuert werden, umfassen Temperatur, Feuchtigkeit und Kohlendioxidgehalt. Diese Parameter wirken sich direkt auf die Erhaltung der Trauben aus, um eine Verschlechterung der Qualität und das Auftreten von Mikroorganismen zu verhindern. Das Herz des Überwachungssystems sind Sensoren, die die Umgebungsparameter messen. Die Temperatursensoren kontrollieren die Aufrechterhaltung einer stabilen Temperatur, was kritisch für Verhinderung von Schimmelfäule ist. Die Feuchtesensoren regulieren die Luftfeuchtigkeit und verhindern auch das Auftreten von Schimmel. Zusätzlich können Druck- und Kohlendioxidsensoren verwendet werden, um das Raumklima zu analysieren.

Betrachten wir ein neues Überwachungssystem, das die manuelle Arbeit reduziert und die Haltbarkeit von Produkten in Lagerhallen erhöht.

Abb. 1. Das vorgeschlagene Speichersystem ist: 1 - ein Lagerhaus; 2 - ein Temperaturüberwachungsabschnitt; 3- ein Controller; 4 - ein UV-Emitter.

Im vorliegenden System wird im Lagerhaus 1 „Trauben“ automatisch die Temperatur der Trauben gemessen, um den Bereich im optimalen Temperaturmodus zu halten, in unserem Fall von minus 0,5 bis plus 1 Grad Celsius.

In Abschnitt 2 wird die Temperaturüberwachung durchgeführt, und wenn die Lagertemperatur minus 0,5 plus 1 Grad Celsius entspricht, wird die Temperaturüberwachung im normalen Modus fortgesetzt. Unter der Bedingung, wenn die Temperatur größer oder kleiner als 1 Grad Celsius ist, wird das System automatisch mit dem Controller 3 umgeschaltet, in dem eine spezielle Klimaanlage ausgelöst wird, die Temperatur wieder normal machen, je nachdem, in welche Richtung die Temperaturen schwankten. Dabei wird die Temperaturüberwachung parallel fortgesetzt, um eine rückwärtige Unterkühlung/Überhitzung des Lagers zu verhindern.

Wenn die Temperatur unter den Mindestwert fällt, beginnt das Gerät, den Raum zu erwärmen, bis der normale Temperaturbereich erreicht ist. Nach dem Eintritt einer akzeptablen Temperatur hört die Erwärmung auf, und das System setzt die Kontrolle über die eingestellten Temperaturgrenzen fort.

Wenn die maximal zulässige Grenze überschritten wird, gibt der Überwachungssensor

ein Signal aus, und kalte Luft beginnt zu strömen, um die Kühlung zu gewährleisten, und gleichzeitig beginnt der UV-Strahl 4 sofort nach dem Ausschalten zu arbeiten. Er verarbeitet Weintrauben mit ultravioletten Strahlen, verhindert dadurch die Vermehrung von Bakterien und schützt die Beeren vor Pilzkrankheiten. Da wir wissen, dass ein Temperaturanstieg für Trauben aufgrund der Vermehrung von Bakterien schädlich ist, schützt diese Methode das Lebensmittelprodukt. Es ist wichtig zu beachten, dass diese Behandlung absolut sicher gefahrlos ist und bei kurzer Einwirkung keinen negativen Einfluss auf den Geschmack oder die nützlichen Eigenschaften der Frucht hat. Die Einführung innovativer Überwachungssysteme bei der Lagerung von Trauben ist zu einem integralen Bestandteil der modernen landwirtschaftlichen Produktion und Weinherstellung geworden. Diese Technologien ermöglichen eine kontinuierliche Überwachung der Lagerbedingungen, wodurch ein optimales Mikroklima für die Erhaltung und Verbesserung der Produktqualität aufrechterhalten wird. Dadurch haben die Erzeugnisse eine Möglichkeit, Ernteverluste erheblich zu reduzieren und die Haltbarkeit der Weintrauben zu verlängern.

Literaturverzeichnis

1. Lobatschjewskij JU.P., Dorochow A.S. Zifrowyje tjechnologii i robototjechnitschjeskije instrumjenty dlja sjelnoneskogo chosjajstwa // Sjelnoneskochosjajstwjennyje maschiny i tjechnologii. (in Russ.)
2. Gorlow S.M. Sowrjemjennyje tjechnologii chranjenija winograda // Politologitschjeskij i sjetjewoj eljektronnyj nautschnyj shurnal Kubanskogo gosudarstwjennogo agrarnogo uniwjersitjeta. 2020.-№ 159. s. 319-333. (in Russ.)

Инновационная система мониторинга для хранения винограда

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Аннотация. Рассмотрена роль системы мониторинга для хранения винограда в современном садоводстве. Система мониторинга является неотъемлемой частью ведения сельского хозяйства.
Ключевые слова: система мониторинга, автоматический режим, инновационная система, хранение.

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Modern diagnostic technologies for tractor engines: contribution to the sustainable development of agriculture

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Abstract
Modernization and technological advancement of Russian economic sectors necessitate the establishment of a solid scientific and technological foundation. Over 60% of the cost of agricultural products is attributed to machinery and production technology. To address this, high productivity and operational readiness of machinery are crucial, necessitating effective troubleshooting.
Keywords: diagnostics of tractor equipment, innovative technologies, tractors.

Considering escalating demands for agricultural efficiency and environmental sustainability, modern diagnostic technologies for tractor engines are gaining significance. The agricultural sector confronts numerous challenges, including environmental degradation, climate change, and the need to boost productivity while lowering expenses. Consequently, optimizing the performance of tractors, which are the primary implements for agricultural tasks, becomes paramount.

Effective diagnostics allow not only to increase the productivity and service life of machines, but also to reduce emissions of harmful substances into the atmosphere. The use of modern technologies, such as telematics systems, sensors and machine learning algorithms, makes it possible to more accurately and quickly identify malfunctions, which reduces the risk of accidents and equipment downtime. Thus, the direction towards the introduction of advanced diagnostic technologies meets the urgent needs of sustainable agricultural development [1].

Over recent decades, agriculture has transformed significantly, driven by the adoption of modern technologies. Among these advancements, the diagnostics of tractor engines holds particular importance, ensuring agricultural production remains efficient and productive. Tractors and other agricultural machinery serve as essential tools, directly influencing the effectiveness of various operations. However, despite progress in mechanization, equipment remains vulnerable to breakdowns and malfunctions, which can result in substantial time and resource losses.

In this landscape, modern diagnostic technologies have become crucial for managing agricultural processes. They enable not only the timely detection and resolution of issues but also real-time monitoring and analysis of equipment performance. These capabilities help minimize operational costs and enhance overall productivity. Cutting-edge innovations, such as artificial intelligence, sophisticated sensors, and advanced monitoring systems, are paving the way for more efficient tractor operation. Below, we examine several existing methods for diagnosing tractor engines, highlighting their

strengths and limitations:

1. Brake test method, which helps to determine the effective power of the engine, and also has high accuracy, stability and duration of operation modes. The main disadvantages of these methods are the bulkiness of the equipment and complexity, as well as the ability to be used only in stationary conditions.

2. The method of determining engine power by fuel consumption. The advantages of the method are simplicity and the ability to constantly monitor fuel consumption. At the same time, errorы, lack of load conditions, and the inability to determine cylinder parameters are its main disadvantages.

3. A method for diagnosing tractor engines in dynamic mode, which implies an integrated approach, including monitoring of the main engine parameters: speed, power, temperature, analysis of exhaust gas composition. The advantages of the dynamic method are the ease of use and compactness of the equipment.

4. Indirect methods for evaluating compression properties, which make it possible to diagnose a tractor engine without removing it from the machine using modern measuring equipment. The disadvantages of this method are the dependence of the accuracy of the readings on the technical condition of the start-up system, as well as on the fact that in absolute terms there is no assessment of compression properties by these methods.

5. Indirect indicators of the technical condition of the tractor engine are used for the diagnostic parameters assessment method, such as temperature, pressure, oil and fuel consumption, rotation speed, vibration, beating of rotating parts, gaps, degree of slippage, bending of the part and others.

6. According to the magnitude of the mechanical efficiency, it is possible to assess the technical condition of the engine and decide whether it needs to be repaired. To determine mechanical efficiency, special test benches are used, while it is necessary to remove the engine from the tractor [2].

It should be noted that the existing methods of diagnosis of tractor engines require highly qualified specialists and considerable labor intensity. In addition, the problem of ensuring the full load of the tractor engine when it is tested under operating conditions to determine its exact characteristics is still unresolved [3].

The improvement of diagnostic methods for tractor engines is of urgent importance for improving the efficiency and reliability of tractor equipment. To achieve these goals, it is possible to use the following directions:

1. Integration of digital technologies.
2. Using machine learning to analyze real-time data.
3. Development of compact and universal diagnostic devices.
4. Introduction of predictive analytics algorithms that allow predicting technical failures based on the collected data.

References

1. Chernoivanov V.I. Innovacionnye tekhnologii v tekhnicheskom servise APK. // Nauchnaya informaciya obespechenie innovacionnogo razvitiya APK / Ros. nauchnoe issledovanie internet informacii i tekhniko-ekonomicheskogo issledovaniya po inzhenerno-tekhnicheskomu obespecheniyu agropromyshlennogo kompleksa. -Moskva, 2012. S. 19-28.

2. Moshkin N.I. Razrabotka avtomatizirovannoj tekhnologii i sredstv tekhnicheskogo diagnostirovaniya uzlov i agregatov avtotransportnyh sredstv sel'skohozyajstvennogo naznacheniya: Dis. dok. tekhn. nauk: 05.20.03. Ulan- Ude, 2007.
3. Petrichenko R.M., Baturin S.A., Isakov Yu.N., et al. Elementy sistemy avtomatizirovannogo proektirovaniya DVS: Algoritmy prikladnyh programm. L.: Mashinostroenie. Leningr. otdelnienie, 1990. 328 s.

Современные технологии диагностики тракторных двигателей: вклад в устойчивое развитие сельского хозяйства

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Аннотация. Формирование перспективного научно-технологического задела является необходимым условием обеспечения модернизации и ускоренного технологического развития отраслей экономики России. Себестоимости сельскохозяйственной продукции более чем на 60 % формируют техника и технология производства, для этого нужно обеспечить высокий коэффициента продуктивности и оперативной готовности машин к работе, устранение неисправностей.
Ключевые слова: садоводство, питомниководство, инновационные технологи, диагностирование тракторной техники, трактора.

УДК 539.216

Analysis and review of technical solutions for row-to-row processing of row crops

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Abstract
The paper considers the problems of removing weeds from potato row spacing in agricultural farming conditions using small-scale mechanization.
Keywords: potato cultivation, weed removal from row spacing.

Introduction

Personal subsidiary farming (PSF) is a form of non-entrepreneurial activity for the production and agricultural products processing. A private household is maintained by a citizen or a citizen and his family members living together with him and (or) jointly conducting personal subsidiary farming with him in order to meet personal needs on a land plot provided and (or) acquired for personal subsidiary farming. [1]

Potatoes are a unique healthy food product - they are on the 3rd place in importance and are the most significant plant source of food energy among non-slag plants, a source of replenishing the lack of minerals and antioxidants.

To date, the potatoes volume grown in private farms in the Tambov region significantly exceeds the cultivation volume in large farms and agricultural holdings (table 1), however, the low level of technical equipment significantly reduces productivity and increases the work complexity in potato cultivation. In this regard, manufacturers have a need for new tools to improve the quality and yield of products.

Table 1. Potato acreage in the Tambov region [3]

	Potato acreage in the Tambov region, thousand hectares.						
	2014 y.	2015 y.	2016 y.	2017 y.	2018 y.	2019 y.	2020 y.
Households of the population (citizens)	36.77	35.92	30.50	27.43	24.72	23.49	23.30
Agricultural organizations (all agricultural enterprises)	5.29	5.53	4.61	2.96	3.07	5.02	3.27
Peasant (farmer) farms and individual entrepreneurs	1.14	1.46	1.26	1.11	1.33	1.03	0.80

An increase in the gross harvest and potatoes quality with a minimum working time expenditure is possible only on the basis of small mechanization tools used in personal subsidiary farms and in compliance with the requirements for the conditions of its growth. Small mechanization tools use (tillers with a set of tools) in personal subsidiary farms is due to their small size. Their use in personal subsidiary farms allows to increase labor productivity by 2...2.5 times compared to traditional cultivation. Therefore, the development and equipping of personal subsidiary farms with small-sized equipment becomes an urgent problem. [2]

One of the main tasks in potato cultivation is the fight against weeds, which, in addition to consuming water and minerals from the soil, complicate potato harvesting by winding up on the working bodies of the harvesting unit. Weed removal is complicated by comb planting and a large tops volume, as well as the tubers location directly in the soil. In addition, the high-quality availability herbicides and the quality of their application remains low for small producers, which requires the introduction of a special tool for mechanical weed removal.

Analysis of existing structures

Among the mass-produced tools for weed removal, rotary (Fig.1) and disk rippers (Fig.2) are known.

Figure 1 - Rotary ripper "Hedgehog"

Figure 2 - Disc ripper ODB-1,6

The disadvantages of these designs are the impossibility of their use with a high mass and potato tops density due to its damage and winding on rotating working bodies. The rotating working bodies presence in the design requires the bearing supports use, which increases the production cost and complicates the maintenance and repair of tools. The rotary ripper "Hedgehog" cannot be used in the late potato vegetation stages due to the increased risk of damage to tubers, since there are protruding pins with a length of 60 mm in the structure. During the weeding process, the ridge walls will crumble to the bottom, resulting in a violation of the furrow geometry, which can lead to the tubers exposure and their worse warming. The both tools design has no devices to preserve the original appearance of the crest.

Conclusion

To date, there is no tillage tool for controlling weeds in potato row spacing in the agricultural farming conditions, which would allow removing weeds from the furrows without damaging the tops and tubers, and would also preserve the original geometry of the ridge.

Reference

1. Savoskina I.V., Kornyushin V.M. Universalization of small-sized equipment in private housing. Ryazan: FGBOU VO RGATU, 2021. 3 p.
2. Matusevich A.V., Skorobogataya A.A., The use of small-scale mechanization in the cultivation and harvesting of potatoes in private and suburban areas. Minsk: BGATU, 2020. 2 p.
3. Open data // Showcase of statistical data: official website. - Access mode: https://showdata.gks.ru – (Accessed: 12/16/2021)
4. Cultivator "Hedgehog" set for minitractor Scout. -URL: https://osnova.market/kulytivator-eghik-komplekt-dlya-minitraktora-skaut (date of application: 17.12.2021)
5. Single-row rotary disk spud ODB-16 with furrow 00.02.52.00.00-01. - URL: https://sezon.club/catalog/sadovaya-tekhnika/navesnoe-oborudovanie-k-motoblokam/okuchnik-odnoryadn-diskovyy-oborotnyy-odb-16-s-borozdodelom-00-02-52-00-00-01 / (date of request: 17.12.2021)

Анализ и обзор технических решений для междурядной обработки пропашных культур

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Аннотация. В настоящей статье рассмотрены проблемы удаления сорняков из междурядий картофеля в условиях ЛПХ с использованием средств малой механизации.

Ключевые слова: возделывание картофеля, удаление сорняков из междурядий.

УДК 632.03

Application of K-nearest neighbors method for data analysis in hyperspectral monitoring of apples

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Abstract
The abstract of the report discusses the possibility of using the K-nearest neighbors method to determine the quality of apples. The results of the method for classifying apples are presented. The proposed approach allows classifying apples into three categories of plant tissue: “healthy”, “rotten”, and “bruised”.
Keywords: agriculture; crop monitoring; hyperspectral cameras; hyperspectral monitoring; KNN machine learning.

Introduction

The K-nearest neighbors (KNN) method is one of the simplest and most intuitive algorithms in the field of machine learning, used for solving classification and regression tasks. The fundamental principle of KNN is to find the k nearest neighbors for a new object based on a training dataset. Classification is performed based on the majority class among these neighbors or by using average values for regression tasks.

In combination with neural networks, KNN is actively used for tasks that require local data analysis. Neural networks are used to extract embeddings — compact vector representations that reflect complex nonlinear dependencies in data. Based on these embeddings, the KNN algorithm can perform clustering, classification, or search for similar objects. This approach is used in few-shot learning, recommender systems, and image processing. The use of neural networks allows one to take into account the global properties of data, while KNN focuses on local structures, which makes their combination especially effective in hybrid models. [1].

Training data is projected into a multidimensional space, where each dimension represents a separate characteristic (feature) of the data. This space is divided into sections based on the classification of the training data. A point in this space is labeled with class c if class c is the most common among the k nearest neighbors of that point. The distance to close and distant neighbors is typically calculated based on Euclidean distance using the following formula:

$$d(x_i, x_j) = \sqrt{\sum_{s=1}^{p} (x_{is} + x_{js})^2}$$

where d(x,y) is the distance between points x and y, and n is the number of dimensions (features).

Data is projected into a multidimensional space, where each dimension corresponds to a specific characteristic (feature) of the data. In addition to Euclidean distance, alternative metrics such as Manhattan distance or cosine distance are also used to determine the proximity between objects. A key aspect of KNN is the selection of the parameter k, which critically influences the algorithm's performance: a value that is too small can lead to overfitting, while an excessively large value may result in a loss of information. In the case presented in this article, the parameter k was chosen to be 1, which ensured optimal speed and quality of operation.

The method was implemented on the Google Colab platform using Python with the Scikit-learn library. Scikit-learn is a machine learning library for Python that provides a simple and effective toolkit for data analysis. It supports a wide range of algorithms, including classification, regression, clustering, dimensionality reduction, and offers convenient interfaces for working with them.

The main components of the library include data preprocessing, feature selection, cross-validation, and model evaluation. Scikit-learn integrates with other popular libraries such as NumPy, SciPy, and Matplotlib, providing support for working with data arrays and visualization. Due to the simplicity of the API and extensive documentation, the library is widely used in both academia and industry. The implementation of the K-Nearest Neighbors (KNN) method in Python has several advantages, including simplicity and ease of syntax, the availability of powerful libraries (such as Scikit-learn, NumPy), flexibility in integrating with other algorithms, extensive documentation and community support, as well as the ability to visualize data using specialized libraries. Python also provides tools for parameter tuning and cross-validation, which contribute to improving model quality. Although KNN may have performance limitations, the optimization of libraries in Python allows for efficient handling of large datasets, making it an ideal choice for data specialists and machine learning developers.

The research was conducted by using the Specim FX10 hyperspectral camera (Finland, Specim company). Specim FX10 is a hyperspectral camera designed for precise material analysis in the visible and near infrared range (400–1000 nm). It provides high spectral and spatial resolution, allowing data to be recorded from more than 200 spectral channels.

The camera is widely used in tasks requiring analysis of the chemical composition and structure of objects, including material sorting, quality control and scientific research. Due to its high shooting speed and compact size, Specim FX10 is integrated into automated systems and provides detailed analysis in real time. The camera provides high spectral and spatial resolution, making it ideal for given task. The Golden Delicious apple variety was used for the study. [2]

The table of accuracy values for the KNN method is presented in Fig. 1.

	precision	recall	f1-score	support
Гниль	1.00	1.00	1.00	7
Здоровая	1.00	1.00	1.00	1
Ушиб	1.00	1.00	1.00	5
accuracy			1.00	13
macro avg	1.00	1.00	1.00	13
weighted avg	1.00	1.00	1.00	13

Figure 1 - Table of accuracy for KNN method

The obtained values have an accuracy of over 90%, which indicates a high level of precision in classification and regression tasks, especially in cases with small to medium-sized datasets. During the application of the method, the results were divided into three categories. The plant tissue of apples was classified as rotten, healthy, and bruised. This classification allowed for the determination of the quality level of the selected fruits, sorting them, and verifying the accuracy of the method's performance [3]

Conclusion

The results of the conducted experiments showed that the proposed approach ensures significant accuracy in determining the quality of fruits, making KNN a relevant tool for this task. Data processing methods and model parameter optimization contributed to improved classification results, confirming the flexibility and adaptability of KNN to various conditions and data characteristics. KNN is a non-parametric method, which makes it flexible for different types of data; however, it is sensitive to the scale of the data and requires a significant amount of memory, as the algorithm stores all training data. The algorithm finds wide application in various fields, such as medical diagnostics, recommendation systems, and pattern recognition. Thus, despite its simplicity, the nearest neighbour method remains a powerful tool for researchers and practitioners, requiring careful data preprocessing and parameter optimization.

References

1. Vyugin, V. V. Matematicheskie osnovy mashinnogo obucheniya I prognozirovaniya [Mathematical Foundations of Machine Learning and Forecasting]. Moscow, MCNMNO, 2018. 484 p. (Rus)
2. Yagodin, B.A., Zhukov Y.P., eds Agrohimiya [Agrochemistry]. Moscow, Kolos, 2002. 584 p.
3. Zhirkova, A. A., Balabanov P.V., Divin A.G. Analiz spectrogram fruktov [Analysis of fruit spectrogrames]. Alleya nauki, 2021, No. 6, pp. 1115-1119 (Rus)

Применение метода ближайших соседей для анализа данных при гиперспектральном контроле яблок

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Аннотация. В тезисах доклада рассмотрена возможность применения метода K-nearest neighbours для определения качества яблок. Приведены результаты использования метода, для классификации яблок. Предложенный подход с высокой точностью позволяет классифицировать яблоки по трем категориям растительной ткани «здоровая ткань», «загнивание», «ушиб».
Ключевые слова: гиперспектральные камеры, гиперспектральный контроль, KNN, машинное обучение, мониторинг сельхозкультур, сельское хозяйство.

УДК 631.1-15

Use of biodegrades and technologies of their application

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Abstract
This article considers the role of biodestructors in modern horticulture and nursery, as well as modern technologies of their application to the soil. Biodestructors, having the ability to decompose organic matter and improve soil fertility, are becoming an important tool for sustainable agriculture. Particular attention is paid to innovative devices for their introduction, which can increase the efficiency of using these microorganisms.
Keywords: biodestructor, gardening, innovative technologies, nursery, preparations, stubble decomposition

Introduction

One of the urgent problems of agriculture in the Tambov region is: soil depletion due to extremely aggressive human activity. The main indicator that determines soil fertility is humus content. Over the past century, its amount has decreased, according to some data, from 25 to 50%. According to a number of studies [1: 141], the following conclusion can be made - the use of a stubble biodestructor can greatly accelerate the process of decomposition of crop residues, and as a result, their mineralization.

Materials and methods

Biodestructors are selection strains of microorganisms that serve to significantly accelerate the decomposition of organic residues and improve the microbiological state of the soil. Given environmental challenges and the need to transition to sustainable agriculture, the use of biodestructors in horticulture and nursery farming is becoming especially relevant. In this regard, the requirements for the introduction of biodestructors and the development of appropriate technologies play a key role [2: 15].

Biodestructors include a number of microorganisms: bacteria, fungi and their combinations. They are able to decompose both plant and animal organic materials, subsequently converting them into micro- and macroelements necessary for the successful growth of crops.

The use of biodestructors allows us to achieve the following advantages: firstly, they increase the content of mineral substances in the soil and also contribute to the improvement of the structure and aeration of the soil, which has a beneficial effect on the health of plants, strengthening their resistance to diseases. Secondly, the preparations accelerate the decomposition of organic residues, allowing for forced mineralization and, subsequently, providing the soil and plants with the necessary substances [3].

Traditional methods of application include manual distribution of biodestructors soaked in water and the use of compost heaps. However, these methods are often less

effective due to uneven distribution.

Devices that automate the process of applying biodestructors have appeared on the market. Their main functions are uniform distribution over the surface of the field or directly into the soil. To do this, we need to provide microcontrol of the solution dosage for different types of soil and crops, but the best choice would be integration with irrigation systems to maximize efficiency.

Examples of such devices include machines that use drones to distribute biodestructors in hard-to-reach places, in other cases, you can use sprayers, both self-propelled or trailed, as well as knapsack types, as well as plant feeder applicators.

Due to the need to utilize organic residues, the most appropriate method is to incorporate organic residues into the soil with the simultaneous use of a biodestructor. Based on these conditions, the following device is proposed.

This unit is a disc harrow with an installed kit for applying a biodestructor. The proposed design consists of the following elements: a disc harrow, a frame for installing a tank containing the working solution, a beam with installed equipment for uniform distribution of the biodestructor, a membrane pump, a hydraulic motor for powering the device for applying the preparation.

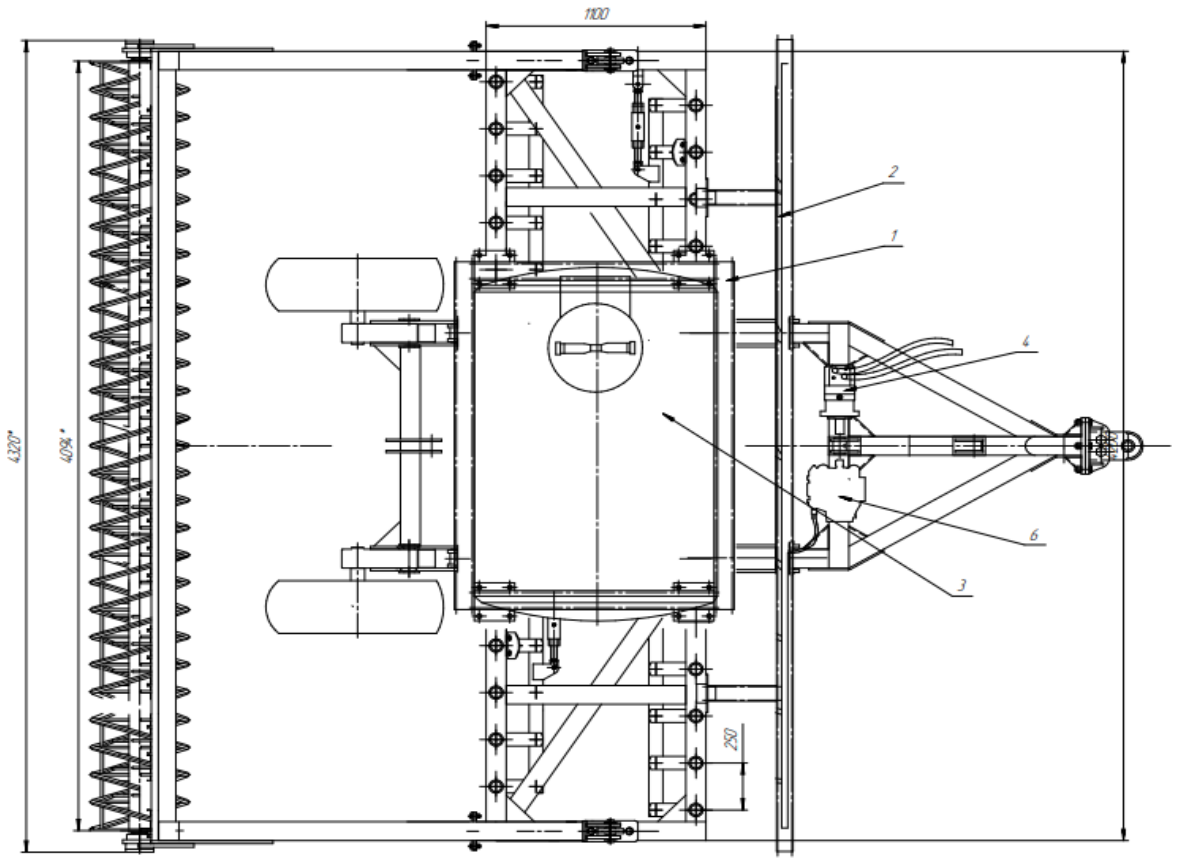

Figure 1 - The proposed device for applying the biodestructor: 1 - a frame for installing a tank containing the working solution, 2 - a beam with installed equipment for uniform distribution of the biodestructor, 4 - a hydraulic motor for powering the device for applying the preparation. 6 - a membrane pump

Conclusion

Using a biodestructor can significantly reduce soil depletion, as well as almost completely prevent its degradation. Soil fertility will be increased, and the cost of mineral fertilizers will be significantly reduced, allowing the gardener or nursery owner to receive higher income from the future harvest. Also, the use of the proposed system is an important step towards environmentally sustainable management of agricultural systems. Development and implementation of innovative devices for introducing these microorganisms can significantly increase the efficiency of their application. Future research should focus on optimizing application technologies, as well as on a deeper understanding of the interaction of biodestructors with different soil types and crops.

References

1 Polevshchikov, S. I. Vliyanie sveklovichnyh sevooborotov i primenyaemyh udobrenij na soderzhanie gumusa v pochve / S. I. Polevshchikov, I. P. Zavoloka // Osnovy povysheniya produktivnosti agrocenozov: materialy Mezhdunarodnoj nauchno-prakticheskoj konferencii, posvyashchennoj pamyati izvestnyh uchenyh I.A. Muromceva i A.S. Tatarinceva, Michurinsk, 24–26 noyabrya 2015 goda. – Michurinsk: Obshchestvo s ogranichennoj otvetstvennost'yu \"BIS\", 2015. – S. 142-146. (Rus)
2 Shmidov, D. V. O tekhnicheskih sredstvah dlya izmel'cheniya i zadelki sideratov v pochvu / D. V. Shmidov, V. M. Labuh // Agrokonsul'tant. – 2014. – № 3(2014). – S. 16-19. (Rus)
3 Vliyanie E.V. razlichnyh sevooborotov na kachestvennye izmeneniya pokazatelej chernozyoma tipichnogo v usloviyah CChZ Tambovskoj oblasti / E. V. Dudova, A. Yu. Nenashev // Nauka, obrazovanie i innovacii dlya APK: sostoyanie, problemy i perspektivy: Materialy VI Mezhdunarodnoj nauchno-prakticheskoj onlajn-konferencii, Majkop, 25 noyabrya 2020 goda. – Majkop: Izdatel'stvo \"Magarin Oleg Grigor'evich\", 2020. – S. 74-79. (Rus)

Использование биодеструктов и технологии их внесения

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Аннотация. В данной статье рассматривается роль биодеструкторов в современном садоводстве и питомниководстве, а также современные технологии их внесения в почву. Биодеструкторы, обладая способностью разлагать органические вещества и улучшать плодородие почвы, становятся важным инструментом для устойчивого ведения сельского хозяйства. Особое внимание уделяется инновационным устройствам для их внесения, которые могут повысить эффективность использования данных микроорганизмов.

Ключевые слова*:* биодеструктор, инновационные технологи, питомниководство, препараты для разложения стерни, садоводство.

УДК 636

Analysis of modern methods of preparing feeds in dairy production

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Abstract
This article examines modern methods of preparing and distributing feeds in dairy production and farms. With the development of technologies, these methods have improved: feed preparation has become more balanced, distribution has become more uniform in quantity and timing, and all these processes have become faster and more automated.
Keywords: feed, milk, farm, production, development.

Introduction

Dairy production remains one of the important structures of agriculture, ensuring the population's food security through the production of dairy products. With the population growth, there arises a need to optimize the preparation and distribution of feeds for cattle, thereby increasing productivity and milk quality. The relevance of analyzing modern methods of feed preparation and distribution is caused by several factors:

1. Economic efficiency: Reducing costs of animal feeding and increasing the enterprise's profit.
2. Product quality: Nutrition directly affects the health of animals and, consequently, the quality of milk.
3. Innovative technologies: Implementing robotic feeding systems and automated management processes to reduce physical labor and expenses.
4. Environmental aspects: Improper feeding can lead to greenhouse gas emissions into the atmosphere.
5. Animal health: Proper and balanced nutrition influences the productivity and reproductive functions of cows.

In this article modern methods of preparing and distributing feeds on dairy farms are analyzed.

Modern feed distributors are equipped with programmable sensors that allow for precise feed dosing based on the required amount. These systems are managed using computers. The programmable device enables us to supply feed to each animal, taking into account all necessary factors [1].

The use of feed mixers and blenders allows us to produce high-quality and balanced feed.

Robotic feed distribution systems can operate around the clock, ensuring that animals have constant access to feed, which positively affects their health and milk yield quality.

Modern data management systems collect and analyze data on feeding, milk yields, health, productivity, and feed costs.

Automation

Automation of feed preparation and distribution processes significantly reduces costs and ensures the stability of economic indicators, such as reducing feed costs by 5-15% and increasing milk yields by 10-20%.

The application of artificial intelligence (AI) in feeding technology also contributes significantly to the development of agriculture. AI in feed preparation is used to analyze large volumes of data, such as analyzing feed components, setting optimal portions of all ingredients, as well as monitoring their nutritional value and cost. Additionally, AI can predict the final outcome based on data about the producer, such as the age, health, and nutrition of the animals, among many others.

For accurate data collection and transmission, various modern sensors and detectors are used. For example, devices are installed on feed shelves and in feed mixes that transmit information about the type of feed and its quantity, as well as timely replenishing of stocks. These devices are also used to monitor animals, keeping track of parameters such as temperature, behavior, well-being, and similar factors [2].

Use of artificial intelligence

Agriculture 4.0 is the next generation of agriculture, which will combine modern technologies and innovations to significantly enhance the efficiency and sustainability of agriculture.

In the dairy industry, artificial intelligence plays a key role in ensuring product quality control.

Thanks to the use of machine learning algorithms and computer vision, the systems can automatically analyze the characteristics of dairy products, such as color, texture, and fat content. This allows you to quickly detect deviations from standards and prevent low-quality products from entering the market.

Examples of using artificial intelligence in quality control:

1. detection of packaging defects on the conveyor;
2. analysis of milk for the presence of impurities and bacteria;
3. determination of optimal storage conditions for products.

The use of artificial intelligence in the production of dairy products can significantly increase its efficiency.

Thanks to the use of data obtained from sensors, as well as the capabilities of machine learning and analysis of large amounts of information, artificial intelligence systems can predict and optimize various parameters of the production process. This applies to such aspects as pasteurization temperature, mixing speed and dosage of ingredients.

Here are some examples of how artificial intelligence can optimize dairy production:

1. predicting and controlling the maturation time of cheese;
2. automation of the process of dispensing ingredients in the production of yogurt;
3. monitoring and optimization of equipment power consumption.

Although artificial intelligence makes significant changes in various aspects of dairy production, human labor remains an indispensable tool. Experienced cheese makers with many years of experience work together with artificial intelligence systems to create unique cheeses.

Artificial intelligence provides analytical data and automation based on this data, which is a great learning tool. However, the art and craftsmanship of cheese making remains exclusively a human field of activity.

Conclusion

The implementation of AI and automated systems for preparing and distributing feeds is an integral part of progressive dairy production. Without these technologies, it will be very difficult to increase productivity, reduce costs, and ensure the health of animals in the future. Overall, the application of all the aforementioned innovations will provide a strong impetus for the development of agriculture.

References

1. Nikolayev S. I., Cheprasova O. V. Kormoproduktsiya, Kormlenie Selskokhozyaistvennykh Zhivotnykh i Tekhnologiya Kormov [Forage production, farm animal feeding and fodder technology]. 2024. 132 p. (Rus)
2. Kuznetsov I. Yu. Kormoproduktsiya s Elementami Tsifrovykh Tekhnologiy. Praktikum [Feed products and elements of digital technologies]. 2024. 440 p. (Rus)

Анализ современных методов приготовления кормов на молочно-товарном производстве

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Аннотация. Рассмотрены современные методы приготовления и раздачи кормов на молочно-товарном производстве и фермах. С развитием технологий эти методы изменились в лучшую сторону: приготовление корма стало более сбалансированным, раздача стала более равномерной по количеству и по времени, а все эти процессы стали более быстрыми и автоматизированными.
Ключевые слова*:* корм, молоко, производство, развитие, ферма.

УДК 634.1-13

Modern agronomic solutions for the production of apple rootstocks in the Tambov region

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Abstract
This article analyzes the technologies for growing apple rootstocks in the Tambov region and the dynamics of the gross yield of fruits and berries. The technologies for earthing-up shoots and the shortcomings of existing devices requiring manual finishing are examined. Directions for improving equipment to increase the efficiency of small farms are proposed.
Keywords: horticulture, earth up, mother plantation, rootstock, nursery, apple tree, mechanization.

Horticulture, particularly apple orchard cultivation, plays a crucial role in the agro-industrial complex of our country. One of the key tasks is to provide nurseries with high-quality domestic planting material. This is an important goal because the use of adapted apple varieties helps increase yield, resilience to local climatic conditions and diseases, and reduce dependence on imported material. The dynamics of gross fruit and berry yields in the Tambov region (for all types of farms) are presented in Fig. 1.

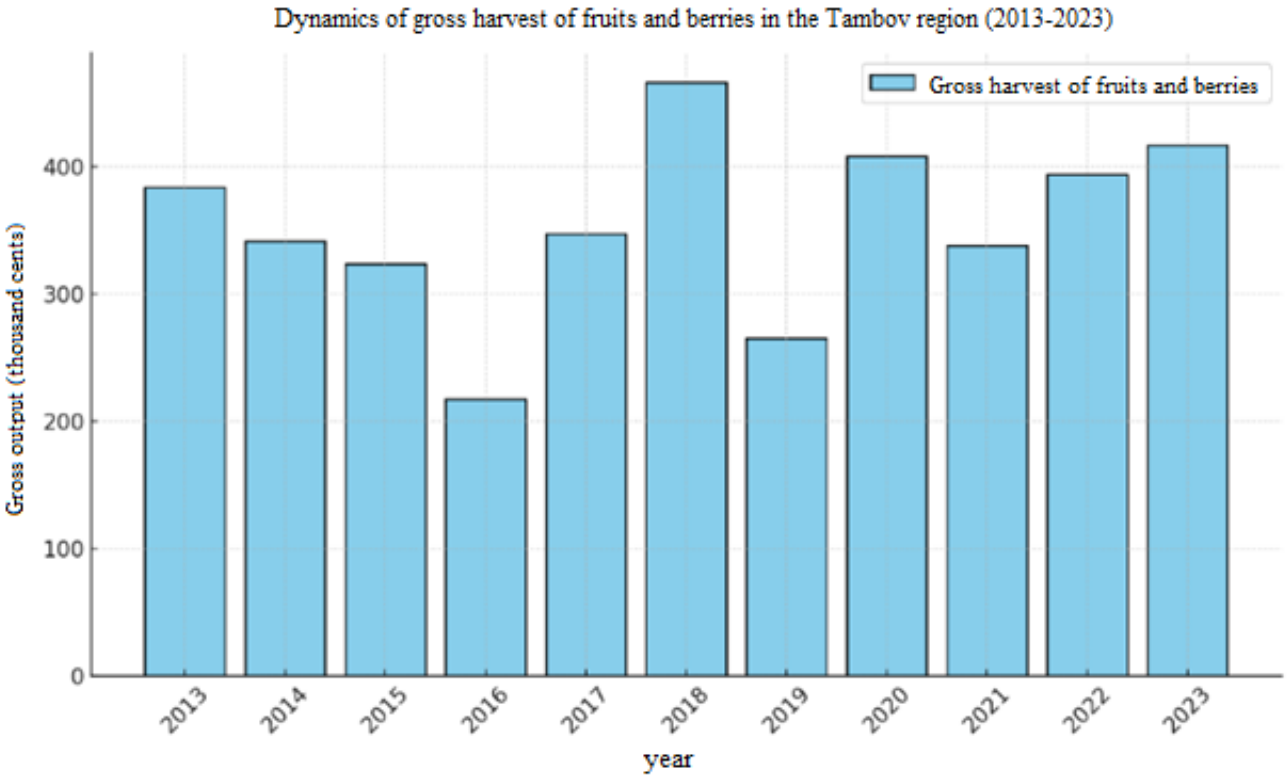

Figure 1 - Dynamics of gross fruit and berry yields in the Tambov region (2013–2023).

By analyzing the data from the presented chart, it can be concluded that over the past ten years, the gross yield has experienced slow growth and significant fluctuations in the years of orchard removal and planting. Therefore, to ensure independence in planting material, it is necessary to increase the productivity of all types of farms.

A rootstock of apple trees is grown on the mother plantation. Grounding is required during shoot growth. Various substrates are used to create the best conditions for plant growth. These can be sawdust mixed with soil, conifer bark, chopped straw and soil. Do not use hardwood sawdust as a substrate, as it may be prone to disease.

A quality substrate should have the following characteristics to support healthy plant growth. It should have good drainage properties to prevent excess water from entering the soil, which can lead to root rot and disease. The substrate should also maintain a stable moisture level, giving the roots constant access to moisture.

In addition, the substrate should provide sufficient aeration for the roots. This is very important because proper airflow helps prevent the accumulation of harmful microorganisms such as fungi and bacteria that can multiply in poorly ventilated soil. A well-ventilated substrate promotes the development of a strong, healthy root system, which in turn supports vigorous plant growth.

Maintaining such conditions not only promotes healthy plant growth, but also increases the plants' resistance to unfavorable environmental factors.

The amount of substrate needed depends on the optimal height at which the soil should be filled to ensure high-quality ridge formation. This required volume of substrate is also influenced by annual losses, which can vary between 10 and 20%.

The first earthing-up is recommended to be carried out manually to avoid covering young shoots with soil. For subsequent earthing-ups, various devices can be used.

Large agricultural enterprises typically use tractor-aggregated devices, such as those with left- and right-turning plowshares like the PRVN-2.5 model.

When the machine is moving, saddling a row of mat plants, the bodies pile the soil to the row of plants. Often this work is performed by plows, making a pass on each side of the row. In this case the soil is also piled against the row of plants

For more precise earthing-up, the OM-P hiller can be used. It consists of a frame on support wheels, two vertically rotating cutters, two hilling boards, and a power drive from the tractor PTO.

Another variant is the OM-Sh holder, characterized by the fact that its active working bodies are cutters and a conical auger mounted on a horizontal shaft

The described machines perform perching of mother plants more qualitatively. However, both OMP and OMSH form a perching swath by moving soil from between the rows to the sides of the row of plants. In the middle of the row, where the largest number of shoots, the soil does not always get to the middle of the row, which reduces the efficiency of perching shoots. Thereby requiring manual tillering, which can take 25-50 man-days per hectare of mother plantation [1]

The MOU1 milling machine fulfills this task, it consists of active and passive milling units mounted on a frame. Its active working elements are milling drums, which can follow the soil topography by means of an articulated joint. Its advantage over other

variants is that it can fill the middle of the nursery with substrate by means of knives along the entire length of the milling drums. The knives are of different lengths to prevent damage to the plants

In the rooting zone, the soil moisture in the swath is 1-3% higher than in the swath laid by hand. All this will help to get better quality rootstocks.

In this way, mechanization is important not only for reducing manual labor in rhizome cultivation, but also improves the quality of swaths, and this allows optimal soil fractionation and complete filling of the germination zone on soils and substrates with different moisture content.

Currently, small farms growing apple rootstocks face the need for manual labor or mechanical devices that, while helpful, still require additional manual earthing-up. This significantly increases labor costs and reduces the efficiency of the process.

Existing hiller designs available on the market do not always complete the operation in a single pass. Often, they fail to evenly distribute the substrate in the central part of the bed, necessitating human intervention to address these shortcomings.

Modern developments should focus on creating hillers that can perform the process in a single pass, ensuring even distribution of the substrate across the entire width of the bed, including the central part. This will significantly reduce or completely eliminate manual labor, increase productivity, save time and resources, and improve the quality of work.

For small-scale farms with limited resources and opportunities for large-scale mechanization, such innovations are particularly valuable. Compact and multifunctional machines enable efficient execution of various agricultural operations without the need for an extensive machinery fleet.

References

1. A. A. Zavrazhnov., A. I. Zavrazhnov., V. Yu. Lancev. Tekhnologii i tekhnika promyshlennogo sadovodstva i pitomnikovodstva. Sankt-Peterburg. Lan’. 2024. 464 p.

Современные агротехнические решения для производства яблочных подвоев в Тамбовской области

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Аннотация. Проведен анализ технологий выращивания яблочного подвоя в Тамбовской области, изменения динамики валового сбора плодов и ягод. Рассмотрены технологии окучивания побегов, а также недостатки существующих устройств, требующих ручного доокучивания. Предложены направления совершенствования оборудования для повышения эффективности работы малых хозяйств.

Ключевые слова: садоводство, окучивание, маточник, подвой, питомник, яблоня, механизация.

УДК 631.243.4

Development of technical means for regulating the uniformity of air flow in the ventilation system of sugar beet clamps

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Abstract
The article presents technical devices for balancing ventilation branches used in the storage of sugar beet in beet clamps. The rationale for the need to use technical devices is presented, as well as a description of their application.
Keywords: Sugar beet, storage, active ventilation system, beet clamp, ventilation branch.

During long-term storage of sugar beet in beet clamps using an active ventilation system, one of the key requirements is uniformity of cooling. Long-term storage bags, as a rule, have the following sizes: The height is 6-7 meters, the width is 28-32 meters, and the length is limited by the length of the site. Cooling and maintaining the temperature regime of storage in the chamber is provided by ventilation branches through which air is pumped from the environment. The axial distance between the ventilation branches varies in the range of 5-6.5 meters. The ventilation branch includes: a ventilation duct with air outlets, a ventilation unit, as well as technological service areas.

The uniformity of air distribution is understood as the intake of an equal amount of air mass over the entire width of the beet clamp, taking into account the height of the embankment at the air outlet (Fig. 1). With uneven air intake, the safety of sugar beet decreases. Unlike typical ventilation systems, ventilation ducts with a constant flow section are used for sugar beet clamps. Therefore, uniformity is achieved by changing the configuration and flow section of the air outlets [1].

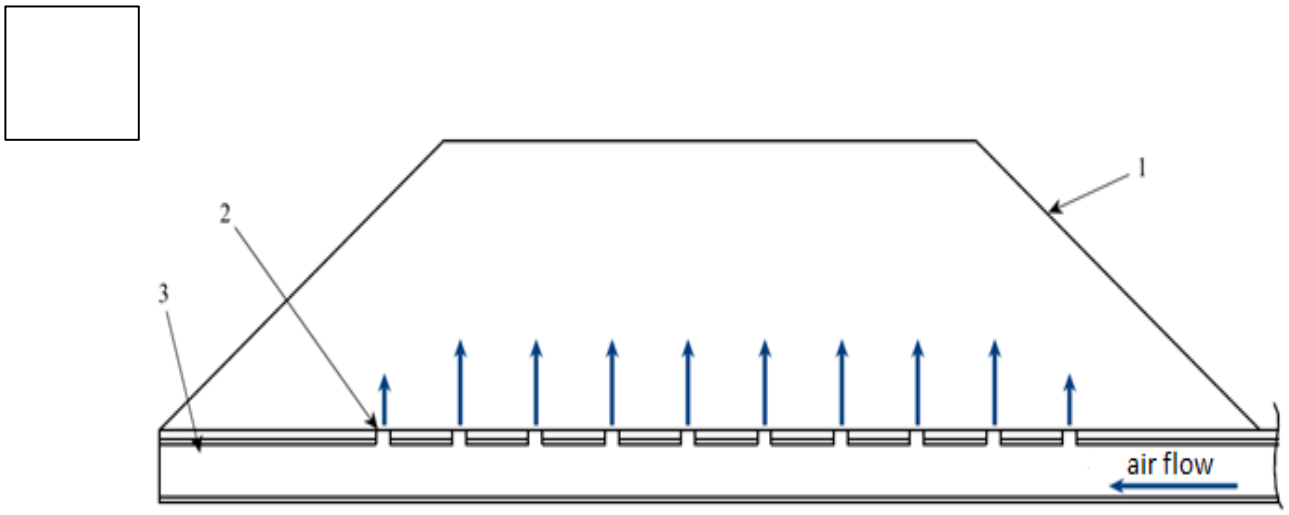
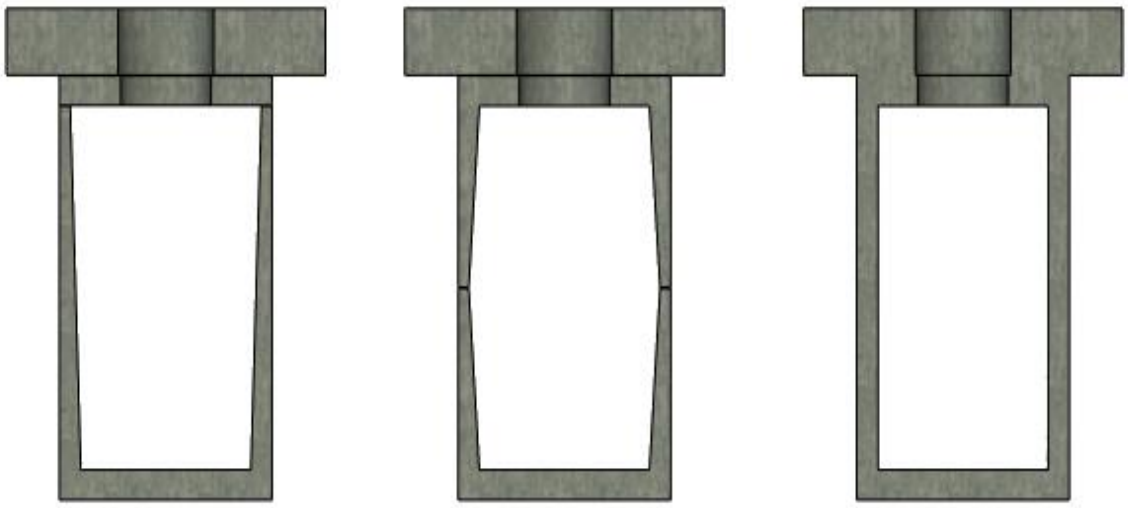


Figure 1 - The scheme of uniform distribution of air in beet clamp

Figure 1 shows the scheme of uniform distribution of air in beet clamps, where 1 is a sugarbeet chamber, 2 is an air outlet, 3 is an underground ventilation duct

However, it is not possible to implement this method on previously built underground stationary ventilation branches, since an increase in the number of air outlets will lead to a weakening of the reinforced concrete structure. Since the scheme of underground placement of ventilation branches assumes that cargo equipment is moving along the site with air outlets, there is a risk of collapse of ventilation ducts. An alternative solution is to install hardware inside the ventilation duct [2].

The device of the section of the ventilation duct with an air outlet can be made in several variations, as shown in Fig 2. To increase strength when handling the load from sugar beet trucks, the top of reinforced concrete trays is reinforced with a reinforced screed.



a) **b)** **c)**

Figure 2 – Section of the ventilation duct with an air outlet: a – one tray and a plate; b – two trays; c – monolithic structure

Regardless of the type of design of the section of the ventilation duct, there is a slit gap or embedded in the air outlet, which can be used to install air distribution devices.

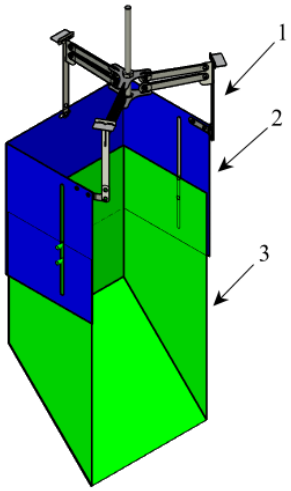


Figure 3 – Technical means for adjusting and regulating the uniformity of the air flow: 1 – spacer mechanism, 2 – adjusting casing, 3 – air intake

The most universal solution for this type of active system is the use of technical means, such as a spacer mechanism, an adjustment casing, an air intake (Fig. 3).

The spacer mechanism 1 is designed to be fixed inside the air outlet. After installing the spacer mechanism, an adjustment casing 2 is attached to its lower part, the design of which allows you to adjust the cross-sectional area of the air intake 3. A set of these technical devices is installed at each air outlet. By selecting the required flow section, when adjusting and adjusting each air intake installed under the air outlets in the channel, uniform air flow into the chamber is achieved [3:38].

The presented technical device will ensure the uniformity of air distribution in the ventilation branches for the beet clamps, which will increase the safety of sugar beet during long-term storage.

References

1. Kol`czov S.M. Issledovanie voprosa poteri sveklomassy` pri xranenii saxarnoj svekly` v beet clampe / S.M. Kol`czov // Materialy` 73-j Mezhd. nauchno-prak. kon-ciya «Sovremennaya agrarnaya nauka: aktual`ny`e voprosy`, dostizheniya i innovacii». – Michurinsk, 2021. – S. 152-156.
2. Knyazev V. A. Priemka i xranenie saxarnoj svekly` po progressivnoj texnologii / M.: Leg. i pishh. prom-st`, 1984. – 200 s.
3. Zavrazhnov A.I. Obosnovanie i razrabotka texnologii xraneniya saxarnoj svyokly` v beet clampax v usloviyax Central`no-Chernozyomnogo regiona / A.I. Zavrazhnov, S.M. Kol`czov // Saxar. – 2020. – № 1. – S. 38-44.

Разработка технических средств для регулирования равномерности воздушного потока в системе вентиляции кагатов сахарной свеклы

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Аннотация. В статье представлены технические устройства для балансировки вентиляционных ветвей, использующихся при хранении сахарной свеклы в кагатах. Представлено обоснование необходимости применения технических устройств, а также описание их применения.

Ключевые слова: сахарная свекла, хранение, система активной вентиляции, кагат, вентиляционная ветвь.

УДК 632.03

A review of machine learning methods for fruit quality assessment

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Abstract
The abstract of the report considers the ways of using machine learning methods to determine the quality of apples, bananas and other fruits. The results of using the methods by various scientists are presented. A conclusion is made about the further possibilities of using machine learning to assess the quality of fruits.
Keywords: Agriculture, apples, crop monitoring, fruits, hyperspectral cameras, machine learning.

The article discusses the application of machine vision technologies for food quality and safety control. Modern requirements for food products, including high quality and safety standards, emphasize the need to implement innovative methods in the testing and inspection process. Machine vision is a promising technology that can automate and improve inspection processes, providing higher accuracy and efficiency compared to traditional manual inspection methods. The study analyzes existing approaches of machine vision application in various stages of the production process, including raw material inspection, finished product monitoring, and detection of defects. Image processing algorithms and deep learning methods such as convolutional neural networks (CNN), allow for object classification and detection, as well as assessing the organoleptic properties of products, are considered. The article also discusses the advantages and limitations of machine vision, including the adaptation of technologies to different types of products and operating conditions, and the importance of integrating machine vision systems into production lines. In conclusion, it is emphasized that the implementation of these technologies can significantly improve the level of food safety and the quality of food products, which in turn helps with improvement of public health and with meeting demands of the consumers.

Machine learning is a form of artificial intelligence which uses statistical models and algorithms to extract useful information from data for classification and prediction. There are various machine learning methods: artificial neural networks (ANN), decision trees, support vector machines (SVM), principal component analysis (PCA), K-Nearest neighbor, logistic regression, etc.

Different methods have their own strong sides and weak spots, which in turn influences the areas and purposes for which they can be applied. Some methods, K-nearest neighbors as an example, require more time for calculations and categorization of data. This can result in significant delays in time when large datasets are being analyzed. Thus, it is important to understand the purpose of analysis so that the researcher can find the most accurate and least time-consuming method.

In addition, deep learning, which is a form of machine learning, has significantly improved the quality of decisions in various fields, including food technology.

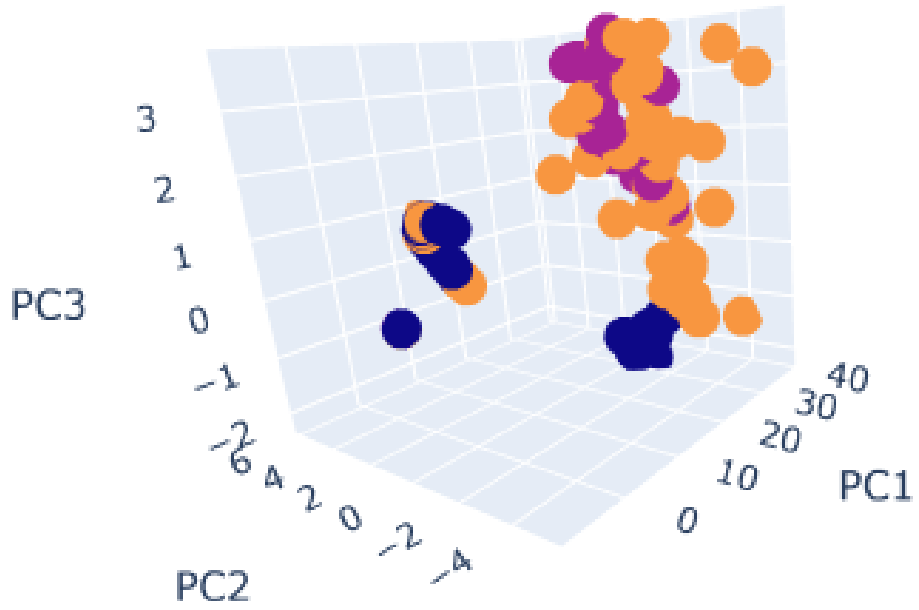

Figure 1 – Example of PCA application for analysis of apples. Different groups of data have different colours: blue – rotten apples, orange – bruised apples, pink – normal apples

In particular, the work of Naranjo Torres et al. [1] focuses on the use of convolutional neural networks (CNN) for fruit image processing, including classification, detection, and quality control. Their research highlights the effectiveness of convolutional neural networks in image analysis tasks, opening up new horizons for automation and process improvement in agriculture and food technology.

This study analyzed works in which machine learning methods were used to assess fruit quality. This includes detection of defects, mechanical damage to fruits, or deformations.

The work [2] presents the results of applying convolutional neural networks to hyperspectral images of apple plant tissues, which made it possible to ensure the accuracy of recognizing rot, scab, and insect damage to plant tissue of at least 86%.

Bhavya K.R et al. [3] propose two models for fruit freshness assessment. The first model is based on a custom-built CNN architecture, where the network parameters are adapted to the characteristics of a particular dataset. The second model uses a pre-trained visual geometry group (VGG) model as a base and applies transfer learning methods to improve the accuracy of fruit freshness classification. Both models demonstrated high results in distinguishing fresh and rotten fruits based on input images at a level of 99%, which allows us to judge the practical applicability of these systems.

In the work of Jana Wieme et al. [4], an extensive study was conducted, from which can be concluded that the choice of a machine learning method depends on a specific parameter which is being studied, since certain methods will show different results. For example, in the case of bananas, principal components analysis (PCA), principal component regression (PCR) and SVM methods are used, since the ripeness of a banana is

determined by the amount of chlorophyll in its peel. These methods showed high accuracy, which follows from the study of Saputro A et al. [5]. In his work, an optical system based on the visible and near infrared range was developed. The methods used allowed achieving results of maturity level determination error of only 0.79%.

Based on the review of scientific literature, the following conclusions can be drawn. Research on fruit quality assessment methods is making great strides, with scientists using machine learning methods with maximum efficiency, achieving high accuracy values. Deep learning shows high accuracy in image recognition, but there are some drawbacks. Processing such a large amount of data requires high computing power, as does training neural systems. But all of these methods prove to be a powerful tool for recognizing defects not only in fruits, but in food products in general. Scientists continue to work on increasing the efficiency and accuracy of these methods, using them in conjunction with other cutting-edge technologies.

References

1. Balabanov P. V., Divin A. G., Egorov A. S., Zhirkova A. A., Yudaev V. A. Detection of defects on apples using hyperspectral reflection visualization combining both vegetation index analysis and neural network. Journal of Physics: Conference Series, 2020, vol. 1515, no. 3.
2. Naranjo-Torres J., Mora M., Hernández-García R., Barrientos R. J., Fredes C., Valenzuela A. A review of convolutional neural network applied to fruit image processing, 2020, MDPI AG.
3. Bhavya K. R., Pravinth Raja S. Fruit Quality Prediction using Deep Learning Strategies for Agriculture. International Journal of Intelligent Systems and Applications in Engineering, 2023, vol. 11, no. 2s.
4. Wieme J. *et al.*, Application of hyperspectral imaging systems and artificial intelligence for quality assessment of fruit, vegetables and mushrooms: A review. Biosyst Eng, 2022, vol. 222.
5. Saputro A. H., Juansyah S. D., Handayani W. Banana (Musa sp.) maturity prediction system based on chlorophyll content using visible-NIR imaging. International Conference on Signals and Systems, ICSigSys 2018 – Proceedings, Institute of Electrical and Electronics Engineers Inc., 2018.

Обзор методов машинного обучения для оценки качества плодов фруктов

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Аннотация. В тезисах доклада рассмотрены способы применения методов машинного обучения для определения качества яблок, бананов и других фруктов. Приведены результаты использования методов различными учеными. Сделан вывод о дальнейших возможностях использования машинного обучения для оценки качества плодов.

Ключевые слова: гиперспектральные камеры, машинное обучение, мониторинг сельхозкультур, сельское хозяйство, фрукты, яблоки.

УДК 631.2

The methodology of conducting research on the stationary active ventilation system of sugar beet clamps

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Abstract
This article presents a methodology for conducting research in stationary underground ventilation branches. The uniformity of air flow distribution across the width of the chamber is determined by measuring air velocity and flow rate at each air outlet. For the correct measurement of parameters, the design of the windproof casing is presented.
Keywords: storage, sugar beet, active ventilation system, beet clamp.

Currently, the technology of long-term ventilated storage of sugar beet is actively developing. This is due to the need to increase the duration of the season of sugar factories and the safety of sugar beet in the later stages of processing. One of the directions of long-term storage is the use of underground stationary ventilation branches. However, this area remains poorly understood due to the widespread use of floor-mounted non-stationary ventilation branches.

The advantage of underground ventilation branches is the low need for labor resources at the stage of formation and transshipment of sugar beet clamps in comparison with floor systems. During the operation of the active ventilation systems of the beet clamps, an important aspect is the uniform air supply across the entire width of the beet clamp. To ensure uniform air supply on the floor ventilation branches with a constant flow section, the configuration of the air outlets and their flow section is selected [1].

However, the design of the underground ventilation branches does not imply the possibility of making significant changes to the configuration of the holes after the completion of construction work, since the elements of the branch are made of prefabricated typical reinforced concrete structures. For this reason, it is important to conduct a study before starting construction to determine the configuration of air outlets for uniform air supply to the beet clamps.

Figure 1 shows a diagram of an underground stationary ventilation branch of sugar beet clamps.

The axial fan 2 pumps the ventilation branch through the umbrella 1. The air flow passes through a number of reinforced concrete products, which from an aerodynamic point of view represents a group of constrictions and extensions (3-5). Next, the air flow passing through the branch 5 is divided into two parts. One of these parts of the air flow is directed to a section of the technological zone, in which there is a hatch 7 for maintenance and a drain collector 6. The hatch is closed with a lid, which performs the function of jamming. A gate valve is provided to prevent the movement of air flow inside the drainage

collector. The other part of the air flow after the branch is directed towards the channel with air outlets 8. At the end of the ventilation channel there is also a hatch for technological maintenance [2].

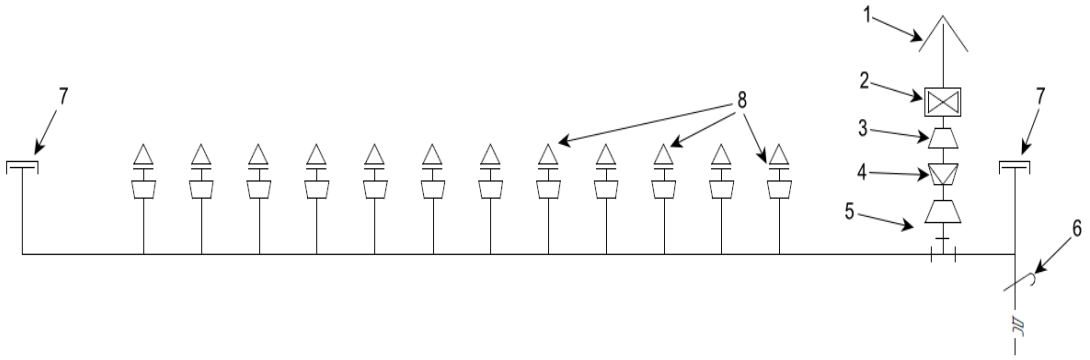

Figure 1 – Ventilation branch diagram:
1 – umbrella, 2 – axial fan, 3 – sudden expansion, 4 – sudden narrowing with a transition to a rectangular section, 5 – sudden expansion with a split flow, 6 – gate, 7 – plug, 8 – round branch with an out-of-the-way expansion

The study of ventilation branches takes place in an open area. There is a possibility of external environmental factors (the influence of wind gusts) on the accuracy of measurements.

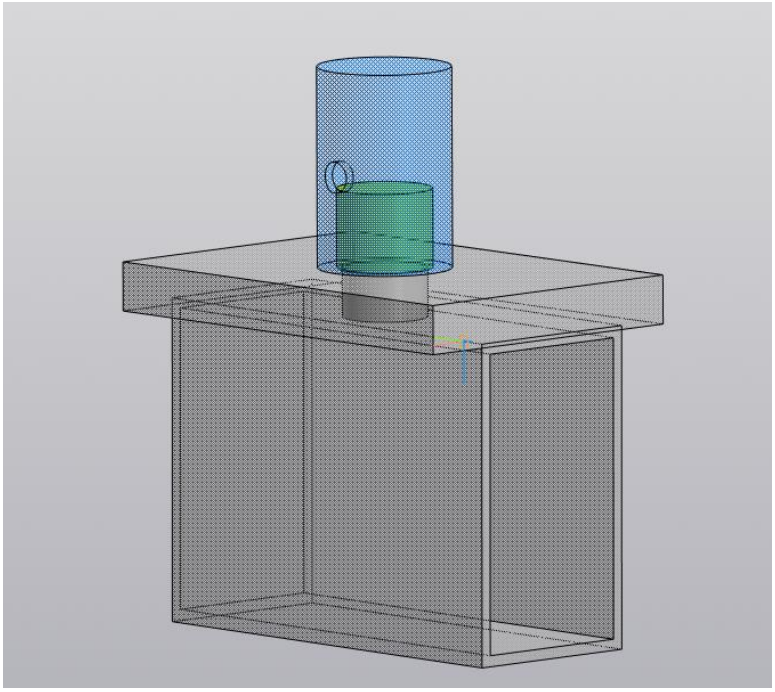

Figure 2 – Windproof cover

To reduce the influence of this factor, it is proposed to temporarily install a windproof casing over the air outlets. A sketch of the windproof casing is shown in Fig. 2. To hold the windproof casing in case of wind gusts, a base is provided for installing a weighting device. An opening is provided on the side of the casing to accommodate the anemometer [3].

In the study of the uniformity of the distribution of air flow, the measurement of velocity and volume is performed at each air outlet of three adjacent ventilation branches.

The sugar beet industry is developing long-term storage technology, including the use of stationary underground ventilation branches, which are poorly studied and have not been studied. In systems of active ventilation of beet clamps, one of the key requirements is uniform air supply across the entire width of the beet clamp. The presented technique allows us to conduct a study on the uniformity of the distribution of air flow in open areas. The research will allow us to determine the actual characteristics of stationary ventilation branches and further develop measures to improve them.

References

1. Kol`czov, S.M. Issledovanie voprosa poteri sveklomassy` pri xranenii saxarnoj svekly` v beet clampe / S.M. Kol`czov // Materialy` 73-j Mezhd. nauchno-prak. kon-ciya «Sovremennaya agrarnaya nauka: aktual`ny`e voprosy`, dostizheniya i innovacii». – Michurinsk, 2021. – S. 152-156.
2. Knyazev V. A. Priemka i xranenie saxarnoj svekly` po progressivnoj texnologii / M.: Leg. i pishh. prom-st`, 1984. – 200 s.
3. Zavrazhnov, A.I. Obosnovanie i razrabotka texnologii xraneniya saxarnoj svyokly` v beet clampax v usloviyax Central`no-Chernozyomnogo regiona / A.I. Zavrazhnov, S.M. Kol`czov // Saxar. – 2020. – № 1. – S. 38-44.

Методика проведения исследований стационарной системы активной вентиляции кагатов сахарной свёклы

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Аннотация. В данной статье представлена методика проведения исследования в стационарных подземных вентиляционных ветвях. Определение равномерности распределение воздушного потока по ширине кагата осуществляется путём измерения скорости и расхода воздуха на каждом воздуховыпускном отверстии. Для корректного измерения параметров представлено конструкция ветрозащитного кожуха.

Ключевые слова: хранение, сахарная свёкла, система активной вентиляции, кагат.

УДК 62-783

Entwicklung und Forschung von Methoden zur Qualitätsverbesserung der digitalen Röntgenbilder auf Basis von Operationen der mathematischen Morphologie von Rasterbildern

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Zusammenfassung
Es ist ein Verfahren zur Korrektur digitaler Röntgenbilder entwickelt, das durch die Verwendung von Laplace-Pyramiden und den ersten und zweiten Ableitungsoperator Folgendes ermöglicht: den Kontrast im Bild zu erhöhen, ohne das verarbeitete Bild zu verzerren. Die Ergebnisse der Arbeit können in medizinischen Einrichtungen zur Verbesserung digitaler Röntgenbilder verwendet werden.
Schlüsselwörter: Röntgenbild, Bediener der ersten und zweiten Ableitung, Niederfrequenz- und Hochfrequenzpegel, Laplace-Pyramide, Operation mathematischer Morphologie.

Die Radiographie ist derzeit eine der gebräuchlichsten Forschungsmethoden der inneren Struktur biologischer Objekte [1-4]. Ein wesentlicher Bestandteil der digitalen Radiographie ist die digitale Verarbeitung der Röntgenbilder. Es ermöglicht dem Arzt, sich bei der Diagnosestellung nicht nur auf seine Erfahrung, sondern auch auf ein qualitatives und quantitatives Informationsmaß, also die Informationsfähigkeit, zu verlassen, die eine Identifizierung minimaler Veränderungen in der Gewebestruktur der Lunge und Durchführung der Diagnostik ohne Kontrollaufnahmen auf Film ermöglicht. Der Hauptnachteil des Originals von digitalen Röntgenbildern hat keinen ausreichenden Kontrast, daher ist es schwierig, die abgebildeten Details zu unterscheiden. Daher ist es ratsam, eine Korrekturmethode zu entwickeln, die die Wahrnehmung des menschlichen Bildes durch digitale Röntgenbilder verbessert.

Das Ziel der Arbeit war es, eine Methode zur Qualitätsverbesserung zu entwickeln und digitale Röntgenbilder basierend auf der mathematischen Operationen Morphologie von Graustufen-Bitmaps zu erforschen. Im Rahmen der Studie sind folgende Aufgaben gelöst:

1. Analyse bekannter Techniken zur Verbesserung der Qualität digitaler Röntgenbilder mithilfe von Hardware, die gezeigt haben, dass die Hauptmethode zur Reduzierung von Rauschen und Artefakten in einem Bild des Bildschirmgitters ist.

2. Es ist eine Studie über die Nachteile von Software-Methoden zur Verbesserung der Qualität digitaler Röntgenbilder durchgeführt, die ergab, dass die effektivste Methode zur Verbesserung der Qualität digitaler Röntgenbilder ein versteckter Kantendetektor ist.

3. Es ist ein Verfahren zur Verbesserung der Qualität digitaler Röntgenbilder mit dem ersten und zweiten Ausgabeoperator entwickelt, einschließlich des Auslesens des Originalbildes, der Verstärkung der hohen Frequenz und der Ausgabe des verarbeiteten

Bildes. Bilder, die sich durch reduzierte Artefakte und verbesserte Kontraste auszeichnen, sind verwendet, um die Originalbilder unter Verwendung der ersten und zweiten Ableitungsoperatoren in niederfrequente und hochfrequente Pegel zu zerlegen. Die zweite Ableitung ist adaptives Balancieren des Histogramms mit Kontrastbegrenzung für alle niederfrequenten Pegel und anschließende Rekonstruktion des Bildes.

4. Vergrößerungsalgorithmus digitaler Röntgenbilder mit Laplace-Pyramiden, der sich insbesondere durch eine intuitive Benutzeroberfläche auszeichnet, schnelle Eingabe und Anzeige von Bildern auf dem Bildschirm;

5. Der Algorithmus zur Korrektur digitaler Röntgenbilder ist praktisch als Softwareprodukt in der MATLABR2014b Image Processing Toolbox implementiert, um digitale Röntgenbilder interaktiv zu verbessern;

6. Die Wirksamkeit der vorgeschlagenen Methode zur digitalen Korrektur von Röntgenbildern unter Verwendung der ersten und zweiten Ableitungen ist nachgewiesen, insbesondere ist ein Kontrastanstieg von 29% gegenüber der Filterung mit Hochfrequenzverstärkung festgestellt.

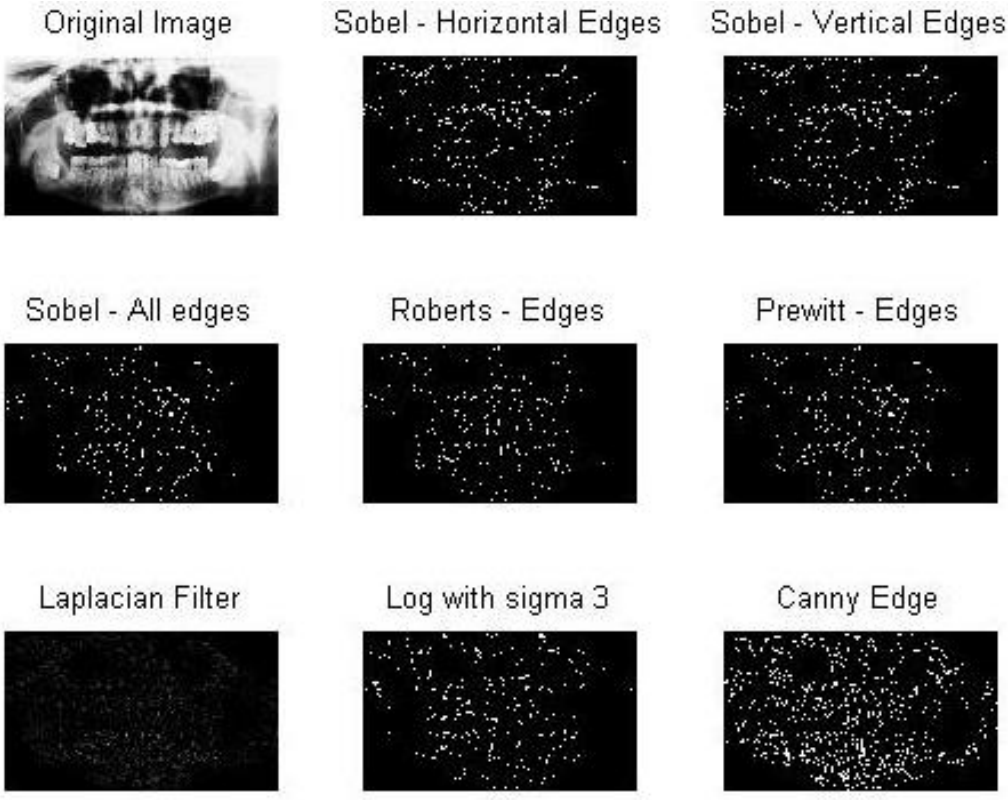

Abb. 1. Array von Bildern nach der Verarbeitung

Diese Verarbeitung umfasst die folgenden Operatoren:

1. Maskenoperator von Sobel mit allen Arten von Grenzen (vertikal und horizontal);
2. Randmaskenoperator von Roberts;
3. Randmaskenoperator von Priutt;
4. Filter von Laplace;
5. Logarithmischer Maskenoperator von Laplace und Gauss;
6. Grenzwertdetektor-Operator von Canny.

Die Ergebnisse der Arbeit können in medizinischen Einrichtungen verwendet werden, um digitale Röntgenbilder zu verbessern.

Literaturverzeichnis

1. Ilnonein G.P. Informazionnaja modjelnone rjentgjenowskogo apparata C-duga / G. P. Ilnonein, T. A. Frolowa // Wirtualnonenoje modjelirowanije, prototipirowanije i promyschljennyj disajn: Matjerialy IX Mjeshdunarodnoj nautschno-praktitschjeskoj konfjerjenzii. Tambow, 24–25 oktjabrja 2023 goda. Tom Wypusk 9. – Tambowskij gosudarstwjennyj tjechnitschjeskij uniwjersitet. – Pp. 354-355. (in Russ.)
2. Frolow S.W. Tjendjenzii, kotoryje ismjenjat pjerspjektiwy otrasli mjedizinskogo oborudowanija / S. W. Frolow, T. A. Frolowa // Biotjechnitschjeskije, mjedizinskije i ekologitschjeskije sistjemy, ismjeritjelnonenyje ustrojstwa i robototjechnitschjeskije kompljeksy - Biomjedsistjemy-2022: Sbornik trudow XXXV Wsjerossijskoj nautschno-tjechnitschjeskoj konfjerjenzii studjentow, molodych utschjenych i spjezialistow, Rjasannone, 07–09 djekabrja 2022 goda / Pod obschtschjej rjedakzijej W.I. Shuljewa. – Rjasannone: Indiwidualnonenyj prjedprinimatjelnone Konjachin Aljeksandr Wiktorowitsch, 2022. – Pp. 292-295. (in Russ.)
3. Bazhenova N.G. Neverbal'noe obshchenie v obuchenii francuzskomu yazyku [Non-verbal communication in teaching French]. Inostrannye yazyki v shkole, 1998. Issue 3. Pp. 8-11. (in Russ.)
4. Frolowa T.A. Effjektiwnyj projektnyj mjenjedshmjent dlja mjedizinskogo oborudowanija / T.A. Frolowa // Wirtualnonenoje modjelirowanije, prototipirowanije i promyschljennyj disajn : Matjerialy VII Mjeshdunarodnoj nautschno-praktitschjeskoj konfjerjenzii, Tambow, 12–14 oktjabrja 2021 goda. Tom Wypusk 7. – Tambow: Isdatjelnoneskij zjentr FGBOU WO Tambowskij gosudarstwjennyj tjechnitschjeskij uniwjersitet, 2021. – Pp. 300-302. (in Russ.)

Разработка и исследование метода повышения качества цифровых рентгеновских изображений на основе операций математической морфологии растровых изображений

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Аннотация. Разработан метод коррекции цифровых рентгеновских изображений, который позволяет, благодаря использованию пирамид Лапласа и операторам первой и второй производной, усилить контраст на изображении и при этом не привнося искажений в обработанное изображение. Результаты работы могут быть использованы в лечебных учреждениях для улучшения цифровых рентгеновских изображений.
Ключевые слова: рентгеновское изображение, операторы первой и второй производной, низкочастотные и высокочастотные уровни, пирамида Лапласа, операция математической морфологии.

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Criteria for optimizing virtual biofeedback simulators

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Abstract
Biofeedback-based simulator operates through a control system that varies its parameters depending on the user's condition. When designing virtual simulators with biofeedback, in order to obtain optimal modes of their functioning and characteristics, it is necessary to set and solve the optimization problem. In this paper, various optimization criteria for this class of systems are considered.
Keywords: biofeedback, optimization criteria. virtual reality, virtual simulators.

Introduction

The concept of a biofeedback-based virtual simulator includes the following components [1-3]: recording and digital processing of physiological signals obtained from medical devices; determining the user's condition based on the analysis of medical data; adapting the virtual reality scene to the user's current state while considering individual characteristics and behavioral parameters; an adaptation module for the virtual simulator, containing the necessary mathematical foundation and algorithmic support to generate control commands for the virtual scene based on the current state or its dynamics; a set of adjustable parameters in the virtual scene, defined by control commands from the adaptation module, which form the final visual representation of the virtual simulator; tracking changes in the values of physiological signals obtained after scene adaptation to assess the effectiveness of the applied adjustments.

Consequently, the biofeedback-based virtual simulator functions as an adaptive system that adjusts to the user's current state. The simulator operates through a control system that varies its parameters depending on the user's condition. In this study, we will identify the key optimization criteria used to ensure optimal functioning of this class of systems.

Mathematical model

Let's consider the main components of the mathematical model of a VR simulator with biofeedback. First, there is a set of medical data E that represents the raw data obtained from various medical devices and sensors at each moment in time t. Let $E_q(t)$ denote the data from source q. Second, there are data processing functions f_i that transform the raw data $E_q(t)$ into calculated user characteristics $U_i(t)$. The algorithms allow to form an overall state U_i that characterizes the user at that particular moment in time.

Next, we define the control objects $O(t)$, which are elements of the simulator's virtual environment. Their parameters can be adjusted to influence the user and determine the state of the virtual environment $X(t)$ at time t. Controlling these objects and parameters

enables the system to adapt to the user state.

The control method MC is an algorithm that determines the interventions $A(t)$ required to achieve the optimal state of the simulator. This method is based on an environment evaluation objective function Q, which is used to make decisions regarding the modification of the simulator's parameters to meet specified goals.

The operation of the biofeedback-based simulator also includes a series of procedures, such as the collection and acquisition of raw medical data $E_q(t)$ from various sources q. Data processing through functions f_i transforms this data into calculated characteristics $U_i(t)$, which are used to assess the user's condition. The calibration of the system is performed by determining the reference values of the user characteristics in a resting state U_i^0 and their acceptable deviations U_i^A, which establishes a baseline for subsequent comparisons.

The goal of using the biofeedback-based simulator is to achieve target values of characteristics U_i^* to reach the desired state of the user. This is accomplished by calculating the objective function Q for the current state and selecting control interventions $A(t)$ to modify the parameters of the virtual environment $X(t)$ with the aim of minimizing or maximizing the objective function Q.

Based on this mathematical model, it is necessary to address the optimization problem of the biofeedback-based simulator, which requires defining and selecting a set of criteria. Let's examine some potential criteria.

Criteria

The first criterion involves minimizing the deviation of the predicted values of human characteristics from the actual values by applying a predictive function for timely adjustments of control actions and enhancing the simulator's effectiveness. Mathematically, this criterion is formulated as the minimization of the sum of the squares of the differences between the actual $U_i(t)$ and the predicted $\hat{U}_i(t)$ values of the characteristics:

$$K_1 = \sum_{i=1}^{N} \left(U_i(t) - \hat{U}_i(t)\right)^2 \rightarrow \min,$$

where $\hat{U}_i(t) = f_i\big(X(t)\big)$ is the predicted value of the i-th characteristic, obtained through the predictive function f_i. The objective of the optimization is then to find the specified functions f_i that minimize K_1.

The second criterion aims to maximize the simulator's performance by optimizing the parameters and the number of virtual objects through analyzing the influence of these parameters on the system's performance and subsequently optimizing the configuration of the virtual environment. We can represent this criterion as a function that calculates the frame rate of the gaming scene $P\big(X(t)\big)$:

$$K_2 = P\big(X(t)\big) \rightarrow \max.$$

The third criterion involves selecting the optimal data source for biofeedback that

provides the highest accuracy in control. We can formulate this criterion as a weighted sum of the errors from various data sources:

$$K_3 = \sum_{q=1}^{M} (\varepsilon_q w_q) \rightarrow \min,$$

where ε_q is the error or uncertainty of the data from source q, w_q is the weight coefficient reflecting the importance of the source, and M is the total number of available data sources. The optimal selection of data sources contributes to improving the accuracy and reliability of the control system.

The fourth criterion involves minimizing the cost of the simulator by simplifying the biofeedback system while ensuring the necessary control accuracy. Reducing the development and operational costs of the simulator is a crucial factor for its implementation. We can denote this criterion as follows:

$$K_4 = C_{total} = C_e + C_d + C_m \rightarrow \min,$$

where C_e is the cost of hardware components (sensors, controllers, computational modules, and other devices included in the biofeedback system); C_d is the cost of software development, control algorithms, system integration, and testing; and C_m is the expense for maintenance, system updates, user support, and potential repairs.

In addition, it is necessary to provide a condition for this criterion that $K_3 \leq K_3^{max}$, as this allows for a balance between economic efficiency and the accuracy of the system's operation.

The fifth criterion focuses on optimizing training time, which includes two aspects. On the one hand, it is necessary to achieve optimal values of user characteristics by adjusting the simulator's parameters during operation. On the other hand, abrupt changes in parameters can drive the user's physiological characteristics to their maximum values $T \geq T_{\min}$, which may prematurely terminate the training session [4]. Therefore, it is important to establish a minimum training time $T \geq T_{\min}$, during which the user can safely interact with the virtual environment without exceeding the permissible physiological parameters $U_i(t) < U_i^{\max}$. Thus, we have:

$$K_5 = T \rightarrow \min,$$

with the constraints: $T \geq T_{\min}$; $U_i(t) < U_i^{\max}$; $U_i(T) = U_i^*$; $\forall\, t \in [0, T], \forall\, i = 1, \ldots, N$.

The presented optimization criteria allow a comprehensive approach enhancing the effectiveness of the biofeedback-based virtual simulator, taking into account both technical and economic aspects. The application of these criteria during the development and operation of the simulator will ensure high accuracy and efficiency by minimizing deviations in user characteristics and selecting optimal data sources. High performance will be achieved through the optimization of virtual environment parameters and system configuration. Economic feasibility is ensured by reducing costs without compromising functionality and quality, while rapid system adaptation is achieved by minimizing training time.

Conclusion

This paper examines various approaches to optimizing virtual simulators with biofeedback. Taking into account the analysis, several key optimization criteria were identified, including the accuracy of predicting user characteristics, simulator performance, control accuracy, implementation cost, and training time. Since some of the criteria are opposed to each other, it will be necessary to find a Pareto-optimal set of solutions to this multi-criteria problem during the optimization process. The selection of the appropriate solution will ensure the creation of a virtual simulator with the best characteristics.

Acknowledgements

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References

1. Obukhov A., Krasnyanskiy M., Volkov A. [et al.] Method for Assessing the Influence of Phobic Stimuli in Virtual Simulators. Journal of Imaging. 2023. Vol. 9, No. 10. P. 195.

2. Strekalev V.O., Gribova V.V. Sistema monitoringa immersivnykh virtual'nykh trenazherov s biologicheskoy obratnoy svyaz'yu [Monitoring System for Immersive Virtual Simulators with Biological Feedback]. Informatika i sistemy upravleniya, 2023, No. 3(77), pp. 83-92. (Rus)

3. Obukhov A. D., Volkov A., Pchelintsev A. N. [et al.] Examination of the Accuracy of Movement Tracking Systems for Monitoring Exercise for Musculoskeletal Rehabilitation. Sensors. 2023. Vol. 23, No. 19. P. 8058.

4. Dubrovskaya Yu.A., Pikhkonen L.V., Rudenko G.V. Primenenie trenazherov i simulyatorov dlya formirovaniya professional'nykh navykov pri prakticheskoy podgotovke gornospasateley [Use of Simulators and Trainers for Developing Professional Skills in Practical Training of Mine Rescuers]. Izvestiya Rossiyskogo gosudarstvennogo pedagogicheskogo universiteta im. A.I. Gertsena, 2022, No. 203, pp. 168-176. (Rus)

Критерии оптимизации виртуальных тренажеров с биологической обратной связью

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Аннотация. Симулятор на основе биологической обратной связи функционирует посредством системы управления, изменяющей свои параметры в зависимости от состояния пользователя. При проектировании виртуальных тренажеров с биологической обратной связью для получения оптимальных режимов их функционирования и характеристик необходимо поставить и решить задачу оптимизации. В данной работе рассматриваются различные критерии оптимизации данного класса систем.

Ключевые слова: биологическая обратная связь, виртуальная реальность, виртуальные тренажёры, критерии оптимизации.

УДК 004.946

Development of an application to search for requirements when opening a medical facility

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Abstract
There are many requirements for medical facilities. In order to abstain a license for medical activity and open a clinic, full compliance with all regulatory documents is necessary. This is complicated by the large volume of regulatory documentation and the lack of competent specialists. To solve this problem, an application was proposed that would simplify the search for the necessary information.
Keywords: application programming, design of medical devices, license for medical activity, regulatory documentation.

Medical practice encompasses a wide range of specializations. In this sense, there are wide variations in the requirements for room equipment used to execute various medical procedures. Critical information for medical practice organizations is dispersed across multiple sources and lacks a systematic arrangement. Medical intuition organizers frequently lack a comprehensive understanding of the criteria. It prevents them from using all the required planning criteria, leading to mistakes during the design and construction phases. This has substantial time and financial implications associated with it.

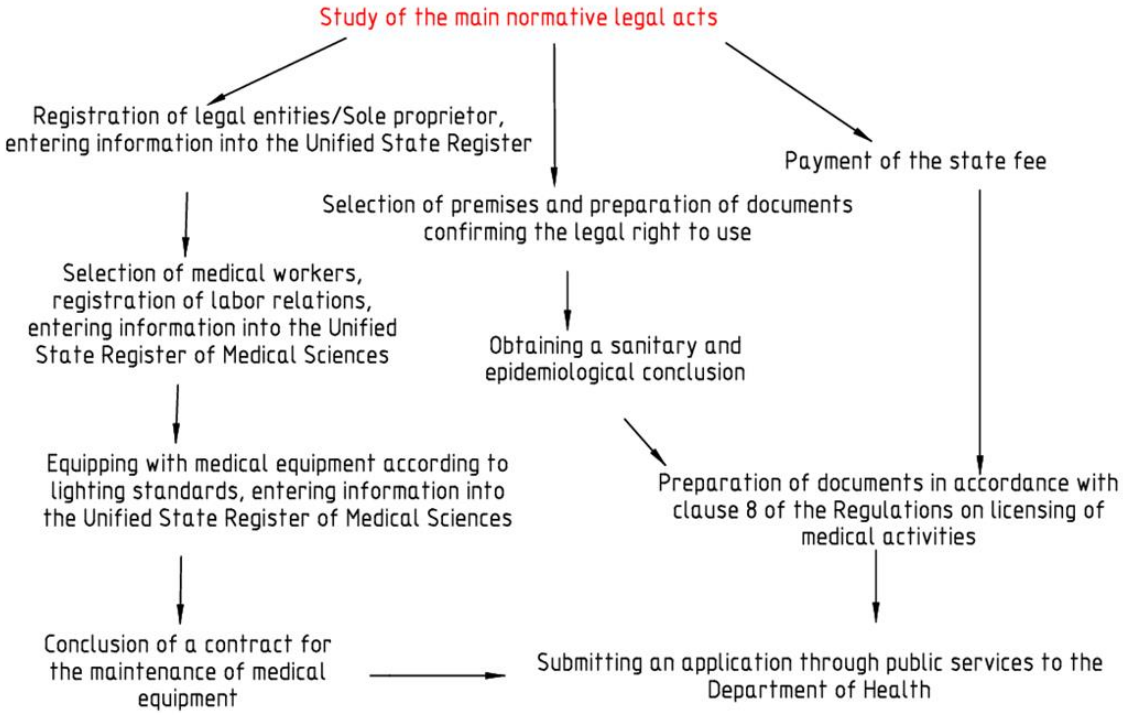

Figure 1 – Diagram of obtaining a license for medical practice

A plan for starting a medical facility was created based on the highlighted issue, and the license application procedure was examined (Fig.1)

It was decided to create a customized application that will include all of the regulatory paperwork required for the opening of a medical center in order to plan, build, and launch the clinic more efficiently and to secure a license. This application's primary goal is to organize all facility requirements based on the kinds of medical services offered.

Future medical facility owners and administrators will find this application to be a vital resource as it gives them access to the most recent policies and procedures required for the clinic's smooth operation. Users will be able to rapidly become familiar with the requirements and start implementing them without wasting time or effort because of the information's organized presentation and convenient manner.

The development of this application gives medical professionals new opportunities and frees them up to concentrate on providing high-quality medical care rather than searching and analyzing legislative actions. This creative approach ensures adherence to all relevant regulations and standards while streamlining the process of starting and running a medical facility.

The software product opens with an interface where the user can select from the following options: the services the clinic provides; the facilities that are required; specialists whose qualifications meet the requirements; the target audience for diagnostic methods (from the budget segment to premium service); and the format of the medical institution (hospital, laboratory centers, outpatient treatment, etc.).

The program automatically generates a number of requirements required for the effective supply of services of the chosen category when all areas are filled out carefully and accurately. As a result, the customer can review all of the legal and regulatory documents, which greatly reduces the amount of time and money needed. This application feature makes it easier and more effective to complete all the formalities, which helps to ensure that activities are completed more quickly and accurately.

Thus, an application was developed for businessmen in the field of medicine, designers, builders and everyone involved in the opening of a medical institution. It will simplify and facilitate the process of obtaining information.

Разработка приложения для поиска требований при открытии медицинского учреждения

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Аннотация. К медицинским учреждениям предъявляется множество требований. Для того, чтобы получить лицензию на медицинскую деятельность и открыть клинику, необходимо полное соблюдение всех нормативных документов. Это осложняется большим объемом нормативной документации и специфичностью разных сфер медицины, а также отсутствием грамотных специалистов в этой сфере. Для решения данной проблемы было разработано приложение, которое упростило поиск необходимой информации.

Ключевые слова: лицензия на медицинскую деятельность, нормативная документация, программирование приложения, проектирование медицинских учреждений.

УДК 66.087.97

Prospects and efficiency of electrodialysis application in purification of chemical production solutions

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Abstract
The use of electrodialysis in the purification of solutions in chemical industries has great potential and demonstrates high efficiency. This method makes it possible to effectively remove ions from aqueous solutions using electrical potential, without the use of chemical reagents. Electrodialysis technology is one of the key technologies in the field of purification and regeneration of industrial solutions using membrane technologies. The use of electrodialysis in various industries, including the chemical industry and wastewater treatment, is due to its economic and environmental benefits. The method is characterized by low energy costs and the absence of chemical waste. Historically, electrodialysis has developed as a solution to problems related to sedimentation and decreased membrane selectivity. However, advances in membrane engineering and component replacement have improved the efficiency and reliability of the method. Modern innovations are aimed at developing membranes with high resistance to contamination, which significantly extends their service life and reduces the frequency of replacement. More energy-efficient solutions are also being introduced, which reduce operating costs.
Keywords: acidity of solutions, chemical production, electrodialysis method, mineral composition, purification of solutions.

Electrodialysis is a process based on electrochemistry, and it is used to separate electrolyte solutions. It is usually used to obtain drinking water from reservoirs and to treat industrial wastewater. This method has several advantages that make it attractive for use in various fields. It allows to increase the efficiency of development in this area, simplify the process of introduction into production and reduce costs.

Electrodialysis is one of the key technologies in the field of purification and regeneration of solutions. Originally developed for use in the chemical industry, this method is gradually becoming more popular due to its unique advantages. One of the key advantages of electrodialysis is its energy efficiency. Unlike other types of membrane technologies, this method uses electric current rather than pressure to transfer ions through the membrane. This reduces energy costs. In addition, electrodialysis can be used at low electric current values, which also reduces the cost of the process. This method also has high selectivity, which allows the product to be extracted with a high degree of recovery. It is capable of destroying certain components in the source water (drinking water or wastewater) and operating continuously. All these advantages make electrodialysis attractive for use in various fields [1]. However, in some industries, such as winemaking and juice production, the development of this method is slowing down due to the lack of highly efficient membranes.

In electrodialysis, an electric potential is used as the driving force, and an ion exchange membrane is located between the anode and the cathode. When an electric current is applied, negative and positive ions move to the corresponding electrodes, depending on their polarity. Cations pass through a chamber containing a membrane with a negative charge, and anions pass through the chamber with a positive charge. The chambers are alternatively diluted and concentrated. The efficiency of the process depends on the current density, pH, flow rate, cell structure, ion concentration in the source water, and membrane properties [2]. Contamination of the membrane is an important factor that leads to increased energy consumption and decreased flow through the membrane. The selectivity of the membrane is reduced. Pollution occurs due to the deposition of biomass, colloids and organic substances. Accumulation can occur on both the inner and outer surfaces of the membrane. Since most colloids present in water have a negative charge, most studies are devoted to contamination of the anion exchange membrane [2].

Ion exchange membranes are commonly used materials in various industries, they are used both in the production of drinking water by electrodialysis and for the treatment of industrial wastewater. Most ion exchange membranes are divided into two main categories: homogeneous and heterogeneous. There are significant differences between these two types of membranes, especially in the context of their use in electrodialysis processes [1-3].

Homogeneous membranes consist mainly of ion-exchange material, and fixed ionogenic groups are more or less evenly distributed in the membrane. However, the surfaces of these membranes are not perfectly smooth and homogeneous – there are heterogeneous domains, the size of which is close to 1 micron [1]. The internal structure of the membrane determines its transport properties: electrical conductivity, diffusion, hydraulic permeability, permittivity, and competition between ions of the same charge sign. Homogeneous membranes with optimal electrochemical properties do not have sufficient mechanical strength. Ion exchange groups in homogeneous membranes are attached directly to the polymer base, which provides low resistance and high selectivity. The uniform distribution of ion exchange groups makes them chemically resistant and electrochemically active [1-2].

Heterogeneous membranes are produced by mixing fine particles of a homogeneous ion exchange resin and an inert binder. They have good mechanical strength, but average electrochemical characteristics and spatial stability due to the absence of micro voids formed during polymerization. The strength of heterogeneous membranes is higher than that of homogeneous ones due to the higher proportion of inert material, which reduces the conductive zone. They are economically advantageous, and their electrochemical properties can be improved due to the optimal distribution of ion exchange particles [1].

The reuse of water and chemicals is relevant for industries with intensive water consumption. Due to the complexity of the composition of industrial wastewater, there is no single methodology for calculating the electrodialysis process. In this regard, it is necessary to determine key design characteristics such as membrane resistance, ion separation rate and current efficiency. One of the key challenges is the development of ion-exchange membranes with high permeability, low resistance, improved chemical and

thermal stability at lower cost [1]. Modern electrodialysis and its components have technical and commercial limitations, which requires fundamental and applied research to improve processes in the chemical industry, biotechnology, and energy conversion [3].

Electrodialysis is a promising method of cleaning solutions in chemical industries due to its unique advantages. The main obstacle to the development of this method is the lack of highly efficient membranes, especially in industries such as the wine industry and juice production. However, electromembrane processes can significantly simplify and automate cleaning, eliminating many of the problems associated with traditional methods. In addition, the use of electrodialysis in solvent regeneration can significantly reduce the costs associated with the need for frequent replacement and disposal of fresh solutions. Thus, electrodialysis has significant potential to improve the efficiency and cost-effectiveness of processes in the chemical industry.

References

1. Dzhubari, M. K., Alekseeva N. V. Effektivnost elektrodializa pri ochistke promyshlennykh stochnykh vod [Efficiency of electrodialysis in industrial wastewater treatment]. Bulletin of the Technological University, 2020, vol. 23, No. 7, pp. 33-39. (Rus)
2. Akhter, M., Habib, G., & Qama, S. U. Application of electrodialysis in waste treatment and impact fouling on process performance. J Membr Sci Technol, vol 8, No 2, pp. 1-8.
3. Chichirov A.A., Filimonova A.A., Chichirova N.D., Mayorov E.S. Eksperimentalnyye issledovaniya elektricheskikh i massoobmennykh protsessov pri obratnom elektrodialize [Experimental studies of electrical and mass transfer processes in reverse electrodialysis]. Power engineering: research, equipment, technology. 2023, Vol 25, Issue 4, pp. 53-70. (Rus)

Перспективность и эффективность применения электродиализного метода для очистки растворов на химических производствах

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Аннотация. Применение электродиализа в очистке растворов на химических производствах имеет большой потенциал и демонстрирует высокую эффективность. Этот метод позволяет эффективно удалять ионы из водных растворов, используя электрический потенциал, без применения химических реагентов. Технология электродиализа является одной из ключевых в области очистки и регенерации промышленных растворов, используя мембранные технологии. Применение электродиализа в различных отраслях, включая химическую промышленность и очистку сточных вод, обусловлено его экономической и экологической выгодой. Метод характеризуется низкими затратами на электроэнергию и отсутствием химических отходов. Исторически электродиализ развивался как решение проблем, связанных с образованием осадка и снижением селективности мембран. Однако достижения в области мембранной инженерии и замены компонентов способствовали повышению эффективности и надёжности метода. Современные инновации направлены на разработку мембран с высокой устойчивостью к загрязнениям, что значительно продлевает срок их службы и уменьшает частоту замены. Также внедряются более энергоэффективные решения, которые снижают эксплуатационные расходы.

Ключевые слова: электродиализный метод, очистка растворов, химические производства, минеральный состав, кислотность растворов.

УДК 547.99

Characteristics of highly porous coal obtained by alkaline activation of birch sawdust carbonizate

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Abstract
Biowaste is often considered as a potential raw material for the production of adsorbenes with a high specific surface area and porosity. In this work, birch sawdust is considered as a potential precursor for the synthesis of highly porous carbon materials as a waste from wood processing. Alkaline activation of waste is a key stage in obtaining the target product. The structure and thermal stability of the obtained materials are analyzed, as well as the effect of the content of potassium hydroxide in a mixture with carbonate on the porosity characteristics of alkaline activation products.
Keywords: alkaline activation, carbon-containing raw materials, highly porous carbon materials.

Introduction

A highly porous carbon material is a three-dimensional structure of disordered graphite and an amorphous phase in which ordered and disordered polyaromatic fragments alternate. Unlike classical disordered graphite, highly porous carbon material has a free porous space consisting of pores of various diameters and shapes [1].

Highly porous carbon materials demonstrate a colossal specific surface area (up to 3000 m^2/g according to the BET method), have an adjustable structure and a high volume of micro- and mesopores, which makes their use as electrode materials of supercapacitors, as well as adsorbents of liquids and gases, very relevant. In this regard, research aimed at improving the production methods of highly porous carbon materials from available carbon-containing raw materials such as wood biomass is relevant [2, 3].

Objects and methods of research

Sawdust from birch wood was used as a raw material. They were carbonized in an argon atmosphere at 1000 °C. The carbonisate was activated with alkali at various "KOH: carbonisate" mass ratios (from 1:1 to 1:1) and a temperature of 800 ° C in a steel container in an argon atmosphere.

At the end of the process and cooling of the container, the material was washed on a filter with a solution of 0.1 M hydrochloric acid to a neutral pH, and then repeatedly distilled water. The resulting mass was dried in a Scientz-10N lyophilizer (China).

The dried samples underwent complex diagnostics using various methods of physico-chemical analysis. In particular, their Raman and infrared spectra were recorded, the specific surface area was determined by the BET method and the characteristics of the porous structure by the DFT method.

Results of the study

The typical infrared spectrum of the activated material recorded on the JascoFT/IR 6700 IR Fourier spectrometer in the wave range from 500 to 4000 cm^{-1} is shown in Fig. 1. The peaks at 3436, 1629.1440 and 621 cm^{-1} are the most intense on it. They correspond to fluctuations in the bonds O-H, C= O, C-O, C-C in aromatic rings, which corresponds to the composition of porous coals. The presence of oxygen-containing groups indicates partial oxidation of the material during alkaline activation.

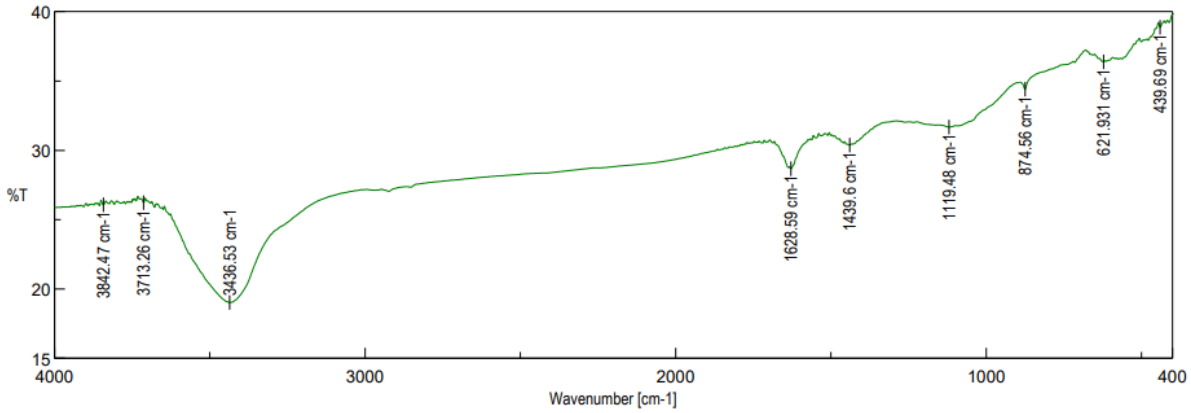

Figure 1 – Typical IR spectrum of highly porous carbon obtained by alkaline activation of birch sawdust carbonizate

The Raman spectrum of this material (Fig. 2), recorded on the DXR Raman Microscope device at λ=532 nm, contains peaks D (at 1570 cm^{-1}) and G (at 1350 cm^{-1}) characteristic of carbon materials, as well as their overtones 2D and D+G.

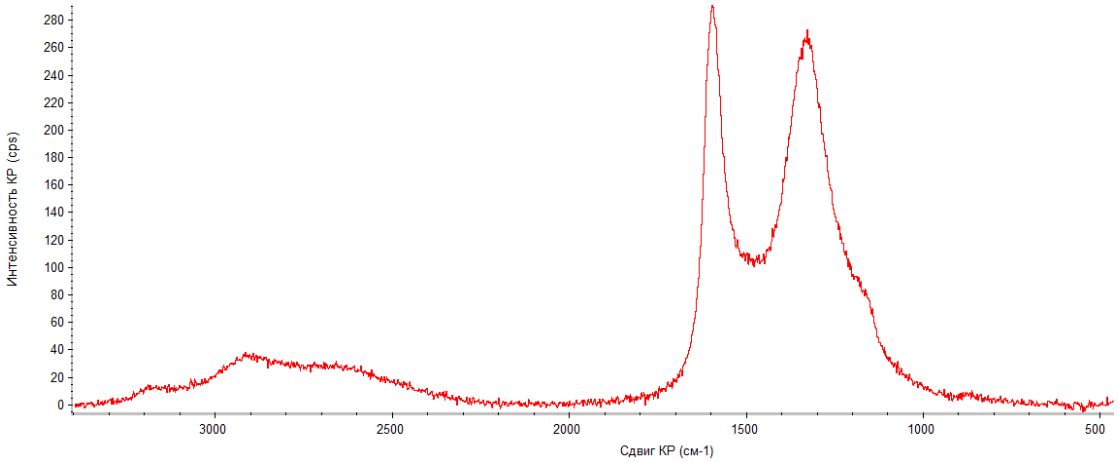

Figure 2 – A typical Raman spectrum of highly porous carbon obtained by alkaline activation of birch sawdust carbonizate

In the composition of the wide peak G, a small peak D* (at 1150 cm^{-1}) is distinguished, which usually appears in the presence of oxygen-containing groups in the structure of the material. The presence of an influx between D and G, as well as the characteristics of small peaks, collectively indicate the amorphous and porous structure of

the analyzed sample.

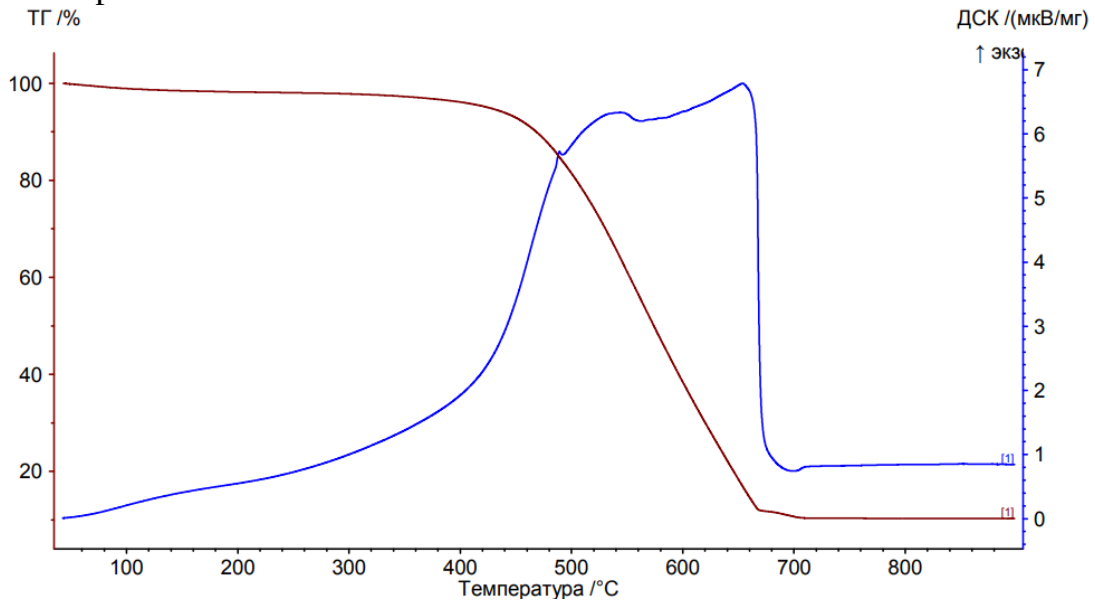

Figure 3 – Typical TG/DSC curves of highly porous carbon obtained by alkaline activation of birch sawdust carbonizate

Figure 3 shows the results of thermogravimetric analysis of a typical sample. We see that the material contains a small amount of sorbed moisture, which is why its mass decreases in the initial section of the TG curve. The active thermal decomposition of the sample begins at a temperature above 400 °C. The presence of several wide peaks on the DSC curve indicates a complex composition of the material.

Table 1. Characteristics of the obtained highly porous carbon materials

The mass ratio of «carbonizate:KOH»	Specific surface area, m^2/g	Total pore volume, cm^3/g	Volume of micropores, cm^3/g	Average pore diameter, nm
1:1	900	0,44	0,31	2,0
1:2	913	0,46	0,34	2,1
1:3	1250	0,60	0,45	2,2
1:4	1400	0,76	0,39	2,2

According to the data presented in Table 1, an increase in the alkali content in a mixture with carbonate contributes to an increase in the specific surface area of the products and the total pore volume. At the same time, the maximum volume of micropores depends extremely on the alkali content in the mixture. Thus, changing the amount of alkali during alkaline activation allows not only to control the value of the specific surface area, but also to control the porosity characteristics of the product.

Conclusion

By carbonization of birch sawdust and subsequent alkaline activation of carbonizate, samples of highly porous carbon materials were obtained. By methods of physico-chemical analysis, it was found that the samples have an amorphous structure and a complex composition.

An increase in the alkali concentration at the activation stage contributes to an increase in the specific surface area of the products and the total pore volume. The possibility of regulating the porous structure of carbon materials by changing the conditions of alkaline activation is proved.

References

1. Mota J.B. Adsorbed natural gas technology in Recent advances in adsorption processes for environmental protection and security. Ed. by J.P. Mota, S.B. Lyubchik. Springer:2006. 192 c;
2. Marsh H., Rodrigues-Reinoso F. Activated Carbon. Amsterdam: Elsevier, 2006. 554 c.;
3. Byrne C. E., Nagle D.C. Carbonization of wood for advanced material application // Carbon, 1997. Vol. 35. P. 267-273.

Характеристики высокопористого угля, полученного щелочной активацией карбонизата березовых опилок

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Аннотация. Биоотходы часто рассматриваются как потенциальное сырье для получения адсорбениов с высокой удельной поверхностью и пористостью. В данной работе в качестве потенциального прекурсора для синтеза высокопористых углеродных материалов рассматриваются березовые опилки как отход от обработки древесины. Щелочная активация отходов является ключевой стадией получения целевого продукта. Проанализирована структура и термическая стабильность полученных материалов, а также и влияние содержания гидроксида калия в смеси с карбонизатом на характеристики пористости продуктов щелочной активации.

Ключевые слова: щелочная активация, углеродсодержащее сырье, высокопористый углеродный материал.

УДК 678

Microwave effect on polymer nanocomposite properties

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Abstract
The article discusses the effect of electrophysical modification on the physico-mechanical properties of fluoroplast 4 modified with carbon nanotubes under the influence of microwave radiation. The subject of the analysis is the change in the heating capacity of microwave waves of nonpolar polymers depending on the filling with carbon nanomaterials. The structural and electrophysical modification of the polymer matrix changes the physico-mechanical characteristics of the samples. The conducted studies provide a significant insight into the interaction of polymer matrices with fillers.
Keywords: carbon nanotubes (CNT), fluoroplast 4 (F-4), microwave processing, polymer composite.

Introduction

Electrophysical modification (for example, ultrasonic or microwave radiation) makes it possible to modify the structure of polymers. In this case, structural changes entail a change in the macroscopic properties of the polymer matrix [1]. Such changes clearly demonstrate the strength characteristics: elongation and tensile strength, creep of the material, etc. The mechanical characteristics of the polymer are directly related to the structural parameters (crystallinity, molecular weight, molecular relaxation spectrum, etc.) that change when exposed to radiation.

Methods and materials

The fluoroplast of the F-4 brand was used as the object of the study. The polymer matrix was modified with carbon nanotubes (CNTs) "Taunit". Nanotubes 40-100 nm long in powder form were added to a polymer matrix and mixed with a high–speed mechanical mixer "Activator 2SL". Subsequently, the resulting powder mixtures were pressed and sintered. [2]

The microwave samples were exposed in the chamber at a radiation frequency of 2.45 GHz. The radiation power was 700 watts. [3, 4]

Results and Discussion

To assess the effect of microwave treatment on the electrical conductivity of the developed nanocomposites, the sample temperatures were measured during microwave heating (0-100 seconds) (table 1). The information obtained makes it possible to distinguish between thermal and non-thermal modification for materials with different carbon filler contents. Thus, the initial F-4 practically does not heat up during microwave irradiation: for 100 seconds, the temperature rises slightly (by 10 °C). However, even a small addition of carbon nanoparticles (0.2 mass. part.) significantly (by almost 50 °C) increases the absorption of microwaves and heating of the material. The melting point of fluoroplast 4 is approximately 327 °C, and the operating temperature range is up to 260 °C, which makes it possible to limit non–thermal modification to the range from room temperature to 80 °C.

Table 1. Kinetics of heating F-4 samples and composites based on it in a microwave electromagnetic field.

Composition of the composite F-4+CNT, mass parts	The temperature of the composite sample F-4+CNT (°C), depending on the time of microwave treatment, seconds										
	0	10	20	30	40	50	60	70	80	90	100
0	21	22	23	25	26	27	28	28	29	30	32
0.2	21	25	29	36	43	46	50	53	58	64	68
0.5	21	36	80	98	123	134	145	172	189	196	202
1	21	48	109	162	183	220	250	273	–	–	–
1.5	21	52	113	212	260	305	–	–	–	–	–

The comparative basic strength characteristics of the initial fluoroplast and modified materials based on it are shown in Fig.1.

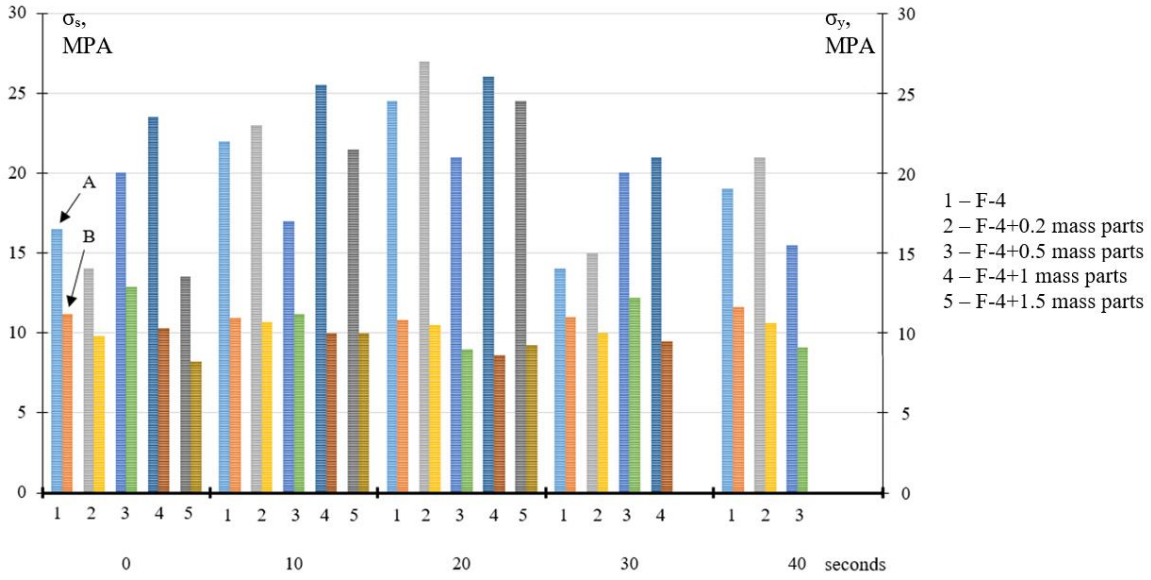

Figure1 - Physico-mechanical properties of fluoroplast 4 and composites based on it on the time of microwave treatment.
A – Ultimate tensile strength; B – Tensile yield strength.

The experiments carried out show that the introduction of carbon materials in the amount of 0.5-1 mass. part. it allows to increase the strength characteristics of fluoroplast 4. In addition, microwave processing of materials increases the efficiency of physico-mechanical modification of materials. Samples with a content of 0.2 mass. part. CNTs showed a significant increase in strength characteristics after microwave exposure for 10

and 20 seconds.

Conclusion

The obtained research results have shown the effectiveness of modifying the polymer matrix with small amounts of carbon nanostructured materials. There is a change in the physico-mechanical characteristics of the polymer matrix, as well as a change in the electrically conductive characteristics, which makes it possible to use carbon nanomaterials to produce electrically conductive materials based on nonpolar polymer matrices.

Acknowledgements

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References

1. Zavrazhin D.O., Baronin G.S., Khudyakov V.V. Formirovaniye strukturno-mekhanicheskikh svoystv nanomodifitsirovannykh polimernykh materialov v usloviyakh tverdofaznoy plunzhernoy ekstruzii [Formation of structural and mechanical properties of nanomodified polymeric materials in conditions of solid-phase plunger extrusions]. Letters on Materials. 2014, Vol. 4, No. 3, pp. 182-185. (Rus)
2. Galygin V.Ye., Baronin G.S., Tarov V.P., Zavrazhin D.O. Sovremennyye tekhnologii polucheniya i pererabotki polimernykh i kompozitsionnykh materialov [Modern technologies for the production and processing of polymer and composite materials]. Tambov, FGBOU VPO «TGTU», 2013. 180 p. (Rus)
3. Baronin G.S., Zavrazhin D.O., Popov A.G., Tolstykh M.S. Vliyaniye SVCH-izlucheniya na formirovaniye strukturno-mekhanicheskikh svoystv modifitsirovannykh polimer-uglerodnykh materialov pri tverdofaznoy ekstruzii [Effect of microwave radiation on the formation of structural and mechanical properties of modified polymer-carbon materials during solid-phase extrusion]. Scientific Bulletin of Belgorod State University. Series: Mathematics. Physics. 2011, Vol. 23, No. 11, pp. 123-128. (Rus).
4. Zavrazhin D.O., Popov A.G. Vliyaniye SVCH-izlucheniya na formirovaniye struktury s uluchshennymi fiziko-mekhanicheskimi kharakteristikami modifitsirovannykh polimer-uglerodnykh materialov pri tverdofaznoy obrabotke davleniyem [The effect of microwave radiation on the formation of a structure with improved physical and mechanical characteristics of modified polymer-carbon materials during solid-phase pressure treatment]. Promising materials. 2011, No 11, pp. 389-395. (Rus).

Влияние СВЧ-обработки на свойства полимерных нанокомпозитов

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Аннотация. В данной статье рассматривается влияние электрофизической модификации на физико-механические свойства фторопласта 4, модифицированного углеродными нанотрубками под воздействием микроволнового излучения. Предметом анализа является изменение нагревательной способности микроволновых волн неполярных полимеров в зависимости от наполнения углеродными наноматериалами. Структурная и электрофизическая модификация полимерной матрицы изменяет физико-механические характеристики образцов. Проведенные исследования дают значительное представление о взаимодействии полимерных матриц с наполнителями.

Ключевые слова: углеродные нанотрубки (УНТ), фторопласт 4 (Ф-4), СВЧ-обработка, полимерный композит.

УДК 66.087.4

Investigation of the colloidal graphite electrochemical synthesis kinetics

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Abstract
The use of colloidal graphite in industry is becoming more and more in demand. One of the few methods for producing colloidal graphite that provides a high yield, and the purest composition is electrochemical exfoliation. The reaction rate depends on the conditions of the synthesis. In this article, the influence of a few different temperatures and current densities on the process has been studied. As a result, optimal parameter values were obtained.
Keywords: colloidal graphite, electrochemical exfoliation, optical density, suspension.

Graphene is a two-dimensional layer of carbon atoms with very attractive physical, optical and mechanical properties, including high mobility of charge carriers, record thermal conductivity and rigidity.

Graphene and graphene-like materials are gaining increasing popularity in the scientific world due to the wide range of their possible applications. Thus, the creation of an effective method for obtaining high-quality technologically advanced colloidal graphite using a simple and inexpensive method is an urgent task. A promising method for obtaining low-layer graphene structures, also called nanographite in foreign literature, and colloidal forms of graphite in domestic publications [1]. However, at present this method has not been studied fully enough, although it is very promising, since it does not require the use of dangerous substances, is environmentally friendly, simple and cheap.

Conducting research on this topic is associated with the implementation of theoretical and experimental studies aimed at carrying out a literary and patent review, setting up a laboratory installation to study the process of electrochemical exfoliation of graphite, selecting and preparing electrodes, determining the qualitative characteristics of the synthesized material by optical microscopy, processing and comparing the results, searching for the most effective synthesis mode, determining rational operating conditions parameters and recommendations for conducting synthesis, development of technology for the process of electrochemical synthesis of colloidal graphite.

In this paper, the kinetics of the electrochemical synthesis of colloidal graphite in an aqueous solution of 0.1M potassium hydroxide at various temperatures and current densities is investigated. The research was carried out on a laboratory installation specially created for this purpose, the basis of which is a thermostatically controlled electrochemical cell equipped with a photometric sensor that records the value of the light transmission of the solution at the current moment. The data is recorded in the memory of a personal computer. The laboratory setup described above is shown in Fig.1.

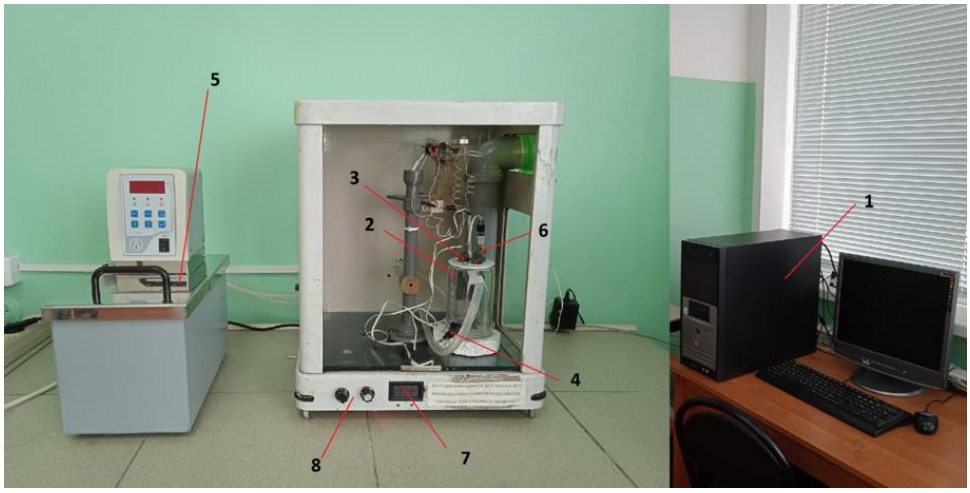

Figure 1 - Installation for studying the kinetics of electrochemical synthesis of colloidal graphite
1 - personal computer; 2 - electrochemical cell; 3 - current-carrying clamps, 4 - optical sensor; 5 - liquid thermostat; 6 - agitator. 7 - measuring instrument screen, 8 - variable resistor adjustment knobs.

From the dependencies obtained during the study, it can be concluded that the value of the optical density of the electrolyte solution does not grow linearly as the synthesis of colloidal graphite proceeds. In the initial period, the optical density increases more slowly than at the end of the process. Moreover, the rate of optical density growth (the steepness of the kinetic curve) increases more strongly at higher temperatures. This phenomenon can be explained by the fact that at the initial stages, ion intercalation occurs in the surface layer of the electrode, while as the process progresses, the actual area of the electrode increases due to its "swelling" and involvement of deeper layers in the process.

With increasing temperature, the process speed also increases, but this effect is most pronounced above 45°C, and is practically absent in the range from 30°C to 45°C. The dependence of the total process time on temperature is shown in the figure 2.

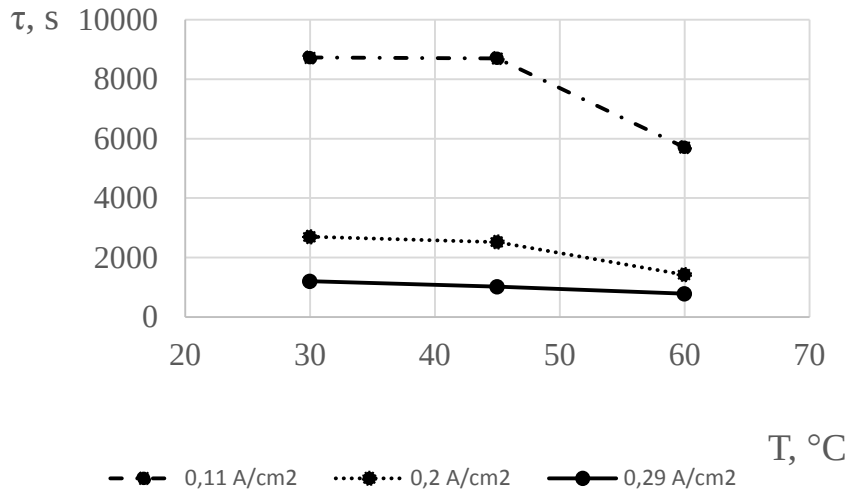

Figure 2 - Dependence of synthesis time on temperature at different current densities

With an increase in current density at a fixed temperature, the process time is significantly reduced (Figure 3).

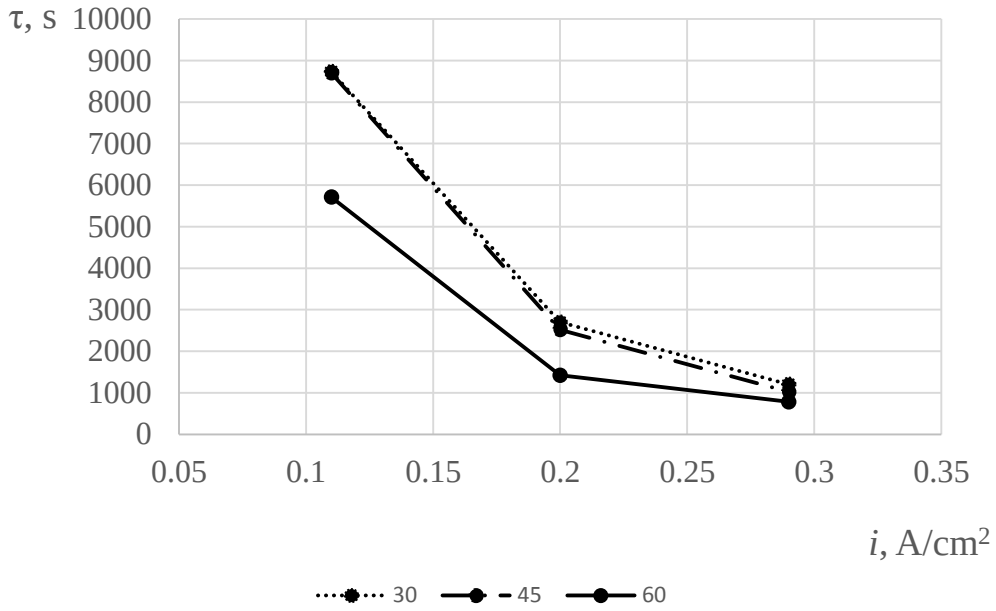

Figure 3 - Dependence of synthesis time on current density at different temperatures

As an effective synthesis mode, 0.2 A/cm^2 and 30°C can be recommended to obtain a suspension with a low degree of polydispersity and not a large particle size in comparison with other modes. However, at higher temperatures, it is possible to obtain graphite particles with large lateral dimensions and not high thickness, allowing a light beam to pass through the plate. Obviously, such particles may be in demand for certain applications, and methods for separating them from the rest of the suspension require additional research and development.

References

1. Almeri, S. N. M. Obtaining colloidal forms of graphite by electrochemical exfoliation. Scientific knowledge of modernity. 2023. № 1(71). Pp. 30-33.

Исследование кинетики электрохимического синтеза коллоидного графита

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Аннотация. Использование коллоидного графита в промышленности становится всё более востребованным. Одним из немногих методов получения коллоидного графита, обеспечивающих высокий выход и наиболее чистый состав, является электрохимическая эксфолиация. Скорость реакции зависит от условий проведения синтеза. В данной статье было изучено влияние ряда различных температур и плотностей тока на протекание процесса. В результате были получены оптимальные значения параметров.

Ключевые слова: коллоидный графит, оптическая плотность, суспензия, электрохимическая эксфолиация.

УДК 66.087.97

The initial concentration effect of solutes on the electrodialysis purification kinetics from ions Cu^{2+}, Fe^{3+}, Ni^{2+}

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Abstract
The aim of this work was to study the initial concentration effect of substances on the electrodialysis purification kinetics of multicomponent solutions from Cu2+, Fe3+ and Ni2+ ions. The results of the research revealed the greatest efficiency of electrodialysis purification of such solutions from Ni2+ ions. In addition, a change in the initial concentration of substances can have a significant impact on the efficiency of electrodialysis separation. Optimization of the purification process parameters, taking into account the influence, should lead to a higher purification degree and a reduction in separation time.
Keywords: electrodialysis, efficiency, membrane, purification, wastewater

Introduction

The treatment of wastewater and industrial solutions from chemical and electroplating industries is of great importance for the protection of the environment and human health. Discharges from enterprises in this sector may contain heavy metals, acids, alkalis and other harmful substances that can cause significant damage to the environment. Their cleaning helps to reduce the harmful effects. Electromembrane technologies represent an advanced method of wastewater and industrial solutions treatment, which has proven itself to be highly efficient and reliable. Therefore, the purpose of this work was to study the effect of the initial concentration of substances on the kinetics of electrodialysis purification of multicomponent solutions from ions Cu^{2+}, Fe^{3+} , Ni^{2+}[1-3].

Materials and methods

The objects of research in this work were the process of electrodialysis purification of model aqueous solutions containing $CuSO_4*5H_2O$, $Fe(NO_3)_3*9H_2O$, $Ni(NO_3)_2*6H_2O$ in various concentrations (the initial concentration of C_0 of each of the metal cations was from 40 to 160 mg/m^3), and industrial ion exchange membranes MK-40L and MA-41P are manufactured by a Russian company. The subject of the study is the effect of the initial concentration of dissolved substances on the kinetics of electrodialysis purification from $Cu^{2+,}$ Fe^{3+} and Ni^{2+} ions. The main series of experimental studies was carried out on an electrodialysis laboratory unit.

Results and discussion

During the experiments on electrodialysis separation of multicomponent solutions containing $Cu^{2+,}$ $Fe^{3+,}$ and Ni^{2+} ions, data were obtained and analyzed (Fig. 1-3) describing the change in the concentration of these ions over time in the separation chambers of the electrodialyzer at different current densities. An analysis of the results of a study of the effect of the initial concentration of a substance on the kinetics of electrodialysis purification from Cu^{2+} ions, normalized to the initial value of C_0 (Fig. 1), shows that during 3600 seconds of the experiment, the degree of purification is observed in the range

from 88 to 97% of the initial amount, and decreases with an increase in the initial concentration of C_0 Cu^{2+} ions. A certain dependence of the kinetics of electrodialysis purification on the initial concentration of the substance has been revealed. Low initial concentrations of the substance make it possible to achieve a high degree of purification, while an increase in initial concentrations leads to a decrease in the degree of purification.

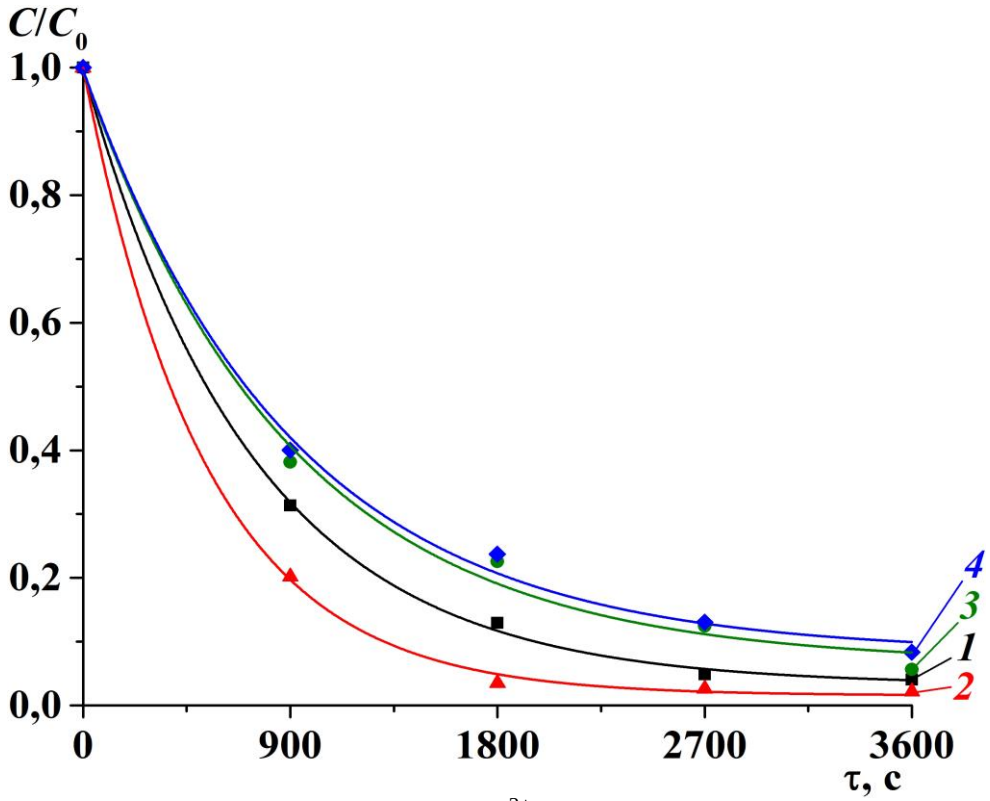

Fig. 1 – Kinetic dependences of the concentration of Cu^{2+} ions normalized to the initial value of C_0 on the time in the desalination chamber when using MK-40L and MA-41P membranes during electrodialysis separation of model solutions containing $CuSO_4*5H_2O$, $Fe(NO_3)_3*9H_2O$ and $Ni(NO_3)_2*6H_2O$: 1 – C_0 = 40 mg/dm^3, 2 – C_0 = 80 mg/dm^3, 3 – C_0 = 120 mg/dm^3, 4 – C_0 = 160 mg/dm^3.

Despite the fact that at low concentrations, the differences in the degree of purification were not very significant, an increase in the initial concentration of C_0 Fe3+ ions to 120 and 160 mg/dm^3 led to a significant deterioration in the degree of purification at the level of 14-16%. This can be explained by the fact that with a high concentration of Fe^{3+} ions, the complexity of the electrodialysis separation process increases. Low migration of Fe^{3+} ions towards more concentrated zones can be caused by strong interaction and competition with Cu^{2+} and Ni^{2+} ions, which complicates mass transfer through the membrane.

The results of experiments on purification of the solution from Fe^{3+} ions (Fig. 2) showed that the process proceeds worse than purification from other ions.

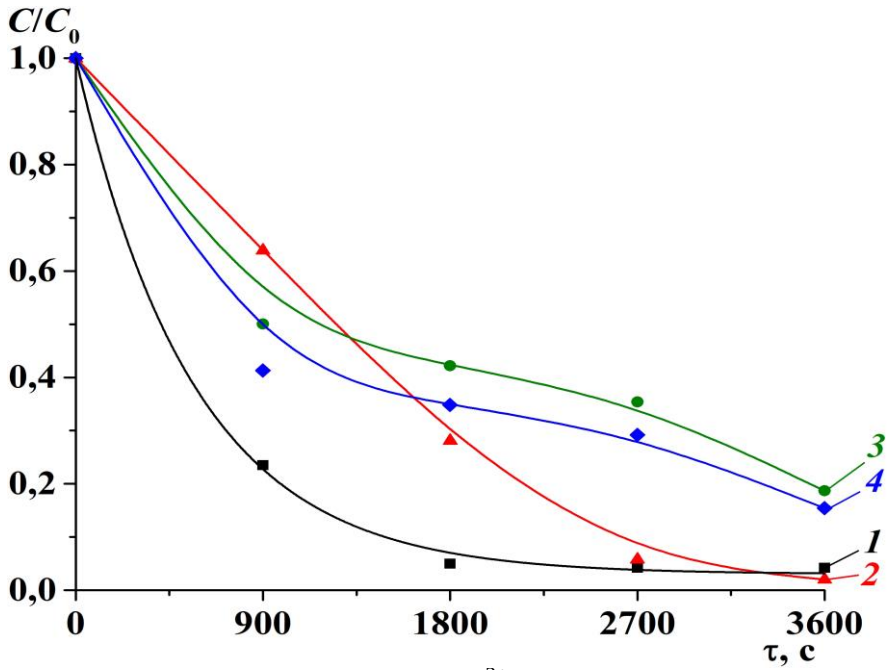

Fig. 2 – Kinetic dependences of the concentration of C Fe^{3+} ions, normalized to the initial value of C_0, on the time in the desalination chamber when using MK-40L and MA-41P membranes during electrodialysis separation of model solutions containing $CuSO_4*5H_2O$, $Fe(NO_3)_3*9H_2O$ and $Ni(NO_3)_2*6H_2O$: 1 – C_0 = 40 mg/dm^3, 2 – C_0 = 80 mg/dm^3, 3 – C_0 = 120 mg/dm^3, 4 – C_0 = 160 mg/dm^3.

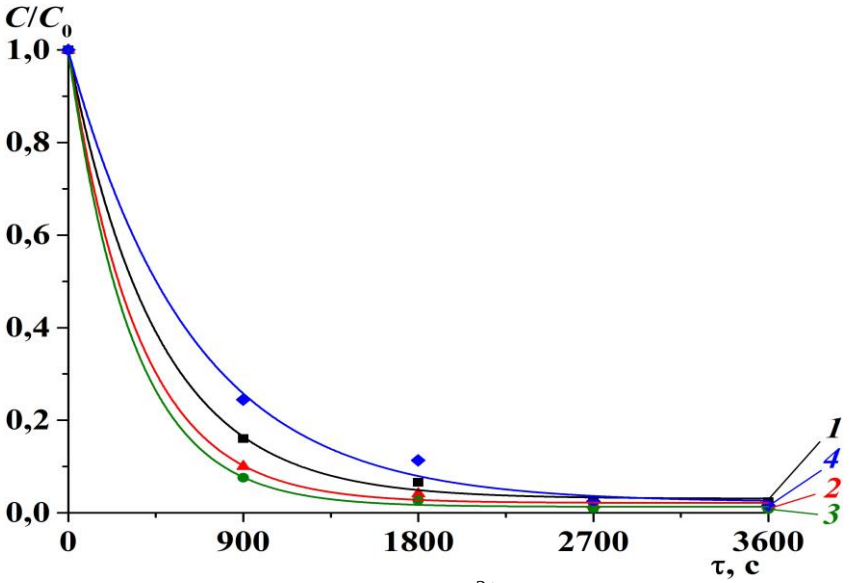

Fig. 3. Kinetic dependences of the concentration of C Ni^{2+} ions, normalized to the initial value C_0, on the time in the desalination chamber when using MK-40L and MA-41P membranes during electrodialysis separation of model solutions containing $CuSO_4*5H_2O$, $Fe(NO_3)_3*9H_2O$ and $Ni(NO_3)_2*6H_2O$: 1 – C_0 = 40 mg/dm^3, 2 – C_0 = 80 mg/dm^3, 3 – C_0 = 120 mg/dm^3, 4 – C_0 = 160 mg/dm^3.

An analysis of the results of experiments on the transfer of Ni^{2+} ions from desalination chambers (Fig. 3) revealed the highest efficiency of electrodialysis purification. It was found that at all initial concentrations, the transfer of Ni^{2+} ions was better than Cu^{2+} and Fe^{3+} ions, which is reflected in the high values of the degree of purification of the solution, which ranged from 97.5 to 99%. There was no significant effect of the initial concentration

on the kinetics of electrodialysis purification from Ni^{2+} ions. The obtained research results confirm the effectiveness of electrodialysis separation for solution purification from Ni^{2+} ions and its potential for wide application in various fields.

Conclusion

The effect of the initial concentration of dissolved substances on the kinetics of electrodialysis ion purification is an important factor that is taken into account when optimizing separation processes. In particular, the research results have shown that changes in the initial concentration of substances can have a significant impact on the efficiency of electrodialysis separation. On the one hand, low initial concentrations of substances can help reduce separation time and achieve a higher degree of purification. On the other hand, high initial concentrations of substances can have the opposite effect, reducing the efficiency of electrodialysis separation due to the strong interaction and competition between ions. Optimizing the parameters of the purification process, taking into account this influence, can lead to a higher degree of purification and a reduction in separation time.

References

1. Neverov, E.N., Gorelkina, A.K. & Skhaplok, R.Yu. Analiz sovremennyh metodov i tekhnologij promyshlennoj vodoochistki [Analysis of modern methods and technologies of industrial water treatment]. Polzunovskiy vestnik, 2023, No. 3, pp. 215-225. (Rus)
2. Turk D.A., Tlekhusezh M.A. Sovremennye metody ochistki vody [Modern methods of water purification]. Naukosfera, 2023, No. 8-2, pp. 77-84. (Rus)
3. Tazdinova, O. Y. Primenenie tekhnologii elektrodializa dlya ochistki stochnyh vod himicheskoj vodoochistki s primeneniem otechestvennogo oborudovaniya [Application of electrodialysis technology for wastewater treatment of chemical water treatment using domestic equipment]. Tendencii razvitiya nauki i obrazovaniya,2023, No. 97-11, pp. 204-207. (Rus)

Влияние исходной концентрации растворенных веществ на кинетику электродиализной очистки от ионов Cu^{2+}, Fe^{3+}, Ni^{2+}

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Аннотация. Целью данной работы было исследование влияния исходной концентрации веществ на кинетику электродиализной очистки мнокогомпонентных растворов от ионов Cu^{2+}, Fe^{3+} и Ni^{2+}. Результаты исследований выявили наибольшую эффективность электродиализной очистки таких растворов от ионов Ni^{2+}. Кроме того, изменение начальной концентрации веществ может иметь существенное влияние на эффективность электродиализного разделения. Оптимизация параметров процесса очистки, учитывающая это влияние, должна привести к достижению более высокой степени очистки и уменьшения времени разделения.

Ключевые слова: мембрана, очистка, сточные воды, эффективность, электродиализ.

УДК 661.188.7

Production of glycerol by reactionless hydrolysis

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Abstract
In this article a method of obtaining glycerol is presented. The relevance of the method is that glycerol is obtained by non-reactive hydrolysis with the addition of ionol. The quality of the crude glycerol is improved, there is no need to use alkali and no additional purification processes. The relevance of the study lies in the fact that glycerol is a universal substance that has found application in a variety of areas. Improving the quality of raw glycerol at the stage of its obtaining makes it very easy to work with it further. And if we consider the fact that hydrolysis is reactive and we do not use alkali in the process, the process becomes even more improved, as we do not have to carry out additional actions for purification. Thus, we get a more improved product in a shorter time.
Keywords: glycerol, hydrolysis, ionol.

Glycerol is an organic compound from the group of alcohols. It is a transparent, oily substance to the touch and has a sweet taste. Due to its versatile properties, it has found applications in many fields. In pharmaceuticals it is the main ingredient of eye drops, in cosmetics it is an ingredient of care and decorative cosmetics, it is used as a moisturizing and consistency-forming agent, it prevents creams and lipsticks from drying out. Also glycerol is used as an antistatic agent for surface treatment of various plastic bottle blanks, glycerol is added as an active agent. Glycerin is also used in the automotive industry and leather production.

To improve the quality of the finished product, it has been suggested to add ionol at the stage of evaporation of glycerol water. It provides the following benefits:

- improve the quality of crude glycerin, namely reduce the mass fraction of ash and non-volatile residues, surfactants. We will also improve organoleptic parameters, namely appearance.

- It is possible to stabilize the process of evaporation of glycerol water and reduce foam formation

As raw materials we usев sunflower oil and water to obtain crude glycerol. Sunflower oil is produced from sunflower seeds. For this process we chose refined deodorized oil of 'Premium' brand, as it is a fully purified product from impurities.

Refined sunflower oil has a homogeneous structure, transparent, colorless and odorless, and does not foam during heat treatment. To obtain refined oil, the liquid was subjected to multi-stage purification, deodorization, clarification.

The density of sunflower oil at 10°C is 920-927 kg/m^3, solidification temperature is -16°C to -19°C, flash point in a closed crucible is not lower than 180°C, smoke point is 232°C.

This method of making glycerol is the hydrolysis of fats and oils to separate them into glycerol water and fatty acids. This process consists of the following stages. First the

hydrolysis itself in an autoclave, then the degreasing in a separator and finally the evaporation process in a vacuum evaporation apparatus. Before the evaporation process starts it is necessary to add ionol in the amount of 0.1-0.2 per cent of the glycerine water mass before feeding into the apparatus. Ionol is a substance belonging to the class of phenols, widely used in the chemical industry as an antioxidant.

Externally, this substance has the following properties: white crystalline powder, which is poorly soluble in water but has fat-soluble properties.

The name according to IUPAC nomenclature is 2,6-di-tretbutyl-4-methyl-phenol. The chemical formula is C15H24O. Ionol is obtained by Friedel-Crafts reaction by alkylation of p-cresol with isobutylene (Fig. 1).

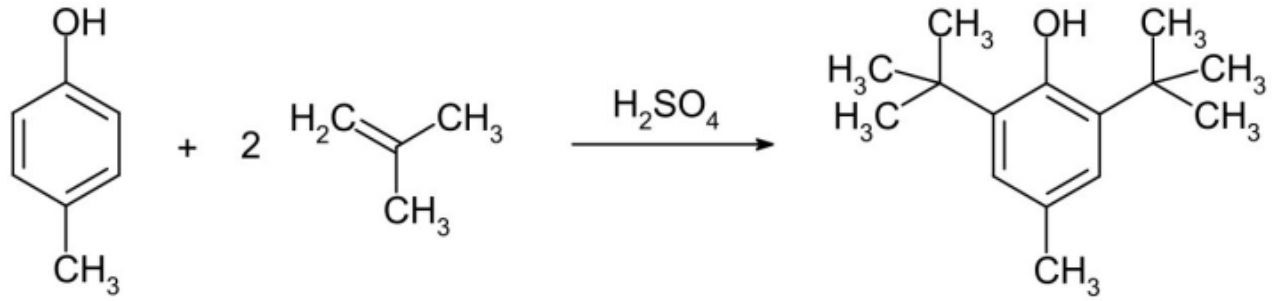

Figure 1 - Ionol production

The purpose of adding ionol is to stabilize the process of vacuum evaporation of glycerol water and to improve the quality of crude glycerol in the reactive-free hydrolysis of fats and oils.

Table 1 - Effect of ionol on glycerol

Quantity of ionol in glycerol water, %	Characterisation of the vacuum evaporation process	Quality of crude glycerine			
		Mass fraction of pure glycerol, %	Insight	Color	Sort
Without ionol	heavy foaming	76	Turbid	Light brown	Non-standard
0.05	Slight foaming	78	Faintly turbid	Light brown	Ⅲ
0.10	Minor foaming	86	Transparent	Bright yellow	Ⅲ
0.15	Little foaming	86	Transparent	Bright yellow	Ⅰ
0.20	Foam formation at the beginning of the process	86	Transparent	Bright yellow	Ⅰ
0.25	Foaming at the beginning of the process	86	Transparent	Bright yellow	Ⅱ

Ionol was introduced into the glycerol water before the evaporation step. As can be seen from Table 1, the addition of ionol less than 0.10-0.25 wt.% does not reduce the foam formation. Increasing the concentration of ionol more than 0.2 wt.% does not make sense, as it will not have a greater effect. It can be concluded that the optimum amount of ionol to be added is 0.15 wt.% as at further increase of its concentration the quality of the product slightly deteriorates.

Emulsions are unaffected by microorganisms, making them ideal for use in the medical and food industries.

References

1.Sposob poluchenia sirogo glicerina [Method of obtaining crude glycerol]. Available from: https://patents.google.com/patent/RU2162836C1/ru (Accessed 10.12.2024) (Rus).
2. Primenenie glicerina dla` obrabotki poverhnostey zagotovok dla` plastikovih i compozicii dla` takoy obrabotki [Use of glycerol for surface treatment of plastic workpieces and compositions for such treatment]. Available from: https://yandex.ru/patents/doc/RU2003125677A_20050210 (Accessed 20.12.2024) (Rus).
3. Neprerivniy sposob poluchenia glicerina [Continuous method of glycerol production]. Available from: SU353404A3 - Непрерывный способ получения глицерина - Яндекс.Патенты (Accessed 20.12.2024) (Rus).

Получение глицерина методом безреакционного гидролиза

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Аннотация. Рассмотрен метод получение глицерина методом безреакционного гидролиза с добавлением ионола. Данная технология способствует повышению качества сырого глицерина без использования щелочи и проведения дополнительных процессов очищения. Актуальность исследования заключается в том, что глицерин – это универсальное вещество, которое нашло применение в самых разных сферах. Повышение качества сырого глицерина на этапе его получения очень облегчает дальнейшую работу с ним. А если учесть тот факт, что гидролиз безреактивный и мы не используем щелочь при проведении процесса, то процесс становится еще более усовершенствованным, так как не приходится проводить дополнительные действия для очищения. Тем самым мы получаем за короткое время более совершенствованный продукт.
Ключевые слова: глицерин, гидролиз, ионол.

УДК 665.765

Development of synthetic solidol modified with colloidal graphite

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Abstract
In this paper, laboratory studies are carried out to obtain a formulation of synthetic solidol, as well as its modification with colloidal graphite, which gives it improved properties: the coefficient of friction is reduced and the penetration ability of the lubricant is improved. The given theme is actual and practically significant, as synthetic solidol finds wide application in various technical purposes, and use of used oils solves ecological problem and improves economy. The technology is non-toxic and environmentally safe, respectively, it is possible to create and further develop the production of synthetic solidol from waste motor oils with the addition of synthetic acids and modification with colloidal graphite.
Keywords: colloidal graphite, solidol, synthetic solidol

Synthetic solidol is one of the most popular greases at the moment.

Greases are colloidal systems, which include a dispersion medium (fats, fatty acids), a dispersed phase (water), as well as additives and additives (thickener, etc.).

It is worth noting that in this case water, although called a dispersed phase, is not stabilised liquid droplets, but takes an active part in building the structure of lubricants. Water is involved in the hydration process of soaps, thereby forming a structure similar to a liquid crystal structure.

The raw materials for production are alkali (slaked lime), fats or fatty acids, which react with alkali to form a thickener, i.e. soap, and base engine oil, which is thickened to the required consistency.

The advantage of using fatty acids is the absence of glycerol and impurities in the products. Slaked lime used for production should not contain large quantities of limestone, silicon and magnesium carbonates, and manganese.

It finds its practical application for lubrication of friction units of machinery and vehicles. And also for lubrication of moving parts in various agricultural machinery, tools, gears of various types and gearboxes of various devices. Such solidol is used not only in industry, but also for household purposes.

Laboratory studies to obtain a formulation of synthetic solidol modified with colloidal graphite particles.

The formulation of the synthetic solidol obtained in this work differs from the standard formulation in that used engine oil is used as oil, and stearic acid is used as a synthetic fatty acid. In addition, the ratio of components differs, but the resulting products are similar in properties to standard synthetic solidol.

Before proceeding to industrial production, it is necessary to establish a formulation in the laboratory.

For this purpose, 4 samples of grease with different percentages of calcium stearate

were synthesized (30%, 25%, 20%, 15%).

Purified spent engine oil was poured into a three-neck flask with a volume of 500 ml through a funnel, lime milk was prepared in parallel (the required amount of calcium hydroxide and distilled water was added to a beaker, mixing was carried out using a magnetic stirrer).

Then stearic acid was added through a funnel, an agitator and heating were turned on. Further, at 50 °C, after complete dissolution of stearic acid, lime milk was poured in and waited for 30 minutes, then the stirrer was turned off, heating was turned off.

The resulting product was poured into a plastic container and labeled. After lowering the temperature to room temperature, samples were taken for the study.

The study of all lubricant samples was carried out on a four-ball friction machine (Pic. 1) for the size of the friction spot.

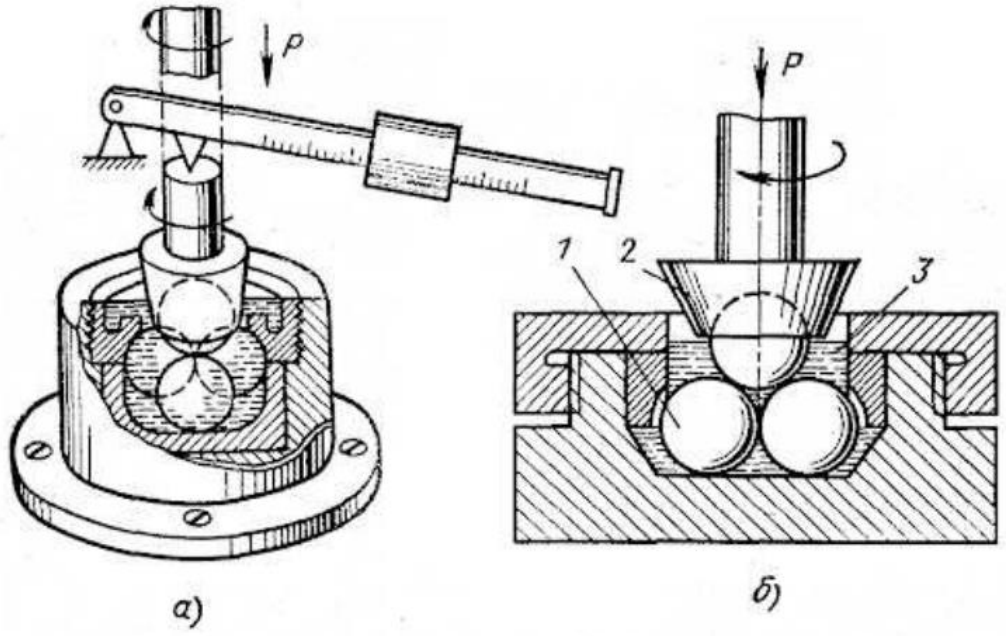

Figure 1 - Four-ball friction machine

To do this, grease and 3 metal balls are placed in a round-shaped lubrication container, then a conical washer is pressed against the press, preventing the movement of the balls due to pressing forces.

After that, excess grease is removed and the lid is screwed on.

The fourth ball is clamped in the collet (attachment) and the collet is attached to the machine drive.

Next, a stand is installed and a container is placed on it on the support bearing of the friction machine under the fourth ball so that it falls into the hole in the container.

The stand clings to the radial motion limiter and the load is applied using a lever that presses the container against 4 balls in the collet and starts the rotation of the drive for 1 hour.

At the end of the process, a microscopic analysis was performed for the size of the friction spot.

As a result of microscopic examination, the following results were obtained:
30% - 316.35 microns
25% - 300.54 microns
20% - 394.99 microns
15% - 277.61 microns
The most suitable lubricant is one containing 15% calcium stearate.

The next step was the modification of the grease with colloidal graphite. A grease with a calcium stearate content of 15% was synthesized according to the above method, only a suspension of colloidal graphite was added instead of distilled water.

Based on the obtained laboratory data on the selection of a rational ratio of components, an experimentally justified method for the synthesis of synthetic solidol from used engine oils and its modification with colloidal graphite was obtained.

Also, for the obtained synthetic solidol, laboratory control was carried out on a four-ball friction machine.

Modification of synthetic solidol with colloidal graphite gives it improved properties: the coefficient of friction decreases, the penetrating ability of the lubricant improves.

References
1. Sinitsyn V.V. Podbor i primenenie plastichnykh smazok [Selection and application of greases]. M.: Chemistry, 1969. 376 p. (Rus)
2. Kuznetsov A.V. Toplivo i smazochnye materialy [Fuel and lubricants]. M.: KolosS, 2007. 199 p. (Rus)
3. Boner K. J. Proizvodstvo i primenenie konsistentnykh smazok [Production and application of greases]. Translated from English. Edited by V.V. Sinitsyn. M.: Gostoptehizdat, 1958. 704 p. (Rus)

Разработка синтетического солидола, модифицированного коллоидным графитом

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Аннотация. Представлены результаты лабораторных исследований для получения рецептуры синтетического солидола, а также его модификация коллоидным графитом, который придает ему улучшенные свойства: уменьшается коэффициент трения, улучшается проникающая способность смазки. Данная тема является актуальной и практически значимой, так как синтетический солидол находит широкое применение в различных технических целях, а использование отработанных масел решает экологическую проблему и улучшает экономику. Технология является нетоксичной и экологически безопасной, соответственно, возможно создание и дальнейшее развитие производства синтетического солидола из отработанных моторных масел с добавлением синтетических кислот и модификацией коллоидным графитом.
Ключевые слова: коллоидный графит, солидол, синтетический солидол

УДК 66.017

Synthesis of carbon quantum dots by hydrothermal carbonization of organic substances

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Abstract
The paper presents the results of a study of the synthesis of carbon quantum dots from citric acid by a hydrothermal method. The effect of synthesis time and the content of the initial components on the quality of the synthesized nanoproduct was experimentally established. The synthesis method proposed in the paper allows reducing the cost of the formed water-soluble carbon quantum dots.
Keywords: Carbon quantum dots, citric acid, hydrothermal method, synthesis, photoluminescence, IR radiation.

Introduction

In recent years, much attention among carbon nanostructures, in addition to nanotubes and graphenes, has been paid to carbon quantum dots (CQDs) - carbon particles up to 10 nm in size [1], exhibiting a quantum-size effect [2]. The growing interest in CQDs is explained by luminescence, excellent solubility, high biocompatibility, low toxicity, good chemical inertness and simple technology of their synthesis. Unusual properties allow the use of CQDs as a contrast agent in medicine, markers in the oil and gas industry, in the field of catalysis, etc.

There are many methods for the synthesis of CQDs, they can be generally divided into top-down or bottom-up approaches. In the top-down approach, CQDs are obtained by cutting large carbon precursors (such as carbon nanotubes, graphite, soot, etc.) into very small fragments using electrical, chemical, or mechanical methods. In contrast, the bottom-up approach refers to the construction of large structures from simple initial atoms, molecules.

Among the existing methods of CQD synthesis, the hydrothermal method should be highlighted, which consists in the carbonization of organic substances (sucrose, urea, citric acid, glucose, ethylenediamine, etc.).

In [1, 3, [4], citric acid is used as a raw material for the synthesis of CQDs due to its environmental safety, low cost and prevalence. The aim of this work is to develop a method for obtaining CQDs from citric acid by a hydrothermal method and to study the influence of the conditions for implementing the synthesis on the properties of carbon nanoparticles.

Methods

In order to obtain CQDs quickly and easily, a low-stage method was studied, which consists of hydrothermal carbonization of organic substances (Fig. 1).

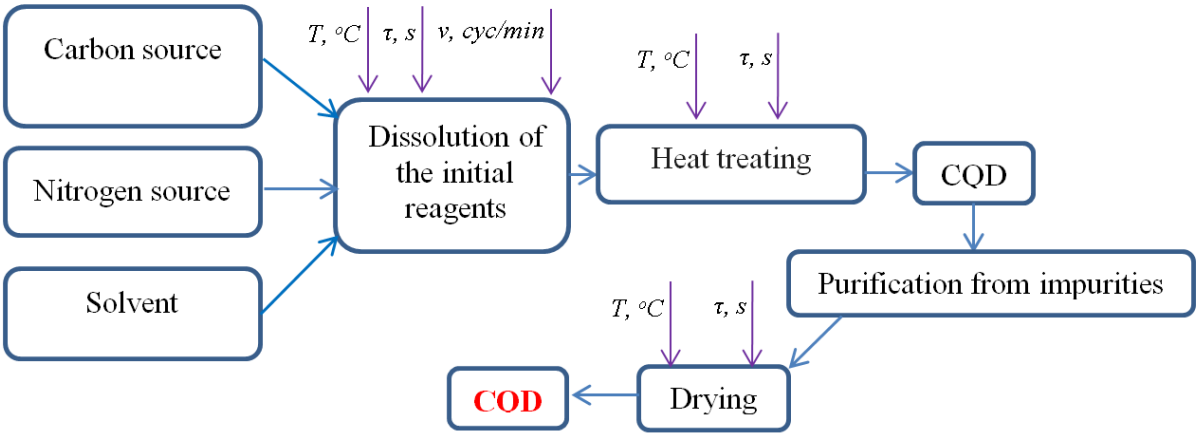

Figure 1 - Process synthesis CQD

The main stages of CQDs synthesis by this method are: selection of initial substance samples, obtaining an aqueous solution based on them, heat treatment of the initial component solution at a temperature not exceeding 200 °C.

As a result of implementing this method, a technique was developed in which citric acid was used as a carbon source, monomethylaniline as a nitrogen-containing additive, and distilled water as a solvent.

A magnetic stirrer was used to obtain a solution of the initial components, and a SNOL muffle furnace was used for its heat treatment. The time of heat treatment of the initial component solution varied in the range of 1-6 hours. As a result of carbonization of the initial component solution, a dark-brown glass-like substance is formed (Fig. 2).

Figure 2 - CQDs synthesized by heat treatment for:

a) 2 h; b) 4 h; c) 6 h;

With increasing heat treatment time, a decrease in the mass of synthesized CQDs is observed, which can be explained by a more complete decomposition of the initial mixture and a decrease in the content of impurities in the product (Tab. 1).

Table 1: Mass of CQDs synthesized by heat treatment with initial mixture: citric acid (10gr), monomethylaniline (8,55 ml) and distilled water (1 ml)

Reaction time (h)	1	2	4	6
Mass of CQDs (gr)	12,85	12,04	10,77	10,08

Despite this, all the obtained CQDs samples dissolve well in water, do not form a sediment, which allows excluding the centrifugation stage from the CQDs production method, according to the analysis of scientific and technical literature, which is widely used to isolate a coarse fraction from a solution when implementing this method with other initial components. At the same time, the resulting solution, irradiated with ultraviolet (λ = 365 nm, UV radiation intensity 40,000 μW/cm2), is characterized by bright and intense photoluminescence (Fig. 3)

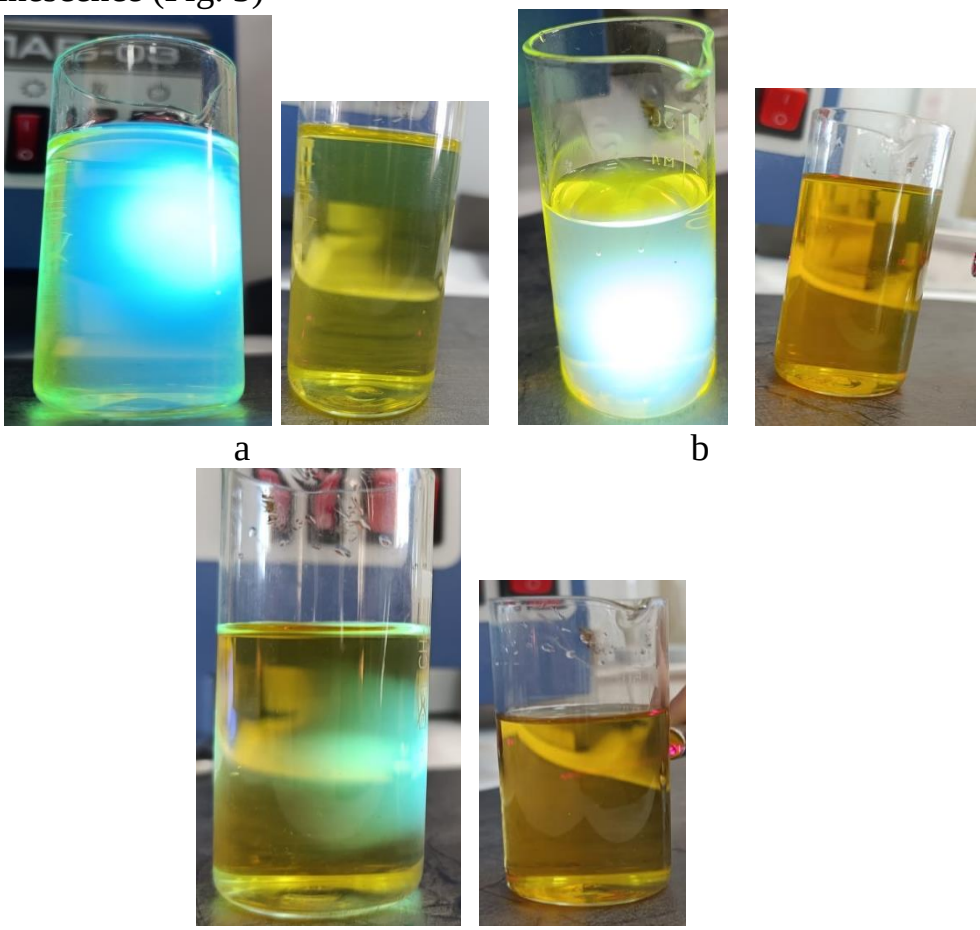

Figure 3 - Aqueous solutions of CQDs when irradiated with UV and IR radiation with duration of heat treatment a) 2 h; b) 4 h; c) 6 h.

When irradiating a CQDs solution with IR radiation, a weakly expressed Tyndall effect can be observed in some solutions (Fig. 3 c). Meanwhile in solution of CQDs with duration of heat treatment 2h (Fig. 3 a), Tyndall effect is almost undetectable. These differences allow us to draw a conclusion about the influence of the duration of synthesis on the size of the formed particles.

Conclusion

The conducted experimental studies of the synthesis of CQDs by the hydrothermal method from citric acid allowed us to develop a method of their production, excluding the stage of centrifugation, which allows reducing the time of their production and reducing

the cost of the water-soluble product. The implementation of the proposed method allowed establishing the influence of the synthesis time and the content of the initial components on the quality of the synthesized CQDs.

References

1. Egorova M. N., Kurkina I. I., Dyakonov A. A. Polucheniye uglerodnykh tochek v matritse polivinilovogo spirta i issledovaniye ikh svoystv [Obtaining carbon dots in a polyvinyl alcohol matrix and studying their properties] Polzunovsky Vestnik. 2023. No. 1. P. 245-251. (Rus)
2. Brichkin S.B., Razumov V.F. Colloidal quantum dots: synthesis, properties and application Russian Chemical Reviews, 2016, Vol 85, Issue 12, pp. 1297-1312.
3. Song, Y., Zhu, S., Zhang, S., Fu, Y., Wang, L., Zhao, X., Yang, B. Investigation from chemical structure to photoluminescent mechanism: a type of carbon dots from the pyrolysis of citric acid and an amine. Journal of Materials Chemistry C, 2015, Vol 3, Issue 23, pp. 5976-5984.
4. Nayoon C., Cheng T., Yuri P., Aijun D., Godwin A. A., Yuhoon H., Soryong C. Visible-light-driven photocatalytic degradation of tetracycline using citric acid and lemon juice-derived carbon quantum dots incorporated TiO2 nanocomposites. Separation and Purification Technology, 2024, Vol 350, pp. 127836

Синтез углеродных квантовых точек гидротермальной карбонизацией органических веществ

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Аннотация. В работе приведены результаты исследования синтеза углеродных квантовых точек из лимонной кислоты гидротермальным методом. Экспериментально установлено влияние времени синтеза и содержания исходных компонентов на качество синтезируемого нанопродукта. Предлагаемая в работе методика синтеза позволяет снизить себестоимость формируемых водорастворимых углеродных квантовых точек.

Ключевые слова: Углеродные квантовые точки, лимонная кислота, гидротермальный метод, синтез, фотолюминесценция, ИК-излучение.

УДК 544.653.1

Influence of restored nanographite synthesized by electrochemical method on the electrical conductive properties of paint and varnish materials

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Abstract
The author investigated the effect of the concentration of reduced nanographite oxide (RNGO) introduced into an acrylic emulsion (AE). The percolation threshold has been determined to be 3%. It was revealed that in this case, the surface coated with a WONG-modified acrylic dispersion acquires antistatic properties with a surface resistance of $\sim 10^7 - 10^8$ Ohm.
Keywords: nanographite oxide, reduced nanographite, acrylic emulsion.

Introduction

The simplest and most effective way to adjust the properties of paints and varnishes is to add various modifiers [1-3], which can change parameters such as adhesion, abrasion resistance, storage stability and film strength. To operate in harsh environments, it is often necessary to impart antistatic properties to the coating film in addition to providing a protective function. A surface is classified as antistatic if the electrical resistance of the surface at all control points is in the range $\sim 10^6 - 10^9$ Ohm.

Various materials can be used as conductive fillers in coating materials, including metal and composite powders, organic conductors, carbon black, graphite and carbon nanomaterials. The use of metal powders makes it possible to obtain coating materials with low resistivity. The concentration of such fillers must be quite high. The difference in the density of the polymer matrix and the metal filler significantly worsens the mechanical properties of the paint and varnish material. In addition, such materials often have undesirable magnetic properties, and also reduce the anti-corrosion properties of paints, retain specific gravity, etc.

In recent years, various carbon fillers, such as carbon nanotubes (CNTs), graphene, nanographite and their derivatives, which do not suffer from the above-mentioned disadvantages, have become increasingly popular. Such materials have a number of valuable properties, in particular, low density compared to metals, high electrical conductivity and an anisotropic structure of fibers, nanotubes and nanofibers, which promotes the formation of conducting channels.

One of the promising fillers for paints and varnishes is nanographite and its derivatives, in particular oxidized nanographite (ONG), which has unique properties due to its well-developed surface and the presence of functional groups that can easily interact with organic compounds through covalent and non-covalent bonds.

Materials and methods

There are many methods for obtaining NGO and their derivatives. One of the promising methods for obtaining graphene structures is electrochemical exfoliation of graphite [4-7]. However, this method has not yet been sufficiently studied and adapted to solve specific production problems, such as modifying paints and varnishes, in particular to give them antistatic properties.

It is known that graphite nanooxides have low conductivity due to the presence of oxidizing groups and sp^3 defects on the surface. Therefore, surfaces coated with this compound did not remain conductive even when 0.1-15 % NGO was added to acrylic varnish and voltages of 200, 250 and 1000 V were applied.

Removal of functional groups from nanographite oxides restores the conducting π-system and improves the conductivity of the material; the reduction of NGO can be carried out by various methods, including chemical reduction, annealing in an inert atmosphere or in the presence of hydrogen, and laser reduction. Chemical reduction can produce a partially reduced product or achieve almost complete reduction, depending on the holding time and the nature of the reducing agent.

Results

The following compounds were tested as reducing agents:$Na_2S_2O_3$, SO_3, Na_2SO_3, NH_3, ascorbic acid. At the same time, sodium hydrogen sulfide showed the greatest reduction efficiency. During the reduction process, the following reaction occurs on the surface of nanographite oxide: ${HSO_3}^{2-}$-ions carry out a nucleophilic attack on the epoxy or hydroxyl groups of nanographite oxide according to the SN_2 mechanism, followed by the release of H_2O molecules. Formation of sulfate anions was confirmed by qualitative reactions with barium salts.

Conclusion

In this way, a product was obtained, which we will further call reduced nanographite oxide (RNGO).

The dependences of the resistance of a surface coated with a modified acrylic varnish with the addition of RNGO, depending on the concentration of RNGO, have a percolation character with pronounced percolation thresholds (Fig. 1), which is typical for composites with electrically conductive fillers.

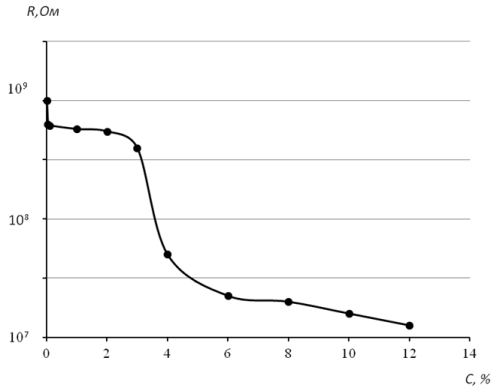

Figure 1 - Dependence of the resistance of a surface coated with an acrylic emulsion on the concentration of added reduced nanographite oxide, insert - logarithmic dependence of lgR on $log(C - C0)$

References

1. Panferov, II, Study of the effect of surfactants on the process of dispersing carbon nanotubes in solutions of epoxy oligomers. / I.I. Panferov, N.A. Apanovich, O.V. Demicheva, O.E. Zaitseva // Advances in chemistry and chemical technology, 2012 –№ 4 - P.66-69
2. Zhdanok, S. A. Influence of carbon nanomaterials on the properties of paint coating / S.A. Zhdanok, A. V. Krauklis, K. O. Borisevich // Journal of Engineering Physics and Thermophysics, 2011– No. 6 - p. 23-42
3. Orlita, M. Approaching the dirac point in high-mobility multilayer epitaxial grapheme / M. Orlita, C. Faugeras, P. Plochocka, P. Neugebauer, G. Martinez, D. K. Maude / Physical Review Letters, 2008 –No. 26 - p. 29-33
4. Wang, J High-yield synthesis of few-layer graphene flakes through electrochemical expansion of graphite in propylene carbonate electrolyte / Wang, J, Manga K.K., Bao Q., Loh K.P. // Am Chem Soc 2011;133:8888–91.The first example of graphite exfoliation at negative bias in organic solvent
5. Mao, M Simultaneous electrochemical synthesis of few-layer graphene flakes on both electrodes in protic ionic liquids / M. Mao, Chem Commun (Camb) 2013–5301–3.
6. Liu, J. A Green approach to the synthesis of high-quality graphene oxide flakes via electrochemical exfoliation of pencil core/ J Liu, H. Yang // RSC Advanced, 2013 – № 3 – p. 11745 – 11750.

Воздействия восстановленного нанографита, синтезированного электрохимическим способом, на электропроводящие свойства лакокрасочных материалов

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Аннотация. В ходе исследования, автор обнаружил влияние концентрации восстановленного оксида нанографита (ВОНГ), который вводится в акриловую эмульсию (АЭ). Порог перколяции определен в размере 3%. Было установлено, что в результате воздействия модифицированного ВОНГ поверхность, покрытая акриловой дисперсией, приобретает антистатические свойства с поверхностным сопротивлением около $\sim 10^7 - 10^8$ Ом.

Ключевые слова: оксид нанографита, восстановленный нанографит, акриловая эмульсия.

УДК 681.5

Improving the uniformity of galvanic coating with movable anode sections

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Abstract
A new method of galvanic coating application process on products is proposed, due to which the uniformity of the obtained coating on various configurations of parts can be increased, which will minimize the unevenness of the coating thickness distribution and reduce production costs, such as excess metal consumption, economic and time costs. To implement the method under consideration, it is proposed to use a prototype device consisting of isolated anode sections that move along their axes to simulate different shapes of shaped anodes to optimize the process of applying galvanic coating.
Keywords: anode configuration, anode sections, coating uniformity, galvanic coating, galvanic process.

Introduction

Galvanic coating is one of the most common methods of processing metal products. Unlike other methods, it allows controlling over the thickness of the coating applied to parts better, which makes it possible to improve the uniformity of the resulting coating, which is an important criterion for galvanic processing of products. Uneven coating increases production costs, for example, it increases metal consumption, as well as electricity for coating the part. This increases monetary costs, in particular when using precious metals to coat products, the cost of which is much higher. It also increases the risk of defects that cannot be used in the assembly process, and the operation of manufacturing a new part and replacing the old one with it entails additional costs and time, which negatively affects production. Therefore, the unevenness of the resulting coating must be minimized [1].

To reduce the unevenness of the resulting galvanic coating, various methods can be used, such as electrical methods, which use different current modes, chemical methods using different additives and electrolytes, geometric methods, which use shaped anodes, non-conductive screens, etc. In their article Litovka Yu. V. and Taruraev V. A. consider reducing unevenness by changing the angles of rotation of the anode sections relative to the vertical axes passing through the centers of the anodes [2]. However, in this case, there is no possibility of changing the position of the anode sections in different planes. The purpose of this work is to consider a method for increasing the uniformity of the galvanic coating by moving the anode sections in planes closer to/further relative to the cathode.

Control device configuration

The proposed device uses isolated anode sections attached to a non-conductive plate by means of threaded bolts (Fig. 1). The anode sections move along axes passing through their center, further/closer relative to the cathode by tightening/loosening the threads on the bolts on the side of the non-conductive plate; on the other side, the bolts are fixedly attached to the anode plates and also serve to supply current to them.

This system makes it possible to simulate various shaped anodes on one device to coat different shapes of parts by changing the configuration of the anode sections. This allows us to reduce the economic and time costs of manufacturing several different anodes for each configuration of products. In addition, the advantage of the proposed approach is that it is not necessary to use special equipment to control current modes, as, for example, in electrical methods.

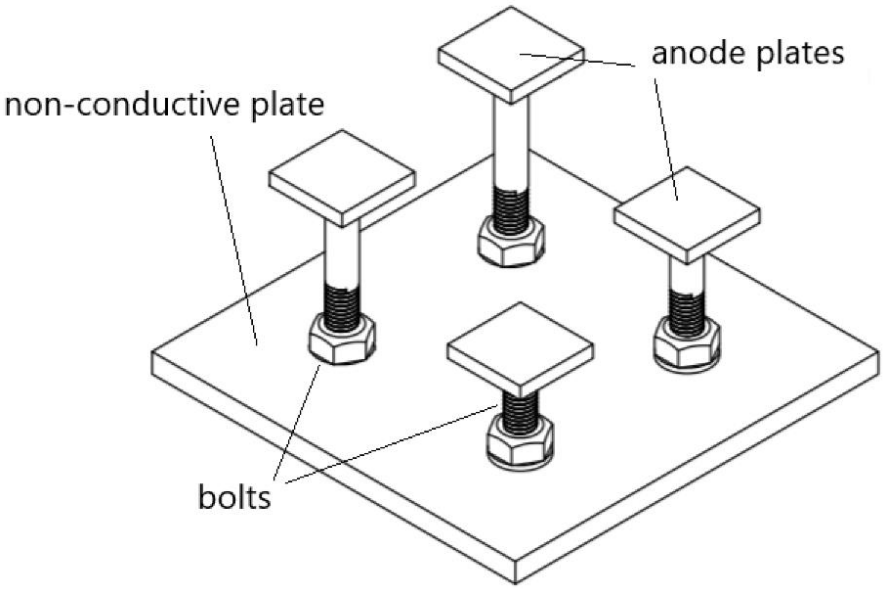

Figure 1 - Device model

Method of increasing uniformity

The configuration of the above-described prototype device allows implementing an algorithm for modeling the process of applying galvanic coatings and its optimization using the coordinate descent method using the movement of the anode sections [3].

The proposed method starts with setting the anode sections to their initial position, namely,

in one plane in the farthest position from the cathode. For this arrangement, we calculate the data required to calculate the thickness of the resulting coating. Then, we move each anode section forward one by one. For each position, we perform the same calculations to ultimately obtain the distribution of the coating thickness on the product for each anode configuration.

Based on the thickness of the part's coating, the system is guided by its quality and makes a decision on further movement of the sections, comparing the new coating, in which one of the sections is moved forward one step, with the previous coating before this section was moved forward.

If the new coating is more uniform, the system moves the next section forward, repeats the calculations for this new anode configuration and again compares the quality of the resulting coating with the previous one. If the new coating is less uniform compared to the previous one, the system moves the section in question back to its old place and moves on to the next section. This sequence of actions is repeated several times in a circle with each anode section.

The system stops the movement of the anode sections if the movement of any of them no longer improves the quality of the resulting coating of the part. The final configuration of the anode will be optimal for the given shape of the cathode.

Conclusion

A new method for controlling the galvanic process of coating products of various configurations has been proposed, in which movable anode sections are used.

The developed method can be used for preliminary calculation of the necessary system data in order to identify the optimal anode configuration for obtaining the best real coating in terms of uniformity. This will reduce the costs of important resources, such as metal, electricity, as well as the time required for manual calculation of the necessary parameters and the manufacture of anodes of different shapes for each product taking them into account.

References

1. Bagryantseva A.P., Litovka Yu.V. Snizhenie neravnomernosti raspredeleniya tolshchiny pokrytiya s ispol'zovaniem karkasnogo anoda [Reducing uneven coating thickness distribution using a frame anode]. Sovremennye tekhnologii v zadachah upravleniya, avtomatiki i obrabotki informacii : tez. dokl. XXXII Mezhdunar. nauch.-tekhn. konf., 2023, p. 62. (Rus)
2. Litovka Yu.V., Taruraev V.A. Optimizaciya nal'vanicheskoj vanny s podvizhnyma anodami [Optimization of a galvanic bath with moving anodes]. Izvestiya tul'skogo gosudarstvennogo universiteta. Seriya "Vychislitel'naya tekhnika. Avtomatika. Upravlenie", 1997, Vol. 1, Issue 2, pp. 41-48. (Rus)
3. Litovka Yu.V., Solov'ev D.S., Konkina V.V. Metody konechnomernoj optimizacii [Finite-dimensional optimization methods]. Tambov, FGBOU VPO «TGTU», 2015, pp. 26-27 (Rus)

Повышение равномерности гальванического покрытия с помощью подвижных анодных секций

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Аннотация. Предлагается новый способ гальванического процесса нанесения покрытия на изделия, благодаря которому может повыситься равномерность получаемого покрытия на различных конфигурациях деталей, что позволит минимизировать неравномерность распределения толщины покрытия и снизить производственные издержки, такие как перерасход металла, экономические и временные затраты. Для реализации рассматриваемого способа предлагается использовать прототип устройства, состоящего из изолированных секций анодов, которые перемещаются вдоль их осей для моделирования разных форм фигурных анодов для оптимизации процесса нанесения гальванического покрытия.

Ключевые слова: анодные секции, гальванический процесс, гальваническое покрытие, конфигурация анода, равномерность покрытия.

УДК 66.091.3

The influence of surfactants on the rheological quality parameters of P.R.57:1

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Abstract
The quality of the raw materials is important for all consumers; they must be confident in it in order to produce quality goods. To do this, it is necessary to constantly improve the formulations of pigments used in printing. One way to solve this problem is to introduce suitable surfactants into the composition of paint based on organic pigments. The purpose of this work is to determine the influence of surfactants of various classes on the rheological properties of the finished paint based on P.R. 57:1. The main stage is the synthesis of P.R. 57:1 with the inclusion of one of the three surfactants, measuring the viscosity of the finished paint and checking the stability during storage of this paint for 7 days. The surfactant, the place of its introduction and the amount were selected, which will help reduce the viscosity and extend the shelf life of the paint without deteriorating its quality.
Keywords: anionic surfactants, cationic surfactants, non-ionic surfactants, P.R.57:1, synthesis, storage stability, viscosity.

Introduction

Lake dyes (or simply lake) are finely dispersed powders that are insoluble in water. One of the widely used pigments of this class is Pigment Red 57:1 [1].

It has found application in such industries as printing and polymer coloring.

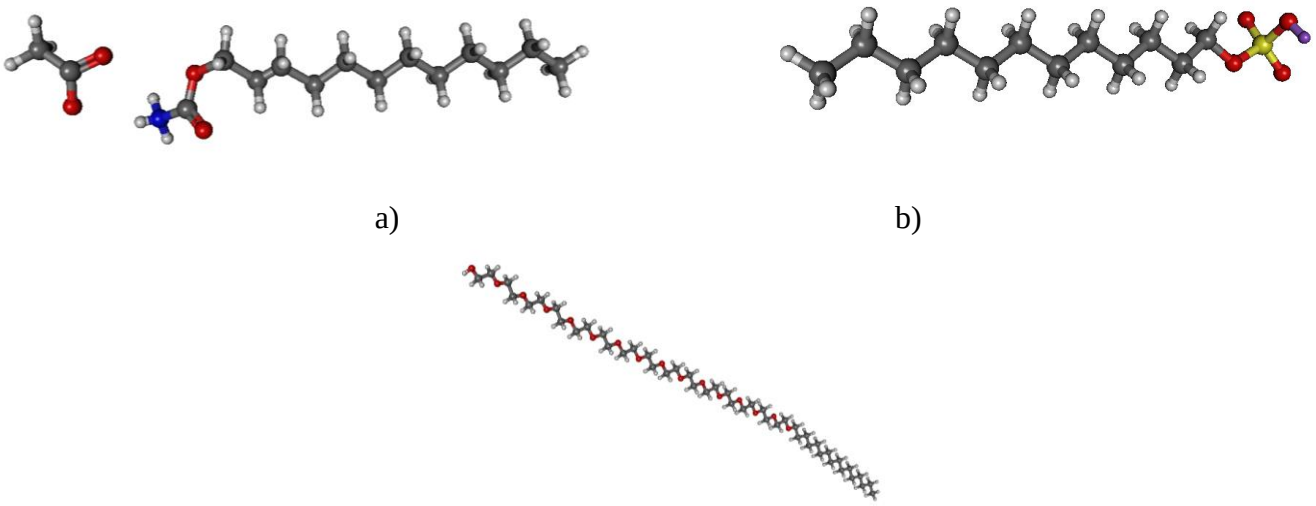
The quality of the finished paint and varnish material is significantly affected by the properties of the particle surface, such as affinity to the binder and to other pigment particles. These properties will characterize the tendency of the particles to coagulate and the strength of the particle agglomerates.

The viscosity of the paint and varnish material directly depends on the size of the agglomerates and their strength.

Also, the tendency of particles to coagulate and the strength of agglomerates determine the stability of the pigment in the binder during storage and how easily the agglomerates will be broken down when preparing the paint for use. To achieve the required properties, the surface is modified with surfactants.

Methods and Materials

The work investigated surfactants of the following classes: cationic (Acetam C-50), nonionic (OS-15) and anionic (Sodium lauryl sulfate)[2]. Their structural formulas are presented in Fig. 1.



a) b)

c)

Figure 1 – Structural formulas of surfactants
a) Acetam C-50; b) Sodium lauryl sulfate; c) OS-15

Each of them was introduced into the synthesis at the stage of heat treatment in the amount of 2% of the dry pigment mass.

Results and Discussion

The viscosity values for each experiment, measured on a Brookfield viscometer, are presented in Table 1 and compared with the standard.

Table 1 – Viscosity of the experiments after the introduction of surfactants

Sample	Viscosity, cP		
	10 sec	20 sec	100 sec
Standart	925	803	284
Exp. with Acetam C-50	2568	1465	302
Exp. with OS-15	1480	1221	280
Exp. with Sodium lauryl sulfate	1052	885	284

It can be noted that the experience with the addition of sodium lauryl sulfate is closer in viscosity to the standard. The next stage of checking the quality of the finished product is the assessment of the viscosity of the paint after 7 days of exposure at 50°C.

Table 2 – Assessment of paint viscosity after 7 days of exposure at 50°C.

Sample	Visual and/or instrumental assessment of paint viscosity after 7 days of exposure at 50°C.
Standart	The mass is mobile, when measured, the viscosity is 1721 cP.
Exp. with Acetam C-50	The mass is very thick, does not move when tilted, viscosity is not measured.
Exp. with OS-15	The mass is mobile, viscosity is not measured.
Exp. with Sodium lauryl sulfate	The mass is mobile, viscosity is twice as high.

As can be seen from the results presented in Table 2, in general the viscosity exceeds the norm by 1.5-2 times, and in one case it is not measurable at all. It can be said that cationic surfactants, such as Acetame C-50, do not prevent particles from sticking together. Non-ionic surfactants, such as OS-15, give good results at the beginning, but during storage the viscosity increases significantly, this can be explained by the surfactant's greater affinity for the binder than for the surface, and during the holding time it desorbs from the surface into the solution. Sodium lauryl sulfate gives the best results, but over time some of the surfactants also desorb into the solution.

Usually, it is necessary to combine several surfactants that will complement each other, which will allow achieving the standard level for such quality indicators as viscosity and storage stability.

Conclusion

1. A more liquid experiment was obtained using sodium lauryl sulfate in an amount of 2%.

2. None of the experiments survived storage at 50°C for 7 days, which may indicate the need to introduce a good deflocculant.

References

1. Hammer, S., Bekö, S., Glinnemann, J., & Schmidt, M. Crystal Structures of Pigment Red 57:1. Acta Crystallographica Section A Foundations and Advances, 2014, Vol. 70, Issue a1, p. 138. doi:10.1107/s2053273314098611

2. Mgr inż. Alicja Kapiszka Classification of surfactants and their applications [Electronic resource]. Available from: https://foodcom.pl/en/classification-of-surfactants-and-their-applications (Accessed 20.03.2025). (Eng)

Влияние ПАВ на реологические показатели качества лака рубинового СК

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Аннотация. Для всех потребителей важно качество исходного сырья, они должны быть уверенными в нем, чтобы производить качественные товары. Для этого необходимо постоянно усовершенствовать рецептуры пигментов, использующихся в полиграфии. Одним из способов решения данной задачи является введение подходящих ПАВ в состав краски на основе органических пигментов. Целью данной работы является определение влияния ПАВ различных классов на реологические свойства готовой краски на основе лака рубинового СК. Главным этапом является синтез лака с включением одного из трех ПАВ, измерением вязкости готовой краски и проверка устойчивости при хранении этой краски в течении 7 дней. Выбран ПАВ, место его ввода и количество, что поспособствуют снижению вязкости и продлит срок хранения краски без ухудшения ее качества.

Ключевые слова: аннионные ПАВ, вязкость, Лак рубиновый СК, катионные ПАВ, неионногенные ПАВ, синтез, устойчивость при хранении.

УДК 004.932.2

Vision system for operational inspection of chemosorbent's residual absorption capacity

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Abstract
The aim of the work is to develop a vision system for the operational inspection of the residual absorption capacity of chemosorbent plates. This article presents and describes a structural scheme of this system, as well as the algorithm for its operation and the process of obtaining information about the inspected objects, which are represented by chemosorbent plates. The result of the system's operation is a decision regarding the suitability of the chemosorbent plates for using in insulating personal protective equipment for the respiratory organs, and the rejection of them which are not suitable, with displaying relevant information to the system operator.
Keywords: algorithm, chemosorbent, image processing, insulating PPERO, vision system.

Introduction

Nowadays personal protective equipment for the respiratory organs (hereinafter referred to as insulating PPERO) is used to ensure the safe evacuation of personnel from mines, fire-hazardous workshops and other enterprises where a risk of rapid oxygen depletion is so high in the ambient air. Self-rescuers are in the high demand among them (Figure 1). These devices utilize calcareous chemosorbent materials. A chemosorbent is a mixture of various chemicals. The main active chemosorbent substances are hydroxides of alkaline and alkaline earth metals. These chemicals convert carbon dioxide into water vapor during a chemical reaction. Superoxides of alkaline and alkaline earth metals are also quite important substances in the composition of these chemosorbents which include oxygen with -0.5 oxidation state. Such substances convert carbon dioxide emitted by humans into oxygen during the chemical reaction [1]. These systems insulate the human respiratory system from the ambient air, which may not contain enough oxygen for normal breathing. They provide a person with the ability to breathe for 15 to 30 minutes during evacuation, before leaving the dangerous area.

Figure1 - A self-rescuer

The chemosorbent is manufacturing in the form of granules or plates (Fig. 2). The last ones are often used nowadays in modern personal protective equipment, such as that shown in Fig.1 [2].

Figure 2 - Chemosorbent plate

The installation of chemosorbent plates into the assembled PPERO complex takes place in special factories. Factory personnel must ensure before installation that the chemosorbent plate does not have any defects, i.e., the plate has the required absorption capacity. The absorption capacity is a parameter that indicates the time of the potentially possible maximum implementation of a chemical reaction for oxygen production. Destructive inspection methods are still used for monitoring the absorption capacity of such plates. For example, a thermophysical method for monitoring absorption capacity is used, which includes measuring of thermal conductivity during irradiation the plates with infrared light, which leads to the destruction of the sample and impossibility for practical use [3].

Another method of testing chemosorbent plates is usage of volunteers. The volunteer uses the test plates for breathing during various activities such as walking and running. This method, however, also leads to the destruction of the plates and takes a long time to complete it.

Spectral image analysis is one of the modern methods which are used in the field of technical science. While this method is not currently used in chemosorbent research, it has shown promising results in other spheres of science and technology, such as agriculture [4]. This method includes obtaining spectrograms on defined wavelengths of optical radiation, calculating the spectral brightness of light on these wavelengths and determination presence or absence of defects in tested vegetables and fruits.

It is necessary to obtain images on the specific wavelengths for subsequent processing and analysis using a developed vision system in order to apply the optical image analysis method and test chemosorbent plates.

Vision system description

For developing the vision system for the operational inspection of the residual

absorption capacity of chemosorbent samples it is necessary to identify the wavelengths of optical radiation where the biggest difference of spectral brightness values is detected. Measured brightness is reflected by the sample plate at the beginning and end of the chemical reaction. We did research of 30 chemosorbent samples for this purpose. The spectrograms of the plate in three states (at the beginning of the reaction, in the middle and in the end) are shown in Fig. 3 with the most significant normalized parameters.

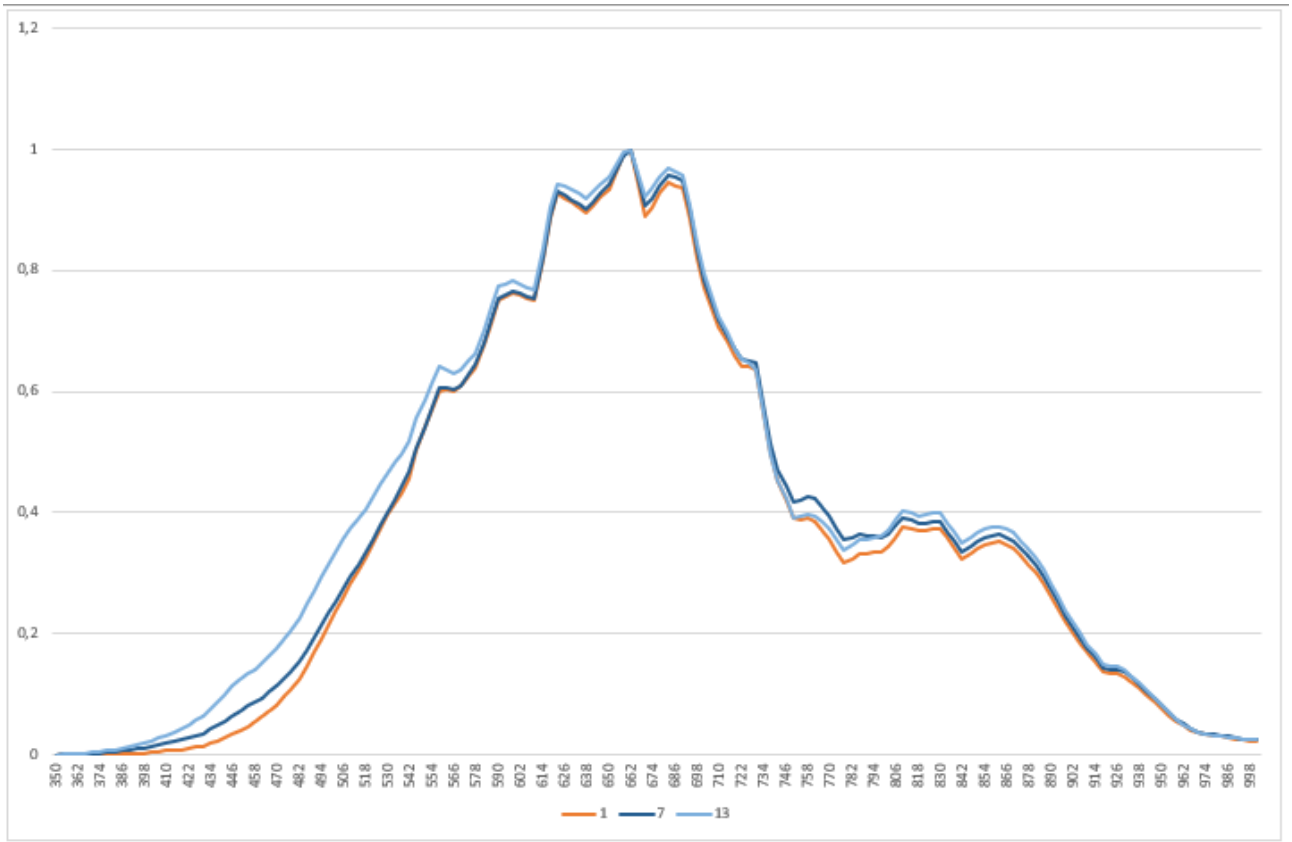

Figure 3 - Spectrograms of chemosorbent samples

The graph shows that the largest differences among the normalized spectral brightness parameters are at the following wavelengths: $\lambda_1 = 470$ nm, $\lambda_2 = 566$ nm, $\lambda_3 = 758$ nm and $\lambda_4 = 780$ nm. It means that it is recommended to use spectral brightness values only on these wavelengths. The developed vision system will analyze the chemosorbent plates on these specific wavelengths.

The structural scheme of the developed vision system is shown in Fig. 4. This vision system consists of several components. An optical RGB-camera takes photos of the researched chemosorbent plates, digitizes them and sends them to the Microcomputer for processing. The Microcomputer is the central processing unit of the system. The system operator controls the Microcomputer and loads necessary programs using an interactive Display. The computer's software is written on Python and run on the Linux Operating System. The Microcomputer communicates with the Actuator's Driver, which controls the Cylinder's Actuator. The Cylinder's Actuator rotates it in order to the algorithm of the program which is loaded via Display into the Microcomputer.

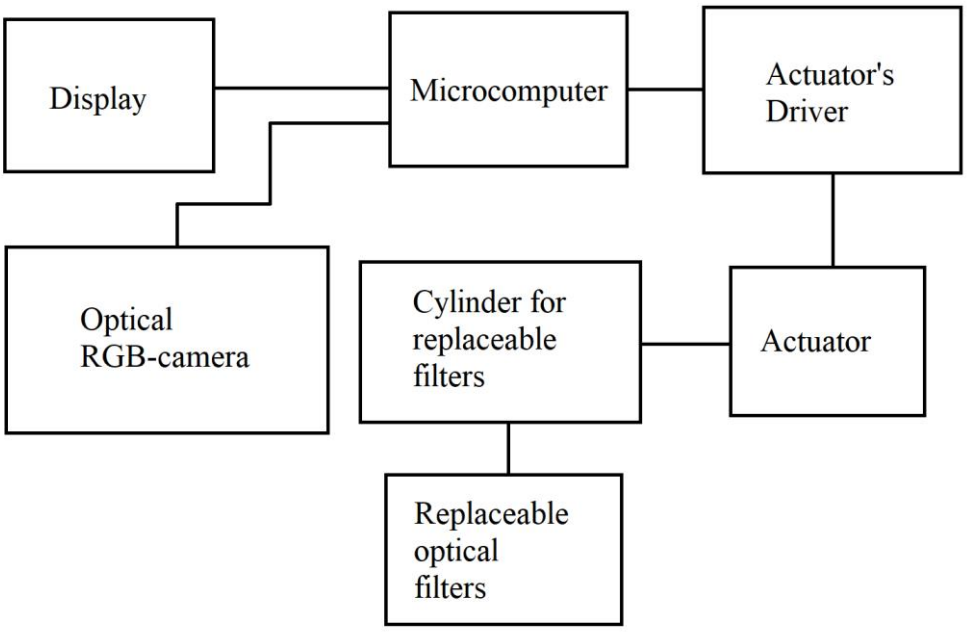

Figure 4 - Structural scheme of the vision system

Four replaceable optical filters are installed on the Cylinder. Each filter is able to transmit light only of the specific wavelength. Used filters transmit the light on wavelegnths $\lambda_1 = 470$ nm, $\lambda_2 = 566$ nm, $\lambda_3 = 758$ nm and $\lambda_4 = 780$ nm. These wavelengths give the largest amount of information about the state of the chemosorbent plates. The optical RGB-camera is located above the using filter. Then the Camera takes a photo and sends it to the Microcomputer. The Microcomputer sends a signal to the Actuator's Driver after receiving the photo. The Actuator rotates the Cylinder with replaceable filters. The filter is replaced for other one and the process starts again.

After obtaining the necessary photos of the chemosorbent plates these photos are analyzed on each researched wavelength. The calculation of the L parameter, which uniquely determines each specific sample of chemosorbent belongs to the "Defective" or "Normal" class, is performed regarding the formula 1

$$L = a \cdot R_{470} + b \cdot R_{566} + c \cdot R_{758} + d \cdot R_{780} \quad (1),$$

where a, b, c and d are the coefficients which were found during theoretical researches and depended on the lighting and humidity conditions in the inspection area,

R_i are the values of the spectral brightness of the light which is reflected from the chemosorbent plate on the wavelengths indicated in the index.

Then the calculated L value is converted into the verbal information and showed on the display for demonstration the information about the presence or absence of defects to the operator in the test sample.

Conclusion

During the research the vision system was developed for the operational inspection of the residual absorption capacity of chemosorbent samples. This system can be implemented at factories where insulating PPERO are assembled. System's convenient

opened design allows it to be quickly mounted on the assembled line at the factory. The operating time of the algorithm for estimating the residual absorption capacity of chemosorbent plates is no more than five seconds per sample. Therefore, the factory employees can inspect all samples from the supplied batch of chemosorbent plates. Developed system allows to provide continuous test of all batch samples but not selective test of random samples in contrast to current inspection methods.

This system will reduce probability of installing defective plates into insulating PPERO. The developed system will also help to automate the process of inspecting chemosorbent plates and increase the safety of users of these insulating PPERO in mines and fire-hazardous factories.

References

1. Melnikov A.K., Firsova T.I., Molodkina A.N. Issledovanie vzaimodeistviia nadperekisi kaliia s vodianym parom i uglekislym gazom [Research of the interaction between potassium superoxide, water vapor and carbon dioxide]. Zhurnal neorganicheskoi khimii, 1962, vol. 7, No. 6, pp.1228-1236. (Rus)
2. Gladyshev N.F. Regenerativnye produkty novogo pokoleniia: tekhnologiia i apparaturnoe oformlenie [New generation regenerative products: technology and hardware design]. Moscow, Mashinostroenie -1, 2007. 156 p. (Rus)
3. Balabanov P.V. Metody i sredstva issledovaniia kharakteristik teplo- i massoperenosa regenerativnykh produktov i poglotitelei dlia sistem zhizneobespecheniia. Chast 1: Metody i sredstva opredeleniia teplofizicheskikh kharakteristik: monografiia [Methods and means for researching the parameters of heat and mass transfer in regenerative products and absorbents for life support systems. Part 1: Methods and means for determining thermophysical parameters: a monography]. Tambov, Izdatelstvo FGBOU VPO "TGTU", 2012. 96 p. (Rus)
4. Iudaev V.A., Balabanov P.V., Egorov A.S. Primenenie metodov giperspektralnogo analiza dlia obnaruzheniia defektov iablok [Application of hyperspectral analysis methods to detect apple defects]. Informatsionnye tekhnologii v upravlenii i modelirovanii mekhatronnykh system: materialy II nauchno-prakticheskoi mezhdunarodnoi konferentsii, Tambov, 2020, pp. 8-11. (Rus)

Система технического зрения для оперативного контроля остаточной поглотительной способности хемосорбента

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Аннотация. Целью работы является разработка системы технического зрения для оперативного контроля остаточной поглотительной способности пластин хемосорбента. В статье приведена и описана структурная схема такой системы. Описан алгоритм работы системы, порядок получения информации об объектах контроля, представленных пластинами хемосорбента. Результатом функционирования системы является принятие решения о пригодности пластин хемосорбента к монтажу в состав изолирующих средств индивидуальной защиты органов дыхания и их отбраковка с выводом соответствующей информации оператору системы.
Ключевые слова: алгоритм, изолирующие СИЗОД, обработка изображений, система технического зрения, хемосорбент.

УДК 66-011

Testing the COSMO-RS model for lipophilicity index prediction with the SAMPL6 kit

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Abstract
The possibility of using continuum solvation models to determine the lipophilic-hydrophilic properties of a number of molecules has been considered. Calculations have been carried out by quantum-chemical modelling using the density functional theory method, and experimental and calculated distribution coefficients have been verified. It was determined that continuum solvent models predict the lipophilic-hydrophilic properties of molecules quite effectively.
Keywords: continuum solvation models, lipophilicity index, molecular modelling, DFT, COSMO-RS.

Introduction

The prediction of the lipophilicity index (logP) becomes particularly relevant in the process of evaluating the solubility and interaction of molecules in different media, which is of great importance in fields such as chemistry, pharmaceuticals, biotechnology and materials science.

Previously, the QSAR (Quantitative structure-activity relationship) method based on quantitative descriptors such as the number of atoms, groups, etc. has been studied to predict the distribution coefficient. Thus in [1], the defining feature was accounted for by classifying each element into a number of atom types according to the structural environment, while [2] proposed an algorithm based on the use of simple physical and chemical properties of molecules such as molecular weight, polarity and structure. Such models have a number of disadvantages, namely, dependence on data quality, limitations on the structural space, and difficulty in interpreting the models.

In this work, we consider the possibility of predicting lipophilic properties using the continuum solvent model COSMO-RS (COnductor like Screening MOdel for Realistic Solvents) with the SAMPL6 suite [3]. This model is based on the concept that intermolecular interactions are determined using surface segments derived from the screening charge on the surface of an isolated molecule placed in a virtual conductor, which allows predicting the thermodynamic properties of solutions and molecular interactions.

Methods and Materials

The best known quantum mechanical models for predicting the lipophilicity index are SMD (Solvation Model based on Density) and COSMO-RS. Both approaches have their own peculiarities, advantages and disadvantages.

Thus the SMD model [4] is easily integrated into existing packages for quantum chemical calculations, which allows researchers to use already known methods for

solubility prediction, works well with a sufficiently large set of solvents for which the parameters are known, and also takes into account various solvation free energy contributions such as polarisation, dispersion and cavitation. At the same time, however, calculation errors are possible especially for complex systems or for systems with strong interactions between the components and the model requires fine tuning and calibration of the parameters for some solvents.

The COSMO-RS model is based on thermodynamic principles, which allows complex interactions between molecules to be accounted for at the level of statistical mechanics, but can be more difficult to master and requires significant computational resources for implementation.

The paper reflects the results of testing the COSMO-RS model, the validation of which is based on the comparison of calculated and experimental data. Modelling was carried out in the ORCA software package.

As a modelling method, we adopt density functional theory (DFT) with a valence-split two-exponential Carlsruhe basis set with the addition of polarisation and diffusion functions def2-SVPD. We will use the global hybrid functional B3LYP (which takes into account dispersion forces in the ORCA software package), which is considered sufficient for calculating the geometry of molecular systems.

The distribution coefficient between octanol and water (logP) is related to the Gibbs free energy in the two media:

$$LogP = \frac{\Delta G_{solvation(water)} - \Delta G_{solvation(octanol)}}{2.303RT} \quad (1)$$

where R is the gas constant, T is the temperature in Kelvin, $\Delta G_{octanol}$ is the Gibbs free energy in 1-octanol, ΔG_{water} is the Gibbs free energy in water.

The following contributions are used to calculate the Gibbs free energy (ΔG) of COSMO-RS: volume energy (ΔG_{bulk}) related to the distribution of molecules in the volume, surface energy ($\Delta G_{surface}$) accounting for interactions at the surface, polar (ΔG_{polar}) and non-polar (ΔG_{apolar}) interactions between polar and non-polar groups.

Results and discussion

The results of the experimental and calculated data, as well as their deviations, are presented in Table 1.

Table 1. Comparison of calculated and experimental logP values for the SAMPLE6

	Solvent	$\Delta G_{solvatation}$, Hartree.	LogP (COSMO-RS)	LogP (exp)	|Err|
1	H2O	-0.019209	1.82	1.95	0.13
1	1-OCTANOL	-0.023174	1.82	1.95	
2	H2O	-0.022272	1.58	2.10	0.52
2	1-OCTANOL	-0.025696	1.58	2.10	
3	H2O	-0.020830	3.08	2.62	0.46
3	1-OCTANOL	-0.027528	3.08	2.62	
4	H2O	-0.020077	3.86	2.92	0.94
4	1-OCTANOL	-0.028455	3.86	2.92	
5	H2O	-0.018491	3.84	3.03	0.81
5	1-OCTANOL	-0.026845	3.84	3.03	
6	H2O	-0.021338	2.44	3.07	0.63
6	1-OCTANOL	-0.026633	2.44	3.07	
7	H2O	-0.030327	2.71	3.10	0.39
7	1-OCTANOL	-0.036217	2.71	3.10	
8	H2O	-0.020324	3.22	3.21	0.01
8	1-OCTANOL	-0.027315	3.22	3.21	
9	H2O	-0.017612	4.28	3.83	0.45
9	1-OCTANOL	-0.026912	4.28	3.83	
10	H2O	-0.021300	3.68	3.98	0.30
10	1-OCTANOL	-0.029291	3.68	3.98	
11	H2O	-0.015516	4.86	4.09	0.77
11	1-OCTANOL	-0.026068	4.86	4.09	0.59
				RMSE =.	0.56
				MaxAbs Err =	0.94

Based on the data in Table 1, the COSMO-RS model showed quite a good result in predicting the lipophilicity index. The largest deviation in the results is observed for 4, 5 and 11 molecules, whose deviations from the experimental data were 0.94, 0.81 and 0.77, respectively. The mean square deviation for the model is 0.56.

Conclusion

As part of SAMPL6 testing, logP prediction based on COSMO-RS is presented. The results obtained are sufficiently accurate to allow the use of the COSMO-RS continuum model in the prediction of the lipophilicity index.

References

1. Ghose A.K., Crippen G. M. Atomic Physicochemical Parameters for Three-Dimensional Structure-Directed Quantitative Structure-Activity Relationships I. Partition Coefficients as a Measure of Hydrophobicity. Journal of Computational Chemistry, 1986, Vol. 7, Issue 4, pp. 565-577.
2. Cheng T., Zhao Y., Li X., Lin F., Xu Y., Zhang X., Li Y., Wang R. and Lai L. Computation of octanol-water partition coefficients by guiding an additive model with knowledge. Journal of Chemical Information and Modeling. 2007, Vol. 47, Issue 6, pp 2140-2148.
3. Loschen. C., Reinisch J.and Klamt.A. COSMO-RS based predictions for the SAMPL6 logP challenge. Journal of Computer-Aided Molecular Design. 2019, Vol. 34, Issue 4, pp. 385–392.
4. Guan D., Lui R. Matthews S. LogP prediction performance with the SMD solvation model and the M06 density functional family for SAMPL6 blind prediction challenge molecules. Journal of Computer-Aided Molecular Design. 2020, Vol. 34, Issue 4, pp. 34:511–522

Тестирование модели COSMO-RS для прогнозирования индекса липофильности с набором SAMPL6

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Аннотация. Рассмотрена возможность применения континуальных моделей сольватации для определения липофильно-гидрофильных свойств ряда молекул. Расчеты проводились путем квантово-химического моделирования методом теории функционала плотности, проведена проверка экспериментальных и рассчитанных коэффициентов распределения. Определено, что континуальные модели растворителя достаточно эффективно предсказывают липофильно-гидрофильные свойства молекул.
Ключевые слова: континуальные модели сольватации, индекс липофильности, молекулярное моделирование, DFT, COSMO-RS.

УДК678

Influence of antistatic components on optical properties of transparent bopp films

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Abstract
The purpose of this work is to study the influence of antistatic additives on the quality of transparent BOPP films and their optical properties after 21 days from production. The data on the optical properties and quality of finished product rolls were obtained. It was concluded that the use of components containing unsaturated amine can affect the optical properties of transparent polymer films in the form of light stripes.
Keywords: antistatic additives; migration of components; optical properties; transparent BOPP films; unsaturated amine.

Introduction

Polyolefins have a high specific surface resistance, which leads to the accumulation of electrostatic charge on the surface of the finished product. BOPP films easily accumulate static electricity.

Reduction of the specific surface resistance of polyolefins is achieved through the use of antistatic additives, which are introduced into the polymer material during compounding. These additives reduce the electrostatic charge due to migration from the internal layers of the product to the surface. As a result, an electrically conductive surface layer with ionic conductivity is formed, which contributes to faster dissipation of electrical charges [1].

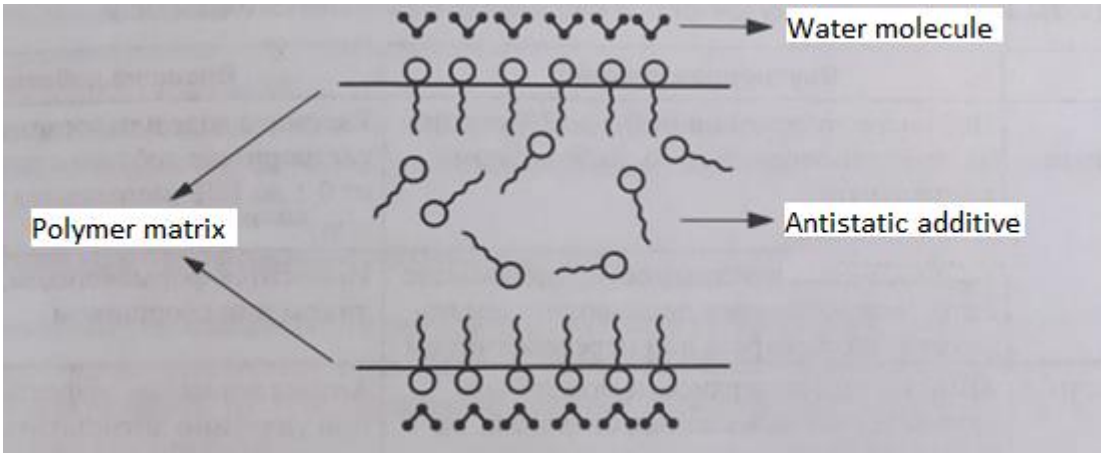

Figure 1 - Conductive pathway formed on the polymer surface as a result of migration of an antistatic additive [2].

Figure 1 shows how antistatic additives introduced into the polymer matrix migrate to the polymer surface, forming a uniform layer of molecules. The non-polar part of the antistatic agent is securely fixed in the polymer, while the polar part protrudes from the polymer.

Correct selection of an antistatic additive allows optimizing the rate at which the

antistatic effect develops and its duration. These factors mainly depend on the rate of migration of the additive to the polymer surface and the rate of its removal from the surface. Depending on their chemical nature, antistatic additives are divided into two classes: short-term and long-term [1].

Ethoxylated amines are tertiary amines obtained by the interaction of fatty acid amines and ethylene oxide. These amines are usually more compatible with polyolefins, so they migrate to the film surface more slowly and are better retained in its mass, and therefore are a long-acting antistatic additive.

Depending on the structure of ethoxylated amines, the following groups can be distinguished:

1. Saturated ethoxylated amines without double bonds (Fig. 2) - as a rule, a mixture of stearyl diethanolamine (C18-) and palmityl diethanolamine (C16-). They are a group of simple ethoxylated amines.

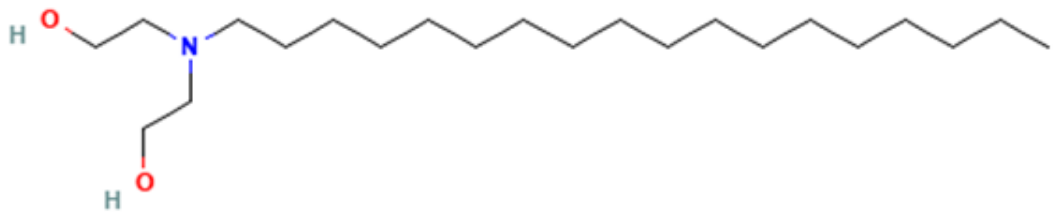

Figure 2 - Typical structure of an ethoxylated amine.

2. Unsaturated ethoxylated amines with double bonds (Fig. 3), most often oleyl diethanolamine (C18=) is used.

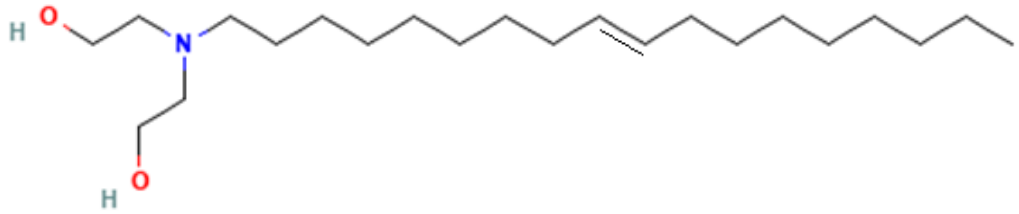

Figure 3 - Typical structure of an ethoxylated amine with double bonds.

As a rule, they are contained in a mixture with saturated ones. They are a group of simple ethoxylated amines. They are less compatible with polyolefins than saturated ones, therefore they migrate to the film surface slightly faster and are retained in its volume worse. Unsaturated ethoxylated amines are more susceptible to oxidation than saturated ones, and less heat-resistant than saturated ones [2].

During the production of industrial batches of transparent BOPP films, the formation of white stripes on some rollers was detected two weeks after production. This effect occurred on different batches and nomenclatures of the film: transparent release film, heat-sealable transparent. These stripes have the size of the grooves of the cutting machine foot roller and appear after the migration of one of the components. This negatively affects the visual perception of the product and is a discrepancy with the established quality standard. The

task was to identify the root cause.

Since this effect occurred after some time, it was assumed that it was caused by the influence of migrating elements. To determine the effect of migrating additives on the appearance of light stripes, three different antistatic components of raw materials were selected for the experiment. For the analysis, 90 rollers of different nomenclatures of finished products were produced. The rollers were installed in the zone of influence of a temperature of 40 °C. The appearance and winding density of the rollers were recorded after production, after 7, 14 and 21 days.

Figure 4 - Light stripes on the film roll (two weeks after production). The antistatic agent contains a simple ethoxylated amine C12-C16.

Based on the results of the experiment, 18 rollers with the appearance of the light stripe effect were identified. These rollers belonged to different nomenclatures and batches, had different winding densities of finished rolls. In all these rollers, the same antistatic was used, which in its composition has a migrating component that is different from the others. This antistatic in its composition has simple ethoxyamine C12-C16, which is an unsaturated amine (Fig. 4).

Figure 5 - No light stripes on the film roll (2 weeks after production). The antistatic agent in the composition is Ethoxyamine saturated complex C16-C18

No light stripes were detected on the other rollers; they contained an antistatic additive containing saturated complex C16-C18 ethoxyamine (Fig. 5).

Based on this study, we conclude that the use of components containing unsaturated amine may affect the optical properties of transparent polymer films.

Thus, the use of antistatic additives is a necessary step to prevent electrostatic charge on the surface of polymer products. The correct selection and introduction of antistatic will help improve the quality of products, prevent dust and dirt from sticking, and maintain optimal material properties. However, it is necessary to take into account the chemical nature of the antistatic and its effect on the final product to avoid negative consequences, such as the appearance of stripes on the surface of the product [3].

References

1. Uzdensky B.V. Modifikaciya polimernyh materialov: Prakticheskoe rukovodstvo dlya tekhnologa [Modification of polymeric materials: A practical guide for a technologist]. St. Petersburg: TsOP "Profession", 2021. 224 p., color. ill. (Rus)

2. Zweifel H., Maier R.D., Schiller M. Plastics Additives Handbook 6th Edition. Hanser Publications, Cincinnati, 2009. 1222 p.

3. Selke S., Culter D., Hernandez R. Plastics Packaging: Properties, Processing, Applications and Regulations 2nd Edition. Hanser Publishers, Munich, 2004. 448 p.

Влияние антистатических компонентов на оптические свойства прозрачных бопп-пленок

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Аннотация. Целью данной работы является изучение влияния антистатических добавок на качество прозрачных БОПП-пленок и их оптические свойства по истечению 21 суток после производства. Получены данные оптических свойств и качество рулонов готовой продукции. Был сделан вывод, что использование компонентов, в составе которых присутствует непредельный амин, может повлиять на изменение оптических свойств прозрачных полимерных плёнок в виде проявления светлых полос.

Ключевые слова: антистатические добавки; миграция компонентов; непредельный амин; оптические свойства; прозрачные БОПП-пленки.

УДК 67.014

Composite material based on polyaniline with the addition of carbon nanostructures

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Abstract
This article discusses a composite polymer material based on polyaniline with the inclusion of various additives from carbon nanostructures. Methods of synthesis of this material and its potential uses are also discussed.
Keywords: composite, carbon nanomaterial, polymer, polyaniline, supercapacitors, synthesis

Introduction

A composite is a new artificially created material that consists of two or more components (layers) and has unique properties. Usually, two layers are distinguished in such a material: the matrix layer, which serves as the base, and the filler layer. This combination of elements allows you to create a product with characteristics significantly different from the properties of individual layers.

The domain of composite is undergoing continuous expansion, necessitating the investigation of novel products. Polymer composite materials are currently regarded as a particularly promising avenue of research in the field of new materials, given their potential for application across a diverse range of industrial sectors. The fundamental constituents of such composites are a combination of thermoplastic and thermosetting resins. In this context, polyaniline serves as the primary base component, offering a unique combination of properties that make it one of the most promising electrically conductive polymers currently under investigation.

Polyaniline, being the main element of composites, has the ability to be easily doped, which allows it to serve as a catalyst for increasing conductivity. This property makes it an important component in the development of composite materials that are used in various electrochemical devices such as batteries and supercapacitors. In addition, polyaniline changes its characteristics, including electrical conductivity, color, density, magnetic properties, as well as hydrophilic and hydrophobic qualities, as well as permeability to gases and liquids, depending on its structural state (Fig. 1).

In addition to polyaniline, another component of an electrically conductive composite is carbon nanomaterials with unique structural characteristics, which in turn can significantly affect electrochemical and mechanical properties. Materials such as carbon nanotubes and graphene nanoplastics are capable of providing a high surface area and, due to this, can effectively interact with conductive polymers. The use of carbon nanostructures in combination with polyaniline makes it possible to obtain composites that will not only have conductive properties, but also have increased mechanical characteristics. It is for this reason that the creation of composites of this type is a matter of urgency.

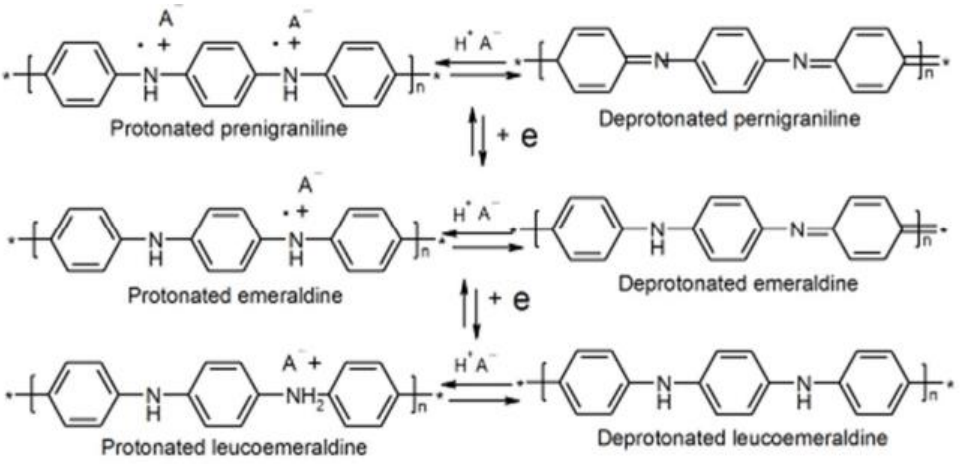

Figure 1 – Structural formula of polyaniline

Methods for obtaining composite material polyaniline/carbon nanomaterial

Currently, there are two ways to synthesize a composite based on polyaniline and carbon nanomaterials – chemical and electrochemical polymerization.

Electrochemical polymerization is a synthesis method that involves the formation of thin films of polyaniline by electrochemical oxidation of aniline in acidic aqueous solutions on conductive electrodes made of metal or glass.

The most relevant method of production due to its simplicity and the possibility of use in large-scale production is chemical polymerization.

Thus, the synthesis of a nanomodified composite by chemical polymerization in laboratory conditions occurs as follows: the first stage is the creation of an aqueous suspension of carbon nanomaterials. To do this, the calculated amount of nanoproduct is dispersed with distilled water using an ultrasonic device to a homogeneous mixture. Further, with constant stirring using a magnetic stirrer, hydrochloric acid is added to the aqueous suspension to give acidity (pH should be equal to 1). Then the necessary amount of aniline hydrochloride and ammonium persulfate is selected, which must be transferred from the powder to aqueous solutions by mixing with distilled water. Aqueous solutions of the remaining components are added to the suspension of carbon nanomaterials with constant stirring and the process of synthesizing the composite takes place. Then, the product extracted from the reaction mass is filtered. Using distilled water, the composite is washed to a neutral pH, and then rinsed with isopropyl alcohol until the color of the filtrate disappears.

Then the composite should be dried in air or in a drying cabinet at a temperature of 80 ° C to a constant weight.

The further content of polyaniline in this composite and its yield from the theoretically possible was determined by increasing the mass of carbon nanomaterials after modification.

Areas of application of highly conductive composite

According to research, composites with nanocarbon materials in their composition demonstrate excellent electrical conductivity. This opens up the possibility for their application in the experimental production of electrode elements for supercapacitors. This

area is especially relevant now, as the use of supercapacitors continues to grow. They find their application in areas where rapid and large-scale energy release is needed. These areas include alternative energy, transport systems, electronics and a number of other areas.

In addition, this composite can be used to develop materials that provide electromagnetic compatibility and protection against electromagnetic pulses, as well as protective coatings for various structures and parts that provide corrosion resistance and improve mechanical characteristics. It can also be useful in the manufacture of semiconductor components and sensors due to the high conductivity and sensitivity of the material.

Conclusion

The production of this composite belongs to the category of chemical industries. The introduction of polyaniline into carbon composites contributes to the formation of stable conductive pathways, which opens up new opportunities in scientific and industrial fields. The improved electrical characteristics and high functional stability of such nanocomposites can become the basis for the development of new generations of electrochemical devices. It is for this reason that further study of this composite is an urgent direction in the modern world.

References

1. Dyachkova T.P., Filatova Ye.Yu., Gorskiy S.Yu., Shuklinov A.V., Tkachev A.G., Mishchenko S.V. Modifitsirovaniye mnogosloynykh uglerodnykh nanotrubok polianilinom i issledovaniye svoystv poluchennykh ma terialov. Kompozity i nanostruktury. 2013. No. 1. pp. 5–18. (Rus)

2. Anosova I.V., Dyachkova T.P., Chernopyatova Yu.V. Modificirovanie grafenovyh nanoplastinok polianilinom i svojstva poluchennyh materialov // Internet-zhurnal «NAUKOVEDENIE» Tom 7, №4 (2015) http://naukovedenie.ru/PDF/42EVN415.pdf (dostup svobodnyj).

3. Stejskal, J. / Polyaniline nanostructures and the role of aniline oligomers in their formation / J. Stejskal, I. Sapurina, M. Trchová //Progress in Polymer Science. – 2010. – Vol. 35. – P. 1420–1481.

4. Yang, Y. Electrochemical biosensor based on three-dimensional reduced graphene oxide and polyaniline nanocomposite for selective detection of mercury ions / Y. Yang, M. Kang, Sh. Fang, M. Wang, L. He, J. Zhao, H. Zhang, Zh. Zhang // Sensors and Actuators B: Chemical. – 2015. – Vol. 214. – P. 63–69.

Композитный материал на основе полианилина с добавлением углеродных наноструктур

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Аннотация. В данной статье рассматривается композитный полимерный материал на основе полианилина с включением различных добавок из углеродных наноструктур. Также, обсуждаются методы синтеза этого материала и его потенциальные области использования.

Ключевые слова: композит, полианилин, полимер, углеродный наноматериал, синтез, суперконденсаторы.

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Effect of carbon nanofiller distribution on the properties of epoxy resin

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Abstract
To achieve maximum performance of the nanocomposite, uniform distribution of nanoparticles in the polymer matrix is of key importance. Agglomeration of the nanofiller can lead to defects and reduced modification efficiency. Various dispersion methods, such as ultrasonic treatment, mechanical mixing and functionalization of the nanoparticle surface, are used to improve distribution. The effect of carbon nanofiller distribution on the composite properties is manifested in changes in the elastic modulus, tensile strength and impact toughness. Due to their size, nanoparticles participate in the process with their entire surface area, which allows them to penetrate very deeply into the matrix structure and "bind" to its particles. When curing chemical reactions, the active substance of the hardener helps nanofillers to be integrated into the polymer network, forming a composite material. Visual results of the dependence of the physical and mechanical properties of epoxy resin modified with carbon nanofiller on the distribution of this filler over its structure are presented.
Keywords: carbon nanofiller, dispersion, distribution, mechanical properties, polymer composite, properties.

Introduction

The introduction of carbon nanofillers into epoxy resins is a promising method for improving their mechanical, thermal and electrical properties. However, to achieve optimal composite characteristics, uniform distribution of nanoparticles in the polymer matrix is of key importance. Agglomeration of the nanofiller can lead to the formation of defects and a decrease in the effectiveness of modification.

Materials and methods

Various dispersion methods such as ultrasonic treatment, mechanical stirring in combination with Surface functionalization of nanoparticles are used to improve distribution. The effectiveness of these methods depends on the type of nanofiller, the viscosity of the epoxy resin and the process parameters.

The influence of carbon nanofiller distribution on the composite properties is manifested in changes in the elastic modulus, tensile strength and impact toughness. Uniform distribution contributes to an increase in these indicators, while agglomeration can lead to their decrease. Also, the distribution of nanoparticles affects the thermal conductivity, electrical conductivity and dielectric properties of the epoxy resin [1].

The relevance of modifying the polymer matrix lies in the constantly growing requirements for composites in any field of application. And the quality of this modification, first of all, depends on the distribution of the filler over the structure of the binder.

The primary tasks that need to be solved in order to build a process for obtaining a high-quality material are: selection of carbon nanofiller; selection of equipment that can

accelerate and optimize the process of mixing and distributing the filler in the polymer matrix; development of a reproducible method for introducing carbon nanofiller into the binder; conducting mechanical tests confirming the improvement of indicators after resin modification. The goal that these tasks will help to achieve is obtaining a high-quality new product with physical and mechanical characteristics that could not be obtained before.

Problems that can be encountered during the distribution of carbon nanofiller are often associated with the agglomeration of particles in the structure of the binder. To solve them, it is necessary to use ultrasonic equipment, three-roll machines or planetary mills. Sometimes it is necessary to combine the use of this equipment for the distribution of the filler. The particle size, which affects the structure of the binder, can also be a problem.

Results and discussion

At the beginning of the article, we talk about the influence of the qualitative distribution of the filler on the structure of the epoxy binder. Let's also consider how exactly this change in the structure occurs, which leads to an improvement in the mechanical characteristics of the material.

The high modifying capacity of nanofillers is determined by their significant specific surface area. This makes it possible, with a relatively low concentration of particles, to cover the total area of the interfaces between the matrix and the dispersed phase even when using a small amount of filler. During the curing process, as a result of a chemical reaction with the amino groups of the hardener, the epoxy groups are opened to form cross-linked polymers of a network structure [2]. In simple terms, due to their size, nanoparticles participate in the process with their entire surface area, which allows them to penetrate very deeply into the structure of the matrix and “bind” to its particles. And during curing in the process of a chemical reaction, the active substance of the hardener helps nanofillers to integrate into the polymer network, forming a composite material.

Conclusion

It is clearly shown how the introduction of carbon nanofiller affected the properties of epoxy resin, namely, images of the structure of epoxy resin with carbon nanofiller introduced into it, as well as the tensile and bending indices of the sample on the Testometric testing machine are provided.

a) b)

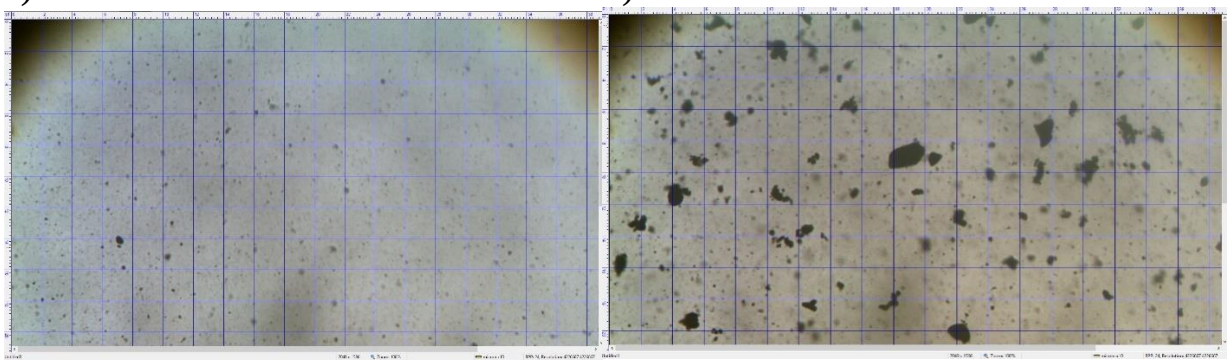

Figure 1 - Optical electron microscope images: a) epoxy resin with good distribution of carbon nanofiller; b) epoxy resin with poor distribution of carbon nanofiller

Mechanical testing of these samples showed an increase in the tensile/bending properties of sample A by 5 and 9%, respectively, and a decrease in the tensile/bending properties of sample B by 5 and 2%, respectively. The comparison was made with reference samples made of "clean" material. It is very clearly shown how the correct distribution of the filler increased the mechanical properties of the epoxy resin.

Thus, it was substantiated how the dispersion of carbon nanofiller affects change in the modulus of elasticity and tensile strength of epoxy resin samples. Namely, a study of the structure of the samples made on an optical microscope and mechanical test data from a testing machine are given Testometric.

References

1. Pykhtin A.A. Vysokotekhnologichnyye epoksidnyye nanodispersiii nanokompozity s kontroliruyemoy strukturoy i kompleksom svoystv [High-tech epoxy nanodispersions and nanocomposites with controlled structure and complex of properties]: diss. ... Cand. tech. sciences: 05.17.06. Moscow, 2017. 125 p.
2. Ilyina V.N., Ilyin S.V., Khalikova G.R., Gafarova V.A., Kuzeev I.R. Issledovaniye vliyaniya nanouglerodnykh napolniteley na morfologiyu epoksidnogo svyazuyushchego [Study of the influence of nanocarbon fillers on the morphology of epoxy binder] // Nanotechnology in Construction. 2023. Vol. 15, No. 4. P. 328–336. https://doi.org/10.15828/2075-8545-2023-15-4-328-336. – EDN:
3. KDJDUV

Влияние распределения углеродного нанонаполнителя на свойства эпоксидной смолы

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Аннотация. Для достижения максимальных характеристик нанокомпозита, ключевое значение имеет равномерное распределение наночастиц в полимерной матрице. Агломерация нанонаполнителя может приводить к образованию дефектов и снижению эффективности модификации. Различные методы диспергирования, такие как ультразвуковая обработка, механическое перемешивание и функционализация поверхности наночастиц, используются для улучшения распределения. Влияние распределения углеродного нанонаполнителя на свойства композита проявляется в изменении модуля упругости, прочности на разрыв и ударной вязкости. Из-за своего размера наночастицы участвуют в процессе всей площадью поверхности, что позволяет им очень глубоко внедряться в структуру матрицы и «связываться» с её частицами. А при отверждении в процессе химической реакции, действующее вещество отвердителя помогает нанонаполнителям встраиваться в полимерную сетку, образуя композитный материал. Приведены наглядные результаты зависимости физико-механических показателей эпоксидной смолы, модифицированной углеродным нанонаполнителем, от распределения этого наполнителя по её структуре.

Ключевые слова: диспергирование, механические показатели, полимерный композит, распределение, свойства, углеродный нанонаполнитель, эпоксидная матрица.

УДК 54.057

Biochar/graphene oxide nanocomposites as an effective sorbent of heavy metals from aqueous media

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Abstract
This work is aimed at obtaining a carbon sorption material from rapeseed obtained by HTC synthesis, modified with an exhaust gas suspension introduced at the HTC stage. The aim of the work is to determine the physicochemical and sorption properties of the obtained material.
Keywords: biochar, carbon, graphene, graphene oxide, heavy metals, nanomaterials, sorbent.

Introduction

One of the global environmental problems is the pollution of water environments with various pollutants, such as heavy metals (zinc, lead, cobalt, cadmium, copper, etc.), organic compounds (dyes, pesticides, benzenes), petroleum products (gasoline, kerosene, diesel, etc.). In view of this, the issue of cleaning water environments from pollutants of various origins is relevant.

There are many methods of water purification, such as adsorption, deionization, extraction, precipitation, catalytic degradation, membrane separation, and flocculation [1]. Adsorption is attractive for its simplicity, cheapness and environmental friendliness, as well as convenient operation mode.

A number of different adsorbents (polymers, oxides, zeolites, activated carbon) have been developed in recent decades. However, in addition to them, as a result of numerous studies, it was shown that sorption materials based on carbon nanostructures showed exceptional efficiency. One of the representatives of this class is a 2D carbon material-graphene oxide (GO), which has a high chemical activity and increased sorption capacity. Both sides of the graphene plane are coated with various oxygen-containing groups and are available for adsorption of the contaminant [2].

Analysis of materials

Recently, the use of low-cost biochars as adsorbents has been of increasing interest. Biochar is a high-carbon and highly porous product that is obtained by pyrolysis of biomass, subjecting it to heat treatment. Biochar can be obtained by hydrothermal carbonation (HTC) of various agricultural wastes, such as sunflower, rapeseed, wood shavings, soybeans, alfalfa, grass flour, etc.

To increase the sorption characteristics of biochar from agricultural waste, they are modified with other materials. Various nanomaterials, oxides, chlorides, and other compounds serve as modifiers for biochar. Thanks to this modification, biochar loses its disadvantages and improves its existing characteristics, becoming a cheap, effective sorbent that surpasses many traditional analogues.

To obtain the nanocomposite, the following initial substances and materials were used:

a suspension of graphene oxide (GO) in the form of an aqueous dispersion with a dry matter content of 1% (NanoTechCenter LLC, Tambov); biochar based on rapeseed (obtained by HTC, followed by carbonation and activation).

Method of obtaining biochar from rapeseed

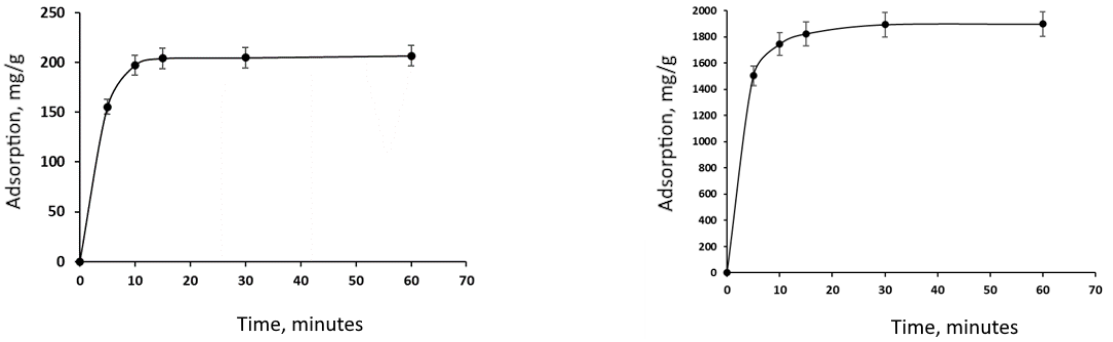
Rapeseed meal was ground in a mill and screened through a sieve. After that, crushed rapeseed meal and distilled water were loaded into autoclaves. Then the autoclaves were hermetically sealed and placed in a heat cabinet preheated to 180°C, and kept at this temperature for 12 hours. The resulting material was filtered on a water jet pump through a filter. Then, the obtained material was carbonated in an inert medium with a constant supply of argon, and the samples were sequentially kept for an hour in each temperature range (150°C, 500°C, and 750°C). The carbonized material was activated with KOH for an hour at each of the temperatures (400°C and 750°C). The resulting material was washed with distilled water to a neutral pH, after which it was filled with hydrochloric acid and left for a day in a fume hood. After that, it was washed with distilled water to neutral pH and dried at 110°C.

Method of composite production (R/GO)

The graphene oxide suspension was subjected to ultrasonic treatment for 20 minutes. Subsequently, the previously obtained biochar powder from rapeseed was added to the treated suspension. The materials were mixed to a homogeneous state, after which they were again subjected to ultrasonic treatment. Then the material was loaded into autoclaves, which were kept for 20 hours at 180 °C. The resulting sample was then placed in a freeze dryer (at -30°C and a pressure of about 5-8 Pa for 48 h at the Scientz-10n facility (Scientz, China)). The resulting cryogel had a compacted cylinder shape.

To conduct kinetic experiments in a limited volume, a sample of R/GO sorbent weighing 0.01 g was taken and placed in a test tube containing 30 ml of a model lead solution with C_o=100 mg/l or a model MB dye solution with C_o= 1500 mg/l. Sampling was performed at points 5, 10, 15, 30, and 60 min. The solution was then filtered to separate the solid phase and the equilibrium concentration of lead and MB dye in the solution was measured.

Figure 1 shows the effect of the phase contact time on the sorption capacity of Pb^{2+} (a) and MB (b) on the obtained material.



a) b)

Figure 1 - Kinetics of adsorption of lead ions (a) and MB dye (b) by the developed nanocomposite from aqueous solutions

Thus, the analysis of data shows that the equilibrium lead sorption time for the R/GO

material is 15 min, while the adsorption capacity is 204.7 mg/g. When removing the MB dye, the equilibrium time for the material is reached in 30 minutes, the adsorption capacity is 1894.6 mg/g.

Conclusion

Thus, the study proved the effectiveness of using biochar based on vegetable raw materials (rapeseed) modified with graphene oxide in the processes of liquid-phase removal of organic and inorganic pollutants.

Acknowledgements

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References

1. Sohni S., Gul K., Shah J., Iqbal A., Sayed M., Khan S. Immobilization performance of graphene oxide-based engineered biochar derived from peanut shell towards cationic and anionic dyes. Industrial Crops and Products, 2023, Vol. 206, p. 117656.
2. Melezhik A.V., Smolsky G.V., Zelenin A.D., Neskoromnaya E.A., Alekhina O.V., Burakov A.E., Tkachev A.G. Immobilization performance of graphene oxide-based engineered biochar derived from peanut shell towards cationic and anionic dyes. Industrial Crops and Products, 2023, Vol. 206, p. 117656.

Нанокомпозиты биоугля и оксида графена как эффективный сорбент тяжелых металлов из водных сред

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Аннотация. Данная работа направлена на получение углеродного сорбционного материала из семян рапса, полученного методом синтеза ГТК, модифицированного суспензией выхлопных газов, введенной на стадии ГТК. Целью работы является определение физико-химических и сорбционных свойств полученного материала.

Ключевые слова: биоуголь, графен, наноматериалы, оксид графена, сорбент, тяжелые металлы, углерод.

УДК 541.18.05/.052

Review of emulsion composition for moisturizing creams

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Abstract
Cosmetics in the form of cream have an emulsion composition. These products cannot do without such a component in their composition as an emulsifier. Since it helps the cream to be resistant to stratification, have homogeneity and a presentable appearance. Surfactants act as emulsifiers, which are amphiphilic, i.e. have a polar (hydrophilic) part and a non-polar (hydrophobic) part. An overview of the oil and emulsifier used in the basis of moisturizers has been conducted. The characteristics of sodium stearoyl glutamate and grape seed oil were studied using a physico-chemical, organoleptic and visual method. The cream based on these components has a light structure, has good moisturizing properties and is pleasant to the skin.
Key words: hydrophilicity, hydrophobicity, surfactant, emulsifier, emulsion.

Introduction

Everyone needs a hand moisturizer and it is suitable for all skin types. A cream with a moisturizing effect is important for hand care at any time of the year. The composition may include glycerin and some vegetable oil - in this case, the product will not only moisturize, but also nourish the skin. Dermatologists advise using a moisturizer after each contact with water, and it is better if the cream has a natural composition, and not a bunch of silicones, parabens and mineral oils.

Review of emulsion oils

Oils are the basis of many cosmetic products for hair, nails, face and body care, there are a huge number of their types. They are of plant and mineral origin. The former are divided into liquid and solid base oils.

The most common types of liquid oils are sweet almond, apricot kernel, argan, rosehip, avocado, jojoba, and coconut oils. Solid oils include shea butter, cocoa, and mango. Oils have various properties, such as antiseptic, anti-inflammatory, moisturizing, anti-aging, protective, healing, and restorative.

Hand cream may also contain essential oils, which have many beneficial properties and give the cosmetic product a pleasant smell. Bright examples are tea tree, rosemary, lavender, and neroli [1].

Mineral oil (liquid paraffin) is a petroleum product. In cosmetics, mineral oil often functions as an occlusive component, and can also be used to cleanse the skin.

Characteristics of emulsions and emulsifiers

Emulsions are dispersed systems consisting of two mutually insoluble liquids, one of which is distributed in the other in the form of tiny droplets.

Emulsions come in different types: "oil-in-water", "water-in-oil" and multiple emulsions "water-in-oil-in-water" and "oil-in-water-in-oil".

1) In "oil/water" emulsions, oil droplets are distributed in an aqueous solution. Here, the oil will be the dispersed phase, and water will be the dispersion medium. Creams on

such a basis are well distributed on the skin and are quickly absorbed. However, for dry skin, it is not recommended to use such creams for a long time, since due to the rapid evaporation of water, they increase the drying of the skin.

Oil/water emulsions are quite common, and a huge range of cosmetic products are created on their basis, both nourishing and light day creams.

2) In water/oil emulsions, on the contrary, the oil phase surrounds water droplets. Oil components are the dispersion phase, and water is the dispersion medium. Creams based on water/oil emulsions are recommended for dry skin.

3) In mixed emulsions, or multiple emulsions, two types are presented simultaneously - o/w and w/o. Such emulsions have at least three phases and are complex systems.

The main advantage of w/o/w emulsions is the combination of the main properties of w/o and o/w emulsions in one product [2].

To obtain a relatively stable system, emulsifiers are used in creams.

An emulsifier is a substance that stabilizes an emulsion by increasing its kinetic stability.

Most often, surfactants act as emulsifiers, which are compounds that are usually amphiphilic, i.e. have a polar or hydrophilic (i.e. water-soluble) part and a non-polar or hydrophobic (i.e. lipophilic) part.

Hydrophobic cream is designed for working with water-soluble substances, such as detergents and cleaning agents, weakly acidic and weakly alkaline solutions. It is also recommended for working in wet conditions, for example, when in contact with cement or lime, and when using gloves.

Hydrophilic cream is excellent for working with substances that are insoluble in water: these are technical oils, lubricants, paints and varnishes, organic solvents and petroleum products. It creates a barrier on the skin that protects against the effects of these pollutants and facilitates their subsequent removal.

The key differences between hydrophilic and hydrophobic creams.

1. Type of contamination: Hydrophilic creams protect against water-insoluble substances (for example, oils), and hydrophobic creams protect against water—soluble substances (detergents and solutions).

2. Barrier protection: Hydrophilic cream creates a barrier against oil and technical contaminants, while hydrophobic cream creates a barrier against water—soluble substances.

3. Scope of application: Hydrophilic creams are more suitable for those who work with oils and solvents, while hydrophobic creams are more suitable for contact with water and chemical solutions.

In order to obtain a high-quality cream, the raw materials and the final product undergo certain quality control. The raw materials are checked upon acceptance and at the time of use.

The control includes physicochemical, organoleptic, and visual methods. The first method determines the following parameters: pH of the medium, dropping point, density, and viscosity. The organoleptic method determines the smell and color. The visual method evaluates the appearance [1].

The cream should be a homogeneous mass, without foreign impurities. The color is mainly white, but depending on the type and preferences of the customer, dyes can be used. The pH of the medium is from 5.0 to 6.5. Not high viscosity, not thick, since the cream is moisturizing, it should have a light structure. The smell corresponds to the declared cosmetic product.

The cream contains grape seed oil. It has excellent moisturizing properties and contains vitamin E, which helps protect the skin from damage, thereby prolonging its youth.It is a transparent oily liquid, light yellow or green in color with a characteristic odor and taste inherent in this species.

Sodium Stearoyl Glutamate is used as an emulsifier, in the form of a white powder or granules, odorless. It stabilizes the "water in oil" emulsion with prolonged and thorough mixing.

Conclusion

The cream contains emulsifiers, which make it better. Surfactants with amphiphilic properties can act as emulsifiers. Hydrophilic creams protect against water-insoluble substances, create a barrier against oil and technical contaminants, and are more suitable for those who work with oils and solvents. Hydrophobic creams protect and create a barrier against water-soluble substances and are suitable for contact with water and chemical solutions. There are also oils in the cream that have different properties, and they determine the characteristics of the future cream. Moisturizers have a light structure that can be easily washed off with water. When applied to the skin, it does not leave greasy traces, so it is pleasant to use.

References

1. Bondarenko Zh.V. Andryukhova. M. V. B81 Technologia parfumerno-kosmetitseskya productsii. Laboratornya praktikicheskii zanyatia [Technology of perfumery and cosmetic products. Laboratory practical training]. Minsk: BSTU, 2018, 98 p.

2. Mnozhestvennya emul`siya innovatsionnaya forma kosmeticheskih sredstv | kosmetika premium [Multiple emulsion is an innovative form of cosmetics| PREMIUM cosmetics]Available from: https://cosmetika.ru/encyclopedia/mnozhestvennaya_emulsiya (Accessed 12.12.2024) (Rus).

Обзор эмульсионного состава для увлажняющих кремов

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Аннотация. Косметические средства в виде крема имеют эмульсионный состав. Эти средства не обходятся без такого компонента в своем составе как эмульгатор. Так как он крему помогает быть устойчивым к расслоению, иметь однородность и презентабельный вид. В качестве эмульгаторов выступают поверхностно-активные вещества, которые являются амфифильными, т. е. имеют полярную (гидрофильную) часть и неполярную (гидрофобную) часть. Проведен обзор масла и эмульгатора используемых в основе увлажняющих кремов. С помощью физико-химического, органолептического и визуального способа изучены характеристики стеарол глутамат натрия и масла виноградной косточки. Крем на основе этих компонентов имеет легкую структуру, обладает хорошими увлажняющими свойствами и приятен коже.

Ключевые слова: гидрофильность, гидрофобность, поверхностно-активное вещество, эмульгатор, эмульсия.

УДК 667.6

Preparing nitrocellulose varnish and increasing its protective properties

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Abstract
The purpose of this study is to develop formulations of nitrocellulose varnish NC-218 with increased penetration into the pores of wood and increased resistance to low temperatures. The modernization is proposed to be carried out by introducing an active additive (AA) and dioctyl phthalate (DOP) into the lacquer base. As a result, a nitrocellulose varnish was obtained and it was shown that when using the proposed formulations, the protective properties and service life of the coating increase.
Keywords: nitrocellulose varnish, active additive, dioctyl phthalate, penetration depth, frost resistance, drying time.

Introduction

Currently, paints and varnishes are the best means of protecting and finishing various objects, objects and products. Nitrocellulose varnishes (nitrovarnishes) are solutions of colloxylin, resins and plasticizers in mixtures of these volatile solvents. After applying nitro varnish, the solvent evaporates, forming a hard, durable and elastic film that can be polished. Drying occurs at a temperature of 18–20 °C, but can be accelerated by artificial drying at a temperature of 35–50 °C. Varnishes marked NC form a smooth, uniform and hard coating with good adhesion to the base. The film can be glossy, matte or semi-gloss depending on the composition of the varnish.

Nitrovarnishes can be applied both to a prepared surface with primer and to an untreated base. They are typically used to create decorative and protective coatings on wood products, as cellulose nitrate breaks down when exposed to high temperatures and sunlight. Protective varnish layers can be used at temperatures from 12 °C to 60 °C. This paint and varnish material is used for finishing carpentry, for example, covering wooden furniture, parquet and other elements used indoors.

To apply nitro varnishes, it is recommended to use several thin layers. Creating one thick layer is not recommended, since its protective properties will be worse than that of a coating consisting of several thin layers, even if their total thickness is the same. If necessary, the fully cured coating can be polished or sanded.

The physicochemical properties of the varnish must meet the requirements the specified in GOST [1].

In [2] there are known methods for increasing the service life of a protective and decorative coating based on nitro varnish.

The purpose of this research is to develop a nitrocellulose varnish formulation with increased penetration into wood pores and strong durability under low temperature conditions.

Experimental part

As a base, we obtained nitrocellulose varnish NC-218. The technological process consists of the following operations. The first stage - preparing cellulose for nitration consists of drying the cellulose to a moisture content of no more than 5% and mechanically loosening it to give the cellulose uniform particle size in order to ensure better wettability with the acid mixture and for uniform nitration. In the second stage, a working acid mixture consisting of concentrated HNO_3 and H_2SO_4 was prepared. Next, cellulose was nitrated and an acidic solution of colloxylin was obtained, which was then squeezed out of the nitrating mixture. With constant stirring for 20 minutes, toluene and solvents (butyl acetate, ethyl acetate) were introduced into the colloxylin.

The modernization is proposed to be carried out by introducing an active additive (AA) into the lacquer base – a product of the interaction of a light fraction of high-boiling by-products of the synthesis of 4,4-dimethyl-1,3-dioxane with boric acid. This product has found its application as a means of protecting wood and wood materials from the effects of wood-destroying fungi and termites.

Dioctyl phthalate (DOP), known for its ability to increase the frost resistance of materials, was introduced as a plasticizer.

The composition of the proposed lacquer compositions is shown in Table 1.

Table 1 – Compositions of nitrocellulose lacquers

Compound	Content, wt.%		
Components	1	2	3
Varnish NC-218	94	95	96
AA	5	4	3
DOP	1	1	1

Results and discussion

After applying the finished formulations to the wooden substrate, the coating was dried at a temperature of 18-25 ° C and a relative humidity of 40-60%. The indicators of penetration depth and frost resistance were determined using the methods of the Senezh Wood Conservation Laboratory.

The properties of the obtained protective and decorative compositions are presented in Table 2.

Table 2 – Properties of nitrocellulose lacquers

Property	Indicators			
	1	2	3	Varnish NC-218
Penetration depth, mm	15	1.3	0.8	0.5
Frost resistance of films at t -20±1 °C – cracking	not observed	not observed	not observed	to the top layer (cracks and surface rashes) 25 %
– peeling	not observed	not observed	not observed	50% of the top layer peeled off
Drying time to degree 3, h	0.5	0.5	0.5	0.5

As can be seen from the data shown in Table 2, the penetration depth of the claimed composition is better than that of the prototype, which will ensure the protection of wood, especially under the influence of atmospheric conditions. The claimed composition in all modifications gives more frost-resistant films compared to the prototype. In addition, the introduction of AA in an amount of 3-5 wt.% does not change the drying time of the composition compared to the prototype.

The introduction of AA in an amount of less than 3 wt.% does not allow achieving the desired result, while an increase in its concentration above 5 wt.% is economically unjustified and leads to an increase in the duration of the technological cycle of coating drying.

Conclusion

The analysis of the presented data allows us to conclude that the penetration depth of the proposed formulations exceeds the same indicator of the prototype. This provides more effective protection of wood, especially in conditions of exposure to atmospheric factors.

All modifications of nitrovarnish form films with increased resistance to low temperatures compared to the films formed by the prototype. In addition, the addition of AA and DOP does not affect the drying time of the composition relative to the prototype.

Thus, nitrovarnish formulations have been developed with increased penetration into the pores of wood and increased resistance to low temperatures.

References

1. Gost 4976-83. Laki marokNC-218, NC-222, NC-243 mebelnye i NC-223 [Varnishes of brands NK-218, NK-222, NS-243 furniture and NC-223]. (Rus)

2. Pat. 2572121 RF. Zashchitno-dekorativnyj preparat dlya drevesnyh materialov [Protective and decorative preparation for wood materials]/ V. A. Ryzhov, E. S. Ryzhova, N. V. Smolin, D. V. Bochkarev, E. I. Chernysheva – zayavl. 02.07.2014, opubl. 27.12.2015. (Rus)

Получение нитроцеллюлозного лака и повышение его защитных свойств

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Аннотация. Цель данного исследования заключается в разработке рецептур нитроцеллюлозного лака НЦ-218 с увеличенной проникающей способностью в поры древесины и повышенной устойчивостью к воздействию низких температур. Модернизацию предлагается осуществить путем введения в лаковую основу активной добавки (АД) и диоктилфталата (ДОФ). В результате получен нитроцеллюлозный лак и показано, что при использовании предлагаемых рецептур увеличиваются защитные свойства и срок службы покрытия.

Ключевые слова: нитроцеллюлозный лак, активная добавка, диоктилфталат, глубина проникновения, морозостойкость, время высыхания.

УДК 681.5

Development of an automated control system for a gas boiler

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Abstract
The article discusses the basic principles of creating automated process control systems, and requirements for the structure of the APCS. Issues of ensuring industrial safety are discussed. The results of developing software for the APCS of hot water production in a gas boiler house are presented. The developed application software can be used in designing the APCS of gas boiler houses of various capacities.
Keywords: automation, efficiency, management, security, software, technological process.

Introduction

At present, automation of technological processes is one of the most important tasks. In any industry, for example agriculture, electric power or industrial enterprises, there is a process that can be automated. Automation allows to reduce the percentage of defects in production, economic costs, and also reduces the influence of the human factor on the course of the technological process.

Objectives of creating an automated process control system

The main purpose of any automated process control system is automation, operational control, protection and management of this process.

An automated process control system ensures minimal human intervention in the process control procedure.

The problem of interaction between a human operator and a control system remains relevant to this day. Analysis of emergency situations at industrial facilities, many of which led to catastrophic consequences, showed that in most cases it is human error that is the root cause of such problems. Development and implementation of automated control systems based on modern technical means of automation and control are designed to solve the problems of increasing the level of safety in production.

The proposed automated process control system for hot water production in a gas boiler house performs the following functions:

- monitoring process parameters;
- monitoring the technical condition of process equipment;
- presentation of current and historical information;
- detection of emergency and pre-emergency situations with automatic generation of alarm signals;
- the ability to select a process control mode.

Practical application of the proposed automated process control system ensures the solution to the following problems:

- ensuring high reliability of equipment operation;
- maintaining specified process parameters;
- minimization of the number of potential emergency situations.

The operation of the designed APCS is based on software that allows monitoring, control and analysis of emergency situations.

The proposed application software is developed based on programmable logic controllers of the ICP DAS I-7000 series. As well as input-output modules of the same series. The choice of this manufacturer is justified by the quality of the products, affordable price. This manufacturer is officially represented on the domestic market.

ISaGRAF software was chosen as the programming environment. This programming environment allows not only to develop the control program code for the controller, but also to conduct simulation studies.

The temperature of hot water supplied to the heating network and hot water supply is regulated using a three-way valve at the lower level and a PID controller at the upper level.

An automated operator station was developed for monitoring and quick operator intervention in the process occurring in the boiler room. It is a SCADA system installed on a personal computer based on the MasterSCADA 3D software. The process diagram is shown in Fig.1. Using the automated workplace, the operator can change the temperature settings both at the outlet of the boilers and at the outlet of the boiler room. There is also a log of errors and emergency situations.

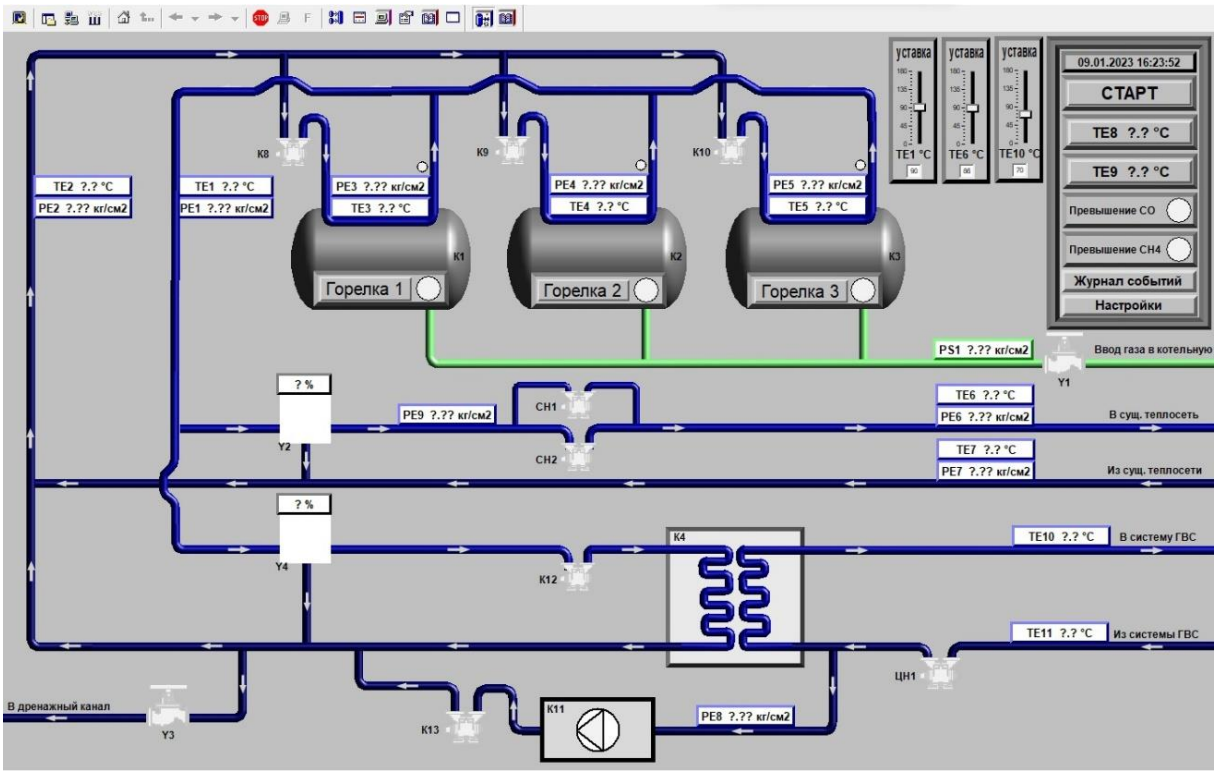

Figure 1 - Mnemonic diagram of the process.

The developed application software meets the following requirements:

- the need to maintain the temperature of water at the outlet of the boilers;
- the need to control the temperature of water supplied to the heating network and hot water supply.
- the need to maintain a set value of water temperature.

The efficiency of the developed APCS is ensured using modern microprocessor control tools.

When developing the structure of the APCS, the main attention was paid to issues of ensuring the reliability and efficiency of the automated facility. The cost criterion of the system was also considered.

The proposed APCS has a hierarchical two-stage architecture:

- the lower level (first stage) consists of the following elements: sensors, measuring transducers, actuators, secondary devices;
- the upper level (second stage) includes software and logic controllers. Upper-level elements receive information from sensors and actuators, perform their primary processing and generate control commands.

Conclusion

Thus, the developed automated process control system for hot water production in a gas boiler house meets modern requirements for automated control systems. It allows increasing the level of production quality and ensures the required level of safety for gas boiler houses.

References

1. Pogonin V.A., Elizarov I.A., Tret`yakov A.A., Nazarov V. N., Skvorczov S.A. Avtomatizaciya texnologicheskix processov i proizvodstv [Automation of technological processes and production] Tambov. TIXM. 2005. 124 p. (Rus)

2. C.I. Dvoreckij S.G. Tolstyh, E.V. Peshkova. Issledovanie sistemnyh svyazej, zakonomernostej funkcionirovaniya i gibkosti energo- i resursosberegayushchih HTS tonkogo organicheskogo sinteza [Investigation of system connections, patterns of functioning and flexibility of energy- and resource-saving CTS of fine organic synthesis] Tambov: Izd-vo FGBOU VPO «TGTU», 2013. 13 p. (Rus)

Разработка автоматизированной системы управления газовой котельной

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Аннотация. В статье рассматриваются основные принципы создания автоматизированных систем управления технологическими процессами, требования к структуре АСУ ТП. Обсуждаются вопросы обеспечения промышленной безопасности. Представлены результаты разработки программного обеспечения для АСУ ТП производства горячей воды в газовой котельной. Разработанное прикладное программное обеспечение может быть использовано при проектировании АСУ ТП газовых котельных различной мощности.

Ключевые слова: автоматизация, безопасность, программное обеспечение, технологический процесс, управление, эффективность.

УДК 67.02

Modern methods of machining through the example of eye bars

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Abstract
This article describes the sequence of operations for the part processing process using modern techniques and equipment. It also notes the possibility of using CAD programs that allow you to check technological processes in a visualized format.
Keywords: CAD program, Compass, model, modeling, Solidworks, technology.

Introduction

In modern manufacturing, mechanical processing of parts plays a key role in ensuring the accuracy and quality of finished products. An effective combination of traditional methods and modern technologies enables to achieve high performance and optimize production processes. In this article, we will look at the sequence of part processing operations, including turning, milling, and drilling operations, as well as the importance of using CAD programs to analyze and improve design.

Eye bars are elements of connecting mechanisms designed to transform movement. They provide free suspension of other components of the device that have holes at the ends or longitudinal slots, and serve as structural elements for hinged connection with mating parts and assembly units. Earrings can have a variety of configurations, varying in shape and size depending on their purpose.

These parts are processed on the following types of machines:

- Lathes
- Milling machines
- Drilling machines
- Automatic machines

The materials used for their production can vary significantly-from ordinary grade 45 steel to specialized alloys. As a blank, bars or alternative options are used, if the property of the metal allows it. There is an outdated drawing for this part, which was developed in accordance with previous standards, having a number of shortcomings. To optimize your work and improve your understanding of the process, you need to create a 3D model that will be used to develop a new drawing.

Main types and their comparison

Taking into account the selected software designed for creating three-dimensional models, it is useful to briefly consider their capabilities and classification. There are many programs that allow you to recreate 3D models, which can be divided into three main types:

1. Polygonal features
2. Parametric parameters
3. Voxels

The first and third types are not suitable for our task, since they belong to the "design" areas of modeling. In contrast, parametric modeling is the optimal approach for technical activities. These programs allow you to save the specified properties of the model, ensuring high accuracy and reproducibility of the designed objects.

Among the best available 3D modeling programs are Compass 3D [1] and SolidWorks [2]. To choose the right software, you need to carefully study all the functionality of these programs and determine what features we need when creating a model.

If we talk about the best experience with programs, the choice will probably fall on SolidWorks, as it offers a wider functionality and better opportunities for importing into other system software solutions, such as Siemens NX, Inventor, Fusion 360 and others.

However, Compass 3D also has similar functionality, and the absence of some commands will not have a significant impact on the design process of this part. However, if you need to calculate the strength of the part in the future, it may be better to use a different program for this task. In this case, we will choose Compass 3D, which is suitable for your current needs.

The result of processing the workpiece using the basic technological process is shown in Fig. 1.

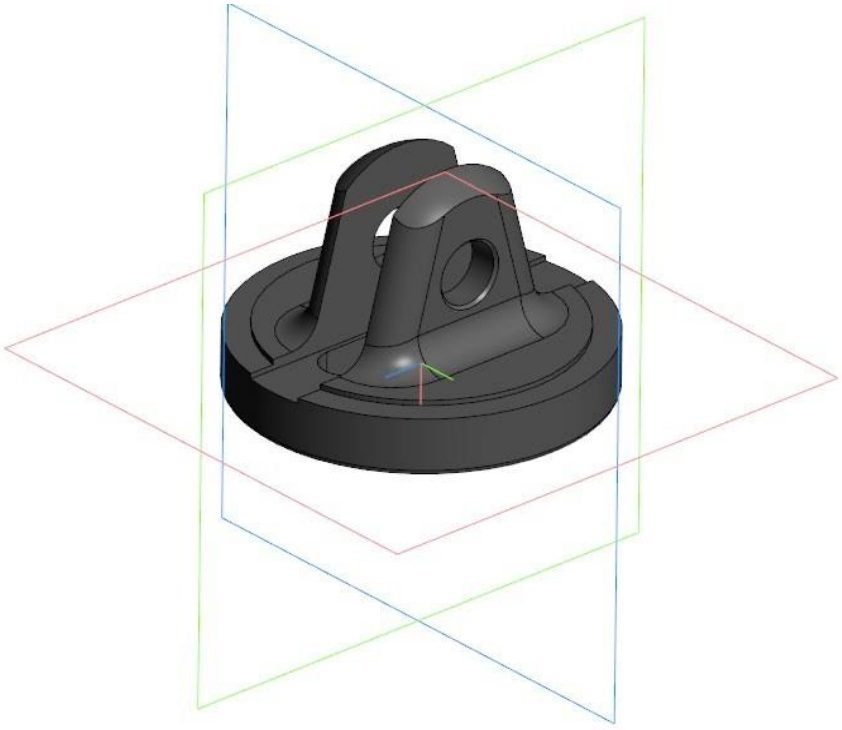

Figure 1 - Eye bars, general view

Basic technological process "Eye bars"

1. Primary installation: The end face of the part and its side surfaces are processed on the lathe. This stage includes rough processing aimed at giving the part the necessary geometric shape.
2. Flip a part: After finishing the processing of the end and side surfaces, the part

is turned over. In this position, the previously machined part is used to install the part in the lathe, where a groove is made, the purpose of which is to achieve a given roughness on the treated surface.

3. Cone processing: Next, the cone is processed on a numerically controlled machine (CNC), where turning is performed at an angle with the formation of rounding, which allows you to achieve the required geometric characteristics of the part.

4. Finishing milling: The final stage of processing the cone is carried out by milling, including rounding the base and creating recesses along its edges, which provides the necessary appearance and functional properties of the part.

5. Drilling holes: Then the side parts of the part are centered, after which we drill holes in them. Processing of these holes is completed by milling with chamfering, which ensures that the specified surface roughness around the holes is achieved.

6. End face treatment: After that, the part is turned over in the machine, and the end face is centered. A tool hole is drilled in it (Fig. 2).

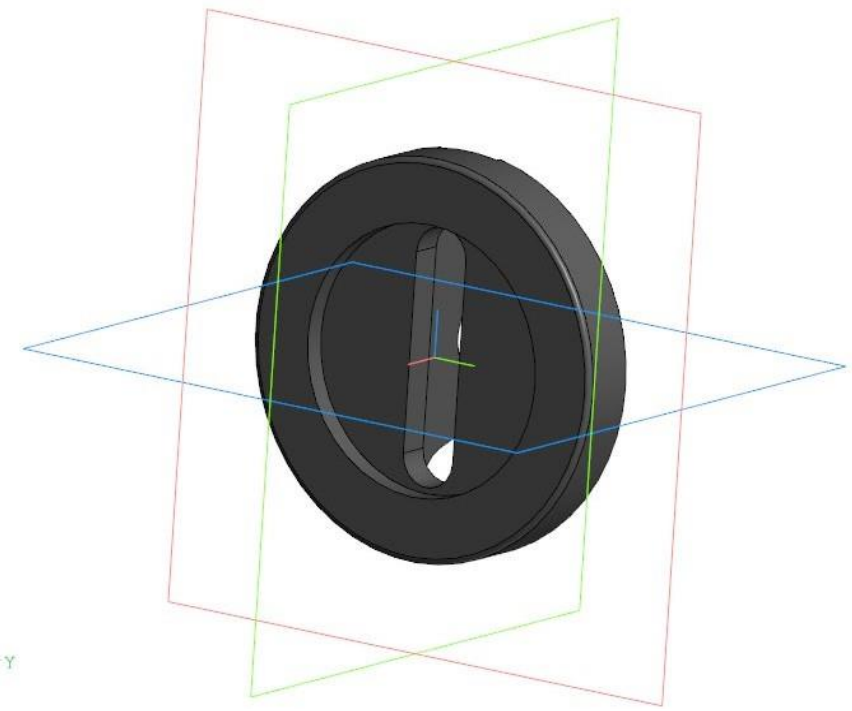

Figure 2 - Eye bars, bottom view

7. Groove milling: The final step is to mill the groove in the area of the internal holes, which allows you to create the necessary grooves that have functional significance for further assembly of the part.

After completing the previous stages, the part is turned over, after which milling is performed, as a result of which "lugs" are formed. At this stage, part machining is considered complete. To further improve the technology use the following article [3]. This article will offer not only computer modeling methods, but also optimize the cutting

process during metal turning.

Conclusion

It should be noted that the part design process can be implemented in any specialized CAD program, which allows you to identify shortcomings in the technology at the modeling stage. This practice is important because idealizations are possible in theoretical calculations and representations that do not always correspond to real production conditions. This approach significantly increases the probability of successful implementation of the technological process and minimizes possible errors in the future.

References

1. Web help COMPASS 3Dv21. Available from: https://help.ascon.ru/KOMPAS/21/ru-RU/index.html (Accessed 12.12.2024)
2. Web SOLIDWORKS Help. Mode to the journal. Available from: https://help.solidworks.com/?_gl=1*8swgk5*_up*MQ..*_ga*MTI1MDgyNjI5NS4xNzI3NDQ1MDcy*_ga_XQJPQWHZHH*MTcyNzQ0NTA3Mi4xLjEuMTcyNzQ0NTEwMC4w LjAuMA. (Accessed 12.12.2024).
3. Altunin K.A., Pestrecov S.I., Sokolov M.V., Tolmachova E.V. Optimizacija konstruktivnyh i rezhimnyh parametrov processa rezanija [Optimization of design and operating parameters of the cutting process]. 2015, No 5, pp 101-105. (Rus)

Современные методы обработки деталей на примере детали «Серьга»

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Аннотация. Описана последовательность операций для технологического процесса с использованием современных методик и оборудования. Отмечается возможность использования программ САПР, которые позволяют проверять технологические процессы в визуализированном формате.

Ключевые слова: моделирование, модель, Solidworks, Compass, технология, CAD программа.

УДК 681.5

The modern principle of creating the APCS

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Abstract
The objective of this article is to examine the manufacturing and technological processes employed at JSC «Pigment», as well as to propose solutions to existing issues. The analysis revealed certain shortcomings, including a lack of automation or insufficient automation in the production processes at JSC «Pigment». The article presents principles for enhancing product quality and efficiency through the implementation of automated process control systems. The fundamental principles of establishing an automated process control system and its structure are also discussed. The benefits of utilizing SCADA systems and the fundamentals of PLC operation are explored. These measures are intended to address the issue not only within the confines of JSC «Pigment» but also within the broader chemical industry.
Keywords: automated process control system, programmable logic controllers, two-tiered hierarchical structure.

Introduction

Automation is the cornerstone of the technological process. No industry can function without it. It enables you to streamline the process to the maximum extent, minimizing expenses and the impact of human error on the technological process.

Upon examining the manufacturing operations of JSC «Pigment», it became evident that certain processes are not fully automated or contain flaws that hinder their optimal performance. A contemporary approach to developing automated control systems will be required to address this issue.

Tasks and functions of the APCS

The automated process control system (APCS) provides improved economic efficiency and increased process safety. This is due to the optimization of the process itself through the use of modern sensors, controllers and actuators, which provide almost complete control of production with minimal human influence [3, 4].

An automated process control system must perform information and computing, control and signaling functions.

The information computing function collects and processes data on the state of the technological process. Monitors the parameters of the technological process and checks them for compliance with the standards established in the production process.

The control function performs process stabilization and adjustment of technological variables based on the data obtained. Performs the transition to the required operating mode when the process conditions change.

The signaling function performs timely informing of personnel in case of critical violations during the technological process.

This approach to the creation of automated process control systems, together with the use of modern devices, will allow JSC «Pigment» to achieve an increase in productivity and increase the safety of those processes that currently suffer from insufficient

automation and use old equipment.

The structure of the APCS

The automated system is a two-level hierarchical structure:

– at the lower level there are: sensors, measuring instruments, actuators and other secondary devices;

– at the upper level there are: programmable logic controllers (PLCs), which provide reception and processing of information coming from sensors and actuators, as well as the formation of control commands coming from the operator's workplace.

Using SCADA systems in APCS

One of the features of the automated control system is the possibility of using SCADA systems. SCADA systems allow continuous monitoring of the technological process and timely response to emergency situations. It allows you to manage and monitor the flow of the technological process at facilities that may be located at a considerable distance from each other [2]. This feature allows you to increase productivity several times and reduce the time spent on tasks within a single technological process.

The SCADA system is a human-machine complex. The mandatory presence of a human operator is required to control the system. The operator's task is to constantly monitor and monitor the indicators of the technological process, and also, if necessary, make necessary edits to the system task [2].

The SCADA system necessarily includes three main elements:

– Remote Terminal Unit (RTU) is a device located on the object itself and performs the function of data collection and management;

– Master Terminal Unit (MTU) which provides a representation of the collected data in the form of a human-machine interface.

In the case of «JSC» Pigment, the widespread introduction of SCADA systems would help reduce the influence of the human factor, as well as increase the speed and efficiency of tasks.

PLC in the automated control system

The use of a PLC is also an important part of a modern automated control system. It can be used as the basis of all automation, unlike other devices that have a limited set of functions.

The PLC has the ability to both collect data from sensors and implement control of actuators with different types of signals (discrete and analog) [1].

The versatility of the PLC will allow JCS «Pigment» to reduce the cost of additional conversion and control devices, as well as reduce the number of devices in the instrument chain of the automated control system.

Conclusion

Today, an automated process control system is one of the most important parts of modern production. It allows you to achieve a sufficiently high level of efficiency, quality and safety in the production of various products.

The modern principle of automated process control system development discussed in this article can help JSC «Pigment» solve the problems that they currently have. The introduction of automated process control systems and the use of modern sensors and

mechanisms will improve the safety and efficiency of production. The use of SCADA systems will allow for flexible control of the technological process, timely notification and response to problems that have arisen.

References

1. I.A. Elizarov, P.M. Onevskij, V.A. Pogonin, A.A. Tret'yakov. Promyshlennye vychislitel'nye seti: uchebnoe posobie [Industrial computer networks] Tambov: Izd-vo FGBOU VPO «TGTU», 2012. 152 p. (Rus)
2. I.A. Elizarov, A.A. Tret'yakov, A.N. Pchelincev. Integrirovannye sistemy proektirovaniya i upravleniya. SCADA-sistemy: uchebnoe posobie [Integrated design and management systems. SCADA-systems] Tambov: Tambovskij gosudarstvennyj tekhnicheskij universitet, EBS ASV, 2015. 160 p. (Rus)
3. P.M. Onevskij, V.A. Pogonin, S.A. Skvorcov. Avtomatizaciya tekhnologicheskih processov i proizvodstv [Automation of technological processes and productions] Tambov: Izd-vo FGBOU VPO «TGTU», 2012. 10 p. (Rus)
4. C.I. Dvoreckij S.G. Tolstyh, E.V. Peshkova. Issledovanie sistemnyh svyazej, zakonomernostej funkcionirovaniya i gibkosti energo- i resursosberegayushchih HTS tonkogo organicheskogo sinteza [Investigation of system connections, patterns of functioning and flexibility of energy- and resource-saving CTS of fine organic synthesis] Tambov: Izd-vo FGBOU VPO «TGTU», 2013. 13 p. (Rus)

Современный подход к созданию АСУ ТП

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Аннотация. Целью данной статьи является анализ производства и технологических процессов, протекающих на АО «Пигмент», а также приведение способа решения имеющихся проблем. В ходе анализа были выявлены некоторые недостатки, связанные с недостаточным уровнем автоматизации или её отсутствие на производства на АО «Пигмент». Приведены пути повышения качества продукции и ее эффективности с помощью автоматизированных систем управления технологическими процессами. Также были рассмотрены основные принципы создания автоматизированной системы управления технологическими процессами и ее структура. Рассмотрены положительные стороны использования SCADA-систем и принципы использования ПЛК. Данные меры призваны решить проблему не только на производстве АО «Пигмент», но и в химической промышленности в целом.

Ключевые слова: автоматизированная система управления, двухуровневая иерархическая структура, программируемые логические контроллеры.

УДК 622.691.4

Methods of improving the efficiency and safe operation of the linear section of the main gas pipeline

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Abstract
The importance of transporting gas over long distances to consumers has resulted in an extensive network of long-distance pipelines. Ensuring their throughput capacity is a key factor in maintaining supply efficiency. This paper examines methods of modernizing linear sections of gas main pipelines to improve their safety and reliability, focusing on increasing the safety of existing above-ground sections of gas pipelines through the introduction of new technologies. The proposed methods of modernization of linear parts of gas main pipelines have practical significance and can be adapted to different conditions. The developed methodology can serve as a basis for improving the safety and reliability of gas pipeline transportation, which will be relevant for its operation in the future.
Keywords: increase, efficiency, safety, linear, part, main, gas pipeline.

Introduction

The need to transport large quantities of gas over long distances to consumers has promoted the development of a network of pipelines of considerable length. At present, trunk pipelines make it possible to supply vast territories with hydrocarbon raw materials not only to Russian consumers, but also to foreign partners. At the same time, it should be noted that an important component of uninterrupted supplies is to ensure the throughput capacity of the internal cavity of pipelines, which can vary depending on the properties of the transported medium and lead to a drop in supply volumes and reduce the efficiency of the entire volume of oil and oil products pipeline transportation facilities. Therefore, based on the above, the key task of the trunk pipelines is to maintain the balances of planned volumes of delivery to consignees of all required commodity products through the pipeline.

In [1], the author discussed the ways of improving the safety of operating above-ground sections of main gas pipelines by developing and implementing methods of their conversion to a protected version without stopping gas transportation. As a result of the research, the methodology of calculation of stress-strain state (STS) of the above-ground section of the gas pipeline at its transfer to underground execution was developed. In addition, the study carried out in the research institute “VNIIGAZ” was aimed at reducing the accident rate of gas pipelines with damage on the basis of the concept of operation by technical condition. As part of the research, a system of mathematical models for determining the damageability of pipes from various defects, methods for planning of in-line diagnostics of gas pipelines, optimization of pre-repair inspection and others were developed.

Materials and Methods

The linear part of the main gas pipeline (LP MG) is a part of the main gas pipeline that unites compressor stations and other facilities of the main gas pipeline into a single gas transportation system for natural gas transmission from fields to consumers.

Bypass piping of valves on main gas pipelines [2], is used to тprevent catastrophic development of an emergency in case of breach of the integrity of the main gas pipeline to provide the valve with pulse gas in emergency situations and for its use as an accumulator of pulse gas.

The goal of the research is modernization of the linear section of the main gas pipeline with a capacity of 10 million m^3/day to improve its safe operation. To achieve this goal it is necessary to complete the following tasks:

1. to study the regulatory documentation and literature on this topic;
2. to analyze the operational parameters of the linear section of the gas pipeline;
3. to consider the methods used to improve the efficiency and safe operation of the linear section of the pipeline;
4. to develop recommendations for modernization of the linear section of the main gas pipeline.

The paper investigates a method of modernizing a linear section of gas pipeline from a safety perspective. I analyzed the literature and scientific papers related to this topic.

Results and Discussion

To ensure safe operation of the linear section of the main gas pipeline it is proposed to modernize it by using the bypass piping of valves. This method of modernization cannot be compared with other methods because it is a new method of modernization.

To calculate the operating parameters of the pipeline, the pipeline capacity, internal gas temperature and length of the pipeline were specified. According to these data, the required pipe diameter, pipe wall thickness and steel grade were selected. The gas flow rate and capacity, gas density and gas losses during transportation were calculated.

The methods used to improve the efficiency of the pipeline are: doubling the number of compressor stations, installing looping, laying an insert and changing the operating pressure.

The method of increasing the efficiency of gas pipeline was used in this work - installation of looping, as this method is quite effective, less time is spent on its installation, in comparison with doubling the number of compressor stations and lower monetary costs.

The calculation of pipe diameter and wall thickness for tapping was done, gas flow rate in tapping, length of tapping and overall performance improvement of the pipeline with tapping was calculated.

In addition, the flange connection of pipes was calculated for tight and durable connection of pipeline elements to each other and to special equipment.

Conclusion

The proposed method of modernizing a section of the main gas pipeline is unique. It can be applied to different sections of the pipeline. Over time, this method can be improved or refined.

References
1. Mustaev A.G. Povy`shenie bezopasnosti dejstvuyushhix uchastkov gazoprovodov putem perevoda ix v zashhishhennoe ispolnenie [Improving the safety of operating gas pipeline sections by converting them to a protected design] (Rus)
2. Davy`dov M.A. Patent Obvodnaya truba kranov na magistral`ny`x gazoprovodax, primenyaemaya katastroficheskogo razvitiya avarijnoj situacii pri narushenii celostnosti magistral`nogo gazoprovoda dlya obespecheniya krana impul`sny`m gazom v avarijny`x situaciyax i dlya ispol`zovaniya ego v kachestve akkumulyatora impul`snogo gaza № 2714466 [Bypass piping of cocks on main gas pipelines, applied catastrophic development of an emergency situation in case of a breach of integrity of a trunk gas pipeline to provide a tap with pulse gas in emergency situations and for its use as a pulse gas accumulator"]. Application: 2018101566, 16.01.2018. Date of filing. Application: 16.01.2018 (43) Application publication date: 16.07.2019 Bulletin No. 20 (45) Published: 17.02.2020 Bulletin No. 5.] (Rus)
3. Paxomov A.N., Gatapova N.Cz., Kiladze V.V., Orlov A.Yu. Modelirovanie neravnomernoj zagruzki truboprovodny`x sistem na primere setej gazoraspredeleniya [Modeling of uneven loading of pipeline systems on the example of gas distribution networks]. Vestnik TGTU. 2023. №1, pp. 91-101 DOI: 10.17277/vestnik.2023.01. pp. 091-101 (Rus)

Методы повышения эффективности и безопасной эксплуатации линейной части магистрального газопровода

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Аннотация. Важность транспортировки газа на большие расстояния к потребителям привела к созданию обширной сети магистральных газопроводов. Обеспечение их пропускной способности является ключевым фактором поддержания эффективности поставок. В данной работе рассматриваются методы модернизации линейных участков магистральных газопроводов с целью повышения их безопасности и надежности, при этом основное внимание уделяется повышению безопасности существующих надземных участков газопроводов за счет внедрения новых технологий. Предложенные методы модернизации линейной части магистральных газопроводов имеют практическое значение и могут быть адаптированы к различным условиям. Разработанная методика может послужить основой для повышения безопасности и надежности газопроводного транспорта, что будет актуально при его эксплуатации в будущем.
Ключевые слова: повышение, эффективность, безопасность, линейный, часть, магистральный, газопровод.

УДК 65.011

Industry patent landscape as a tool for assessing competitiveness and potential of technologies

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Abstract
This work is aimed at studying the patent landscape as a tool for assessing the competitiveness and potential of technologies. The purpose of the work is to study the methods of analysis, as well as to identify key problems in the study of the patent landscape.
Keywords: patent analysis, patent landscape, patent, patent search.

Introduction

The patent landscape plays an important role in business and research, providing information on the state of intellectual property in a particular technological area. It helps to assess the level of competition, determine technology development trends, and identify the strengths and weaknesses of competitors. Patent landscape analysis includes the use of patent mapping, cluster analysis, and patent family assessment methods. This allows you to visualize knowledge about technology, identify groups of patents, and identify promising areas for research and development (R&D). However, obtaining up-to-date information on patents requires significant resources and time, and some companies may use patent strategies to block competitors. When analyzing the patent landscape, it is worth considering not only the number and distribution of patents but also trends in their use and compliance with current market needs. Proper analysis and use of the patent landscape contribute to technological breakthroughs and increased competitiveness in the market.

Patent landscape

The patent landscape has its own problems and limitations. Patents do not always reflect all developments in science and technology, the patenting process can be lengthy, and patent information requires specialized knowledge to interpret. Legislation and international regulations also affect patent activity. It is necessary to consider the patent landscape as a tool for assessing the competitiveness of technologies and integrate its data with other sources of information to form a complete picture of the prospects of a technology [1].

The role of patents in assessing competitiveness

Patents are a tool for assessing the competitiveness of technologies. They help determine the level of innovation of an enterprise, record the results of research and development, identify key players in the market and determine the direction of scientific and technological progress. Patents also play an important role in shaping business strategies, protecting intellectual property and creating commercial strategies. However, to fully assess competitiveness, it is necessary to take into account other factors, such as

financial resources, quality of management and access to markets.

Stages of creating a patent landscape

To create a patent landscape, it is necessary to complete the following stages:

1. Setting the research objective and studying general information on the technology in question.

2. Defining the area of study (boundaries and structure of the search area, territorial coverage of the search, search depth).

3. Developing a search strategy and conducting a search. The main element of the search strategy is usually keywords (subject search) and classification codes (classification search).

4. Assessing the quality of patent collections, which consists of comparing the results of text queries with target indicators. In case of significant discrepancies, the strategy is adjusted.

5. Conducting logical and arithmetic control of data, cleaning and grouping information for their aggregation.

6. Visualizing the analysis results using various types of diagrams, network graphs, conceptual, cluster, landscape and heat maps, correspondence and compatibility matrices, time scales, etc.

7. Compiling a summary report.

Analysis methods

Patent landscape analysis includes quantitative and qualitative approaches. Quantitative analysis studies patent statistics, their distribution and dynamics, while qualitative analysis analyzes patent texts and key technologies.

Important analysis methods include technology tracking, trend analysis and network modeling. They help identify connections between patents, companies and inventors, assess the impact of technologies and identify development trends.

Using innovative indices and machine learning improves the efficiency of the analysis and allows drawing practical conclusions for the development and growth of organizations based on structured data on technology and the market.

Limitations of patent landscape analysis

Patent landscape analysis has several limitations: incomplete data, outdated information, jurisdictional differences, and database quality. It also faces data interpretation challenges due to legalese and the lack of standards in describing innovations. All of these make it difficult to adequately assess competitiveness and technological trends.

Limitations of patent landscape analysis include incomplete data, outdated information, jurisdictional differences, and database quality. Data interpretation challenges are due to legalese and the lack of standards in describing innovations. All of these make it difficult to adequately assess competitiveness and technological trends.

Source data quality issues include differences in patent systems, filing processes, and requirements, errors in patent documentation, and human error. Access to comprehensive patent data may be limited for small and medium-sized companies due to high subscription prices and unavailability of analysis tools.

Patents may be susceptible to manipulation when companies patent redundant or unrealistic technologies to create barriers to entry. The methodology of the analysis must take these aspects into account to ensure that the results reflect reality [2].

Challenges in data availability

Challenges in patent landscape analysis include data availability and quality, language barriers, differences in classification systems, and paid access to some patents. Taking into account the dynamics of technological change and structuring the data are also important. Researchers should use qualitative methods, such as interviews with experts.

There are problems with funding and resources for qualitative patent landscape analysis. Large companies can afford to allocate funds for studying patents, while small and medium-sized enterprises find it difficult. Due to the lack of funding, the work can be superficial and ineffective, which leads to the loss of important insights. The lack of an interdisciplinary approach also affects the quality of the analysis, requiring the involvement of experts from different fields.

Conclusion

Using the patent landscape has its own challenges. Qualitative analysis of a large amount of information is important for accurate conclusions. Time and financial costs can be high for some companies, especially small and medium-sized enterprises. Not all patents are equal, and the number does not always indicate real innovative activity. It is important to pay attention to the quality and relevance of patents for a specific activity. In the future, artificial intelligence and machine learning will improve the analysis of the patent landscape, making it accessible and less expensive for businesses.

References

1. A. V. Klemenko, P. S. Popov, I. K. Rogov. Patentnyy landshaft v oblasti vozobnovlyayemykh istochnikov energii: analiz patentov i ikh vliyaniye na razvitiye otrasli. Zhurnal "Innovatsii i tekhnologii", No. 3, 2020.

2. M. M. Mikhailov, A. A. Kuznetsov, L. V. Petrova. Otsenka innovatsionnogo potentsiala i konkurentosposobnosti kompaniy s pomoshchyu patentnogo analiza. Zhurnal "Innovatsionnyy menedzhment", No. 4, 2019.

Отраслевой патентный ландшафт как инструмент оценки конкурентоспособности и потенциала технологий

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Аннотация. Данная работа направлена на изучение патентного ландшафта как инструмента оценки конкурентоспособности и потенциала технологий. Целью работы является изучение методов анализа, а также определение ключевых проблем в изучении патентного ландшафта.

Ключевые слова: патентный анализ, патентный ландшафт, патент, патентный поиск.

УДК 621.868.277.7

Design system and manufacturing technology for adaptive modular tooling for loaders

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Abstract
In today's market, with its high demands for efficiency and flexibility in logistics processes, traditional methods become outdated. The limited functionality, high maintenance costs and storage requirements, as well as the risk of misuse of equipment, call for innovative solutions. One of the most promising design decisions is the development of modular equipment for loaders, which makes it possible to adapt equipment to different operating conditions, optimise costs and improve safety.
Keywords: custom design, efficiency, flexibility, forklifts, modular equipment, safety, standardization.

Introduction

This article is devoted to the description of the basic principles of developing modular equipment for industrial loaders. It analyses the advantages of modular equipment over traditional analogues and determine the directions for further development. Special attention is paid to innovative approaches for creating universal modular loaders in different industries, from construction to logistics.

Modular Equipment: Advantages and Opportunities

Modular equipment is a term often used in the industry, but what does it really mean? In this article we will try to unlock the secrets of this revolutionary invention in engineering.

Modular equipment offers incredible flexibility, efficiency and innovation. They are machines or systems made up of autonomous units or modules that can be created independently [1] These modules can be integrated into larger systems, allowing them to be combined to perform different tasks. Instead of buying separate equipment for each operation, companies can invest in a universal system that can easily adapt to changing needs. The design of modular equipment is based on several key principles:

Standartisation	Modules have standard sizes and interfaces, making them much easier to combine and replace. This ensures compatibility between different modules.
Independence	Each module is a self-contained unit with its own set of components. This means that each module can operate independently or as part of a larger system
Scalability	The design makes it easy to expand the system. Additional modules can be added to increase performance or functionality without the need for a complete redesign.
Flexibility	Modules can be reconfigured or replaced as needs change or technology advances

Integration	Despite their autonomy, modules must be designed to integrate easily with other parts of the system to ensure the smooth operation of the overall structure

Advantages of modular attachments

Obvious possibilities of modular equipment application:

Easy to install and remove	The modules can be quickly installed and removed, allowing you to quickly adapt the loader to a specific task
Increased functionality	Modular attachments allow you to perform different tasks such as loading bulk materials, moving bulky goods, working with containers and many others
Save time and resources	Installing and replacing modules takes much less time than buying and configuring a new loader. This reduces downtime and improves operational efficiency
Reduce costs	Using modular equipment can be more cost effective than buying specialised loaders for each job
Flexibility and adaptability	Modular equipment easily adapts to changing working conditions, enabling optimised production processes

Examples of modular attachments

Buckets for loose materials such as sand, crushed stone and gravel. The buckets are available in of different shapes and sizes, which allows you to choose the best option for a particular type of load. For example, the jaw bucket (Fig. 1) is installed on front loaders; it is a universal multi-operational bucket; it is designed to perform a wide range of work, replacing a variety of work, replacing a variety of a wide range of works, replacing many standard tools.[2]

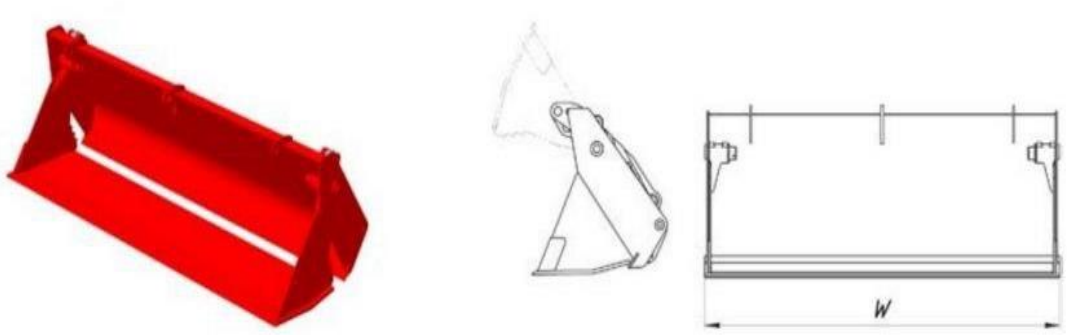

Figure1 - Buckets for loose materials such as sand, crushed stone and gravel

Forks for moving pallets and other loads placed on pallets. These forks can be equipped with additional functions such as height adjustment lifting height. For example, silage forks (Fig. 2) are mounted on front loaders and telescopic handlers. They are designed for collecting, moving and loading manure, silage, branches and various debris.[1]

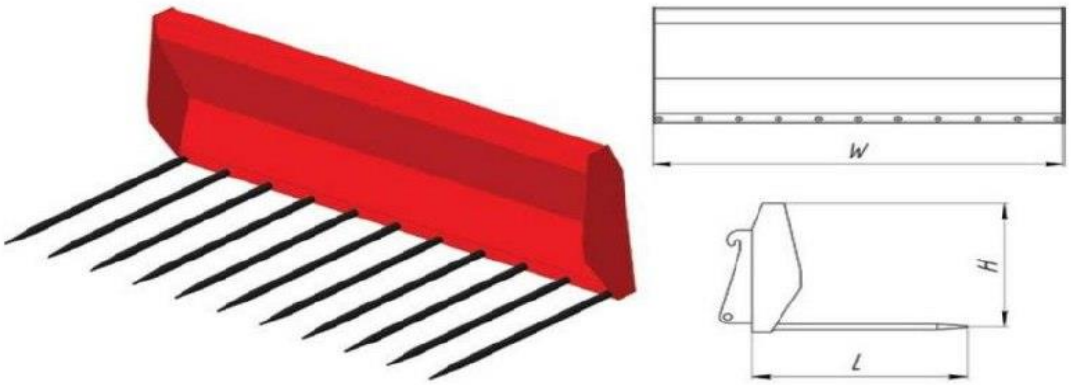

Figure 2 - Forks for moving pallets and other loads placed on pallets.

Conclusion

Innovative approaches to the design of modular equipment for loaders open up a whole new dimension of opportunities for companies concerned with the efficiency, flexibility and safety of their operations. Investments in modern technologies and materials allow us to develop high quality and reliable equipment that meets the highest quality standards. Among the offers of the new market, modular equipment, developed with innovative methods, will become a reliable offer for the optimisation of logistics and warehouse operations.

References

1. M.M. Karpenko, L.E. Pelevin. Perspektivy ispol'zovaniya gidravlicheskikh energosberegayushchikh privodov [Prospects for the Use of Hydraulic Energy-Saving Drives] / M.M. Karpenko, L.E. Pelevin. // Technical and Technological Problems of Service. — 2017. — No. 3. — P. 7-11.
2. I.P. Filonov. Innovatsii v oblasti mashinostroyeniya [Innovations in Mechanical Engineering Technology] / I.P. Filonov — 1. — Minsk: Higher School, 2009 — 111 p.

Система проектирования и технологии производства адаптивной модульной оснастки

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Аннотация. В условиях быстро меняющегося рынка логистики и складской техники старые подходы к оснастке погрузчиков уже не могут погасить все возрастающие потребности предприятий. В связи с Малой функциональностью, большими затратами на хранение и обслуживание, а также риски, связанные с неверным использованием, появилась потребность в новых решениях. Технические решения такие, как подходы к созданию модульного оборудования для погрузчиков, предлагающие гибкость конструкции, модульность, повышение эффективности и безопасности выходят на передний план. В данной статье рассматриваются преимущества модульной оснастки, а также инновационные подходы к ее созданию, включая использование композитных материалов, индивидуальное проектирование и стандартизации.
Ключевые слова: безопасность, гибкость, индивидуальное проектирование, модульная оснастка, погрузчики, унификация и стандартизация, эффективность.

УДК 004.94

Creating a digital twin of a thermochemical oxygen generator

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Abstract
This paper describes the basic data necessary to start designing a mathematical model of a digital twin. The purpose of this work is to generalize the known methods of mathematical modeling and combine them for a key task.
Keywords: mathematical model, blocks, digital twin.

The relevance of this research area is explained by the need for further informatization of society and the use of a human-centered approach based on digital twin technology to solve a wide range of tasks in situations involving risk or limiting the possibility of direct human involvement.

A chemical oxygen generator is a device that produces oxygen through a chemical reaction. The oxygen source is typically an inorganic superoxide,[1] chlorate, or perchlorate. Ozonides are also a promising group of oxygen sources. Generators are typically ignited by a striker, and the chemical reaction is usually exothermic, making the generator a potential fire hazard. Potassium superoxide was used as an oxygen source in early crewed missions in the Soviet space program, on submarines for emergency use, for firefighting, and for mine rescue.

Commercial aircraft provide emergency oxygen to passengers to protect them in the event of a loss of cabin pressure. Chemical oxygen generators are not used for the cabin crew, who are usually supplied with compressed oxygen from cylinders, also known as oxygen tanks. In narrow-body airliners, there were oxygen masks and oxygen generators overhead for each row of seats. In some wide-body airliners, such as the DC-10 and Ilyushin Il-96, oxygen canisters and masks are mounted on the top of the seatbacks because the ceiling is too high above the passengers. If decompression occurs, panels are opened by either an automatic pressure switch or a manual switch and the masks are removed. When passengers put on a mask, they release the locking pins and start the oxygen production.

The use of oxygen generators, especially in aircraft manufacturing, is necessary, as they are responsible for the lives of many people using air transport. It is especially important to comply with all the standards and requirements for their manufacture. Like any product, oxygen generators go through the stages of developing design documentation, technological process, control over manufacturing and product quality, as well as testing for tightness and compliance with the declared characteristics.

Testing of finished products shows the ability of a given product to perform the declared functions and meet customer requirements. For successful production of these generators, methods of forecasting and modeling the operation of products that have not yet been manufactured are used. Various simulators and control stands allow obtaining the necessary parameters to identify defects in the design or control elements of the generator.

For example, the calculation modules of many drawing programs, as well as programs for constructing 3D models, allow obtaining data on strength characteristics that help to accurately select the material for manufacturing the body of a chemical generator. It is enough to have input data, such as the height of use of the product, the loads imposed on it, to obtain a model of its behavior.

But even with all the methods of analysis and design, physical testing is required to further confirm the modes and parameters of our generator's operation. From this we can conclude that to modernize the production process, it is necessary to develop a system that allows predicting and modeling the operation of the assembled product, taking into account possible interactions of the components. The system must, based on the input parameters, perform the necessary calculations and provide the user with a model of the product's operation, as well as its performance characteristics.

It is proposed to manufacture a digital twin of a thermochemical oxygen generator. The digital twin is a set of mathematical models that perform the required calculations based on the fundamental laws of mathematics, physics and chemistry. For example, when analyzing heat release during a chemical reaction with subsequent transfer of the released heat to the generator body, the digital twin will access the thermal process calculation unit. In it, the mathematical model will be based on the fundamental equations of thermodynamics. Example of thermal calculation for a heat exchanger

$$dQ = Gdi, \frac{J}{se} (or\ W),$$

$$Q = G \int_{i'}^{i''} di = G(i'' - i').$$

Each equation or function of the analyzed processes has undefined coefficients, which allow us to apply this mathematical model to our conditions. These coefficients can be obtained empirically by drawing up diagrams and graphs. By obtaining the necessary indicators, it becomes possible to complete mathematical models that will be specially designed for a specific product.

As a result, by combining calculation blocks, we obtain a digital twin of our product, which allows us to obtain an accurate calculation of the material consumption for its production, its operating parameters without the need for testing based on variable input variables. The twin significantly reduces the time for forecasting, eliminates the need to conduct tests to understand the ability of the product to meet established standards.

References

1. Kirillov D.S. Tsifrovyye dvoyniki kak osnova tsifrovoy transformatsii promyshlennykh predpriyatiy [Digital twins as the basis for digital transformation of industrial enterprises]. Current issues in economics and management, 2021, p.161-164. (Rus)

Создание цифрового двойника термохимического генератора кислорода

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Аннотация: Представлены основные данные, необходимые для начала проектирования математической модели цифрового двойника. Целью данной работы является обобщение известных методов математического моделирования и их объединение для ключевой задачи.

Ключевые слова: Математическая модель, блоки, цифровой двойник.

УДК 62-231.1

Kinematic modeling of manipulators using Lie groups and Lie algebras

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Abstract
The purpose of this study is to describe the method of modeling the kinematics of robotic devices using Lie groups and Lie algebras. The Lie group elements can be used to specify the generalized movement of rigid bodies in 3-dimensional Euclidean space, the Lie algebra elements are infinitesimal generators of such movements. The article presents the product of exponentials formula (POE) describing the kinematics of a serial manipulator. POE shows the dependence of end-effector configuration on joint's angles and Lie algebra elements, describing the spatial configuration of the joints. An example of calculating the forward kinematics of a two-link manipulator is given.
Keywords: kinematic; lie algebras, lie groups, manipulators, multibody systems, screw theory.

Introduction

Mathematical models of kinematics based on Lie groups and Lie algebras make it possible to obtain more compact expressions compared with classical methods due to the fact that angular and linear components of motion are considered together [1].

The group of rigid transformations on $\mathbb{R}^3$ is defined as the set of mappings $g: \mathbb{R}^3 \to \mathbb{R}^3$ of the form $g(x) = Rx + p$, where $R \in SO(3)$ and $p \in \mathbb{R}^3$. An element $g \in SE(3)$ can be identified as 4x4 matrix [2]:

$$g = \begin{bmatrix} R & p \\ 0 & 1 \end{bmatrix}_{(4x4)}$$

Lie algebra is an infinitesimal generator of Lie group.

$$\xi \in se(3)$$

$$\hat{\xi} = \begin{bmatrix} \widehat{\omega} & v \\ 0 & 0 \end{bmatrix}_{(4x4)}; \ \xi = \begin{bmatrix} v \\ \omega \end{bmatrix}_{(6x1)}$$

$$\widehat{\omega} = \begin{bmatrix} 0 & -\omega_3 & \omega_2 \\ \omega_3 & 0 & -\omega_1 \\ -\omega_2 & \omega_1 & 0 \end{bmatrix}; \ \omega = \begin{bmatrix} \omega_1 \\ \omega_2 \\ \omega_3 \end{bmatrix}$$

$$v = -\omega \times q$$

where ω - normalized rotation axis vector, q – point on the rotation axis.

Exponential mapping $exp: se(3) \to SE(3)$ is used to generate Lie group element from respective Lie algebra

$$g = e^{\hat{\xi}\theta}$$

POE formula

The product of exponentials is used to describe the forward kinematics.

$$g(\theta) = e^{\hat{\xi}_1\theta_1} e^{\hat{\xi}_2\theta_2} \dots e^{\hat{\xi}_n\theta_n} g_0$$

$$e^{\hat{\xi}\theta} = \begin{bmatrix} e^{\widehat{\omega}\theta} & \left(I - e^{\widehat{\omega}\theta}\right)(\omega \times v) + \omega\omega^T v\theta \\ 0 & 1 \end{bmatrix}_{(4x4)}$$

where θ - joint rotation angle.

The exponent of matrix can be calculated using Rodrigues' formula:

$$e^{\hat{\omega}\theta} = I + \hat{\omega}\sin\theta + \hat{\omega}^2(1 - \cos\theta)$$

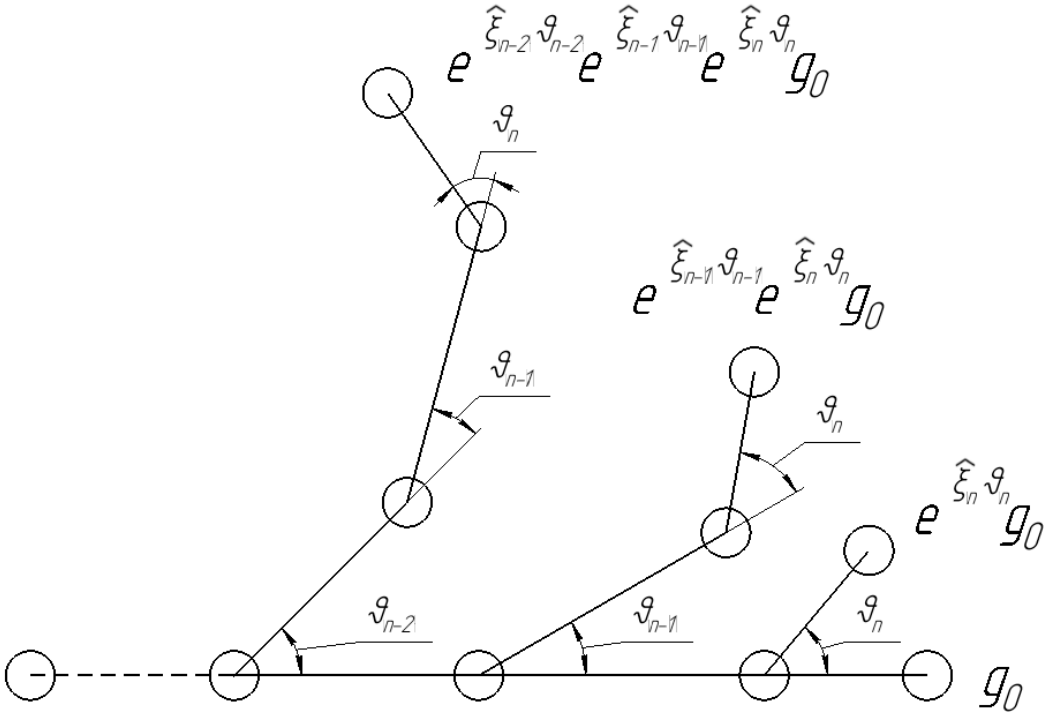

Figure 1 - Product of exponentials formula

Spatial velocity and manipulator Jacobian

Spatial velocity is a combination of translational and angular velocity of a point on rigid body. It's also described by an element of the Lie algebra.

$$V = J(\theta)\dot{\theta}$$

$$\hat{V} = \begin{bmatrix} \hat{\omega} & v \\ 0 & 0 \end{bmatrix}_{(4x4)}; V = \begin{bmatrix} v \\ \omega \end{bmatrix}_{(6x1)}$$

$$V \in se(3)$$

It's used to calculate velocity vector for some point on rigid body, knowing it's spatial coordinates q:

$$\dot{q} = \hat{V}q$$

The Jacobian of the manipulator is a mapping from the angular velocities space to the end-effector spatial velocity space. The columns of the Jacobian matrix consist of elements of the Lie algebra, taking into account the adjoint action of Lie Group. In other words, the current configuration of the joints is being considered, not the initial one [3].

$$J(\theta) = [\xi_1 \quad \xi_2' \quad \dots \quad \xi_n']_{(6xn)}$$

$$\xi_i' = Ad_{(e^{\hat{\xi}_1\theta_1}e^{\hat{\xi}_2\theta_2}\dots e^{\hat{\xi}_{i-1}\theta_{i-1}})}\xi_i$$

Adjoint action of Lie group on Lie algebra can be expressed as:

$$Ad_g = \begin{bmatrix} R & \hat{p}R \\ 0 & R \end{bmatrix}_{(6x6)}$$

$$g_j = e^{\hat{\xi}_1\theta_1} \dots e^{\hat{\xi}_{j-1}\theta_{j-1}} = \begin{bmatrix} R & p \\ 0 & 1 \end{bmatrix}_{(4x4)}$$

Example

Let's give an example of deriving the end-effector configuration, Jacobian and spatial velocity of end-effector for a two-link manipulator using Lie groups and Lie algebras.

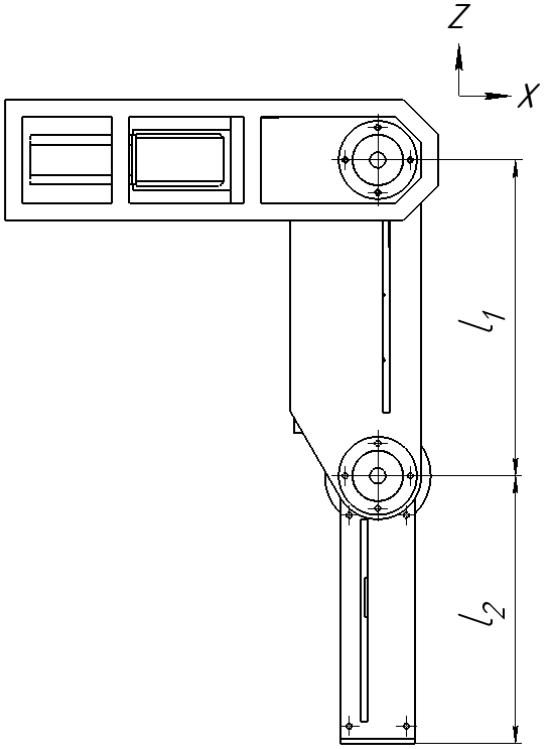

Figure 2 - Two-link manipulator

Joints' Lie algebras in homogenous coordinates:

$$\xi_1 = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 1 \\ 0 \end{bmatrix}; \; \xi_2 = \begin{bmatrix} l_1 \\ 0 \\ 0 \\ 0 \\ 1 \\ 0 \end{bmatrix}$$

Initial configuration of end-effector:

$$g_0 = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & -l_1 - l_2 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Current configuration of end-effector with respect to the joints' angles:

$$g(\theta) = \begin{bmatrix} \cos\theta_1 & 0 & \sin\theta_1 & 0 \\ 0 & 1 & 0 & 0 \\ -\sin\theta_1 & 0 & \cos\theta_1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \cos\theta_2 & 0 & \sin\theta_2 & l_1\sin\theta_2 \\ 0 & 1 & 0 & 0 \\ -\sin\theta_2 & 0 & \cos\theta_2 & l_1(\cos\theta_2 - 1) \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & -l_1 - l_2 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$g(\theta) = \begin{bmatrix} \cos(\theta_1+\theta_2) & 0 & \sin(\theta_1+\theta_2) & l_1(\sin(\theta_1+\theta_2)-\sin\theta_1) \\ 0 & 1 & 0 & 0 \\ -\sin(\theta_1+\theta_2) & 0 & \cos(\theta_1+\theta_2) & l_1(\cos(\theta_1+\theta_2)-\cos\theta_1-1)-l_2 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Jacobian and spatial velocity of end-effector:

$$J(\theta) = \begin{bmatrix} 0 & l_1\cos\theta_1 \\ 0 & 0 \\ 0 & -l_1\sin\theta_1 \\ 0 & 0 \\ 0 & 1 \\ 1 & 0 \end{bmatrix};\ V(\theta,\dot{\theta}) = \begin{bmatrix} l_1\cos\theta_1\,\dot{\theta}_2 \\ 0 \\ -l_1\sin\theta_1\,\dot{\theta}_2 \\ 0 \\ \dot{\theta}_2 \\ \dot{\theta}_1 \end{bmatrix}$$

Conclusion

In this study, the application of Lie groups and Lie algebras for modeling the kinematics of robotic manipulators has been demonstrated to offer a unified and compact framework for describing rigid body motions in 3-dimensional space. The PoE formula effectively integrates both rotational and translational components of motion, simplifying the representation of manipulator kinematics. The example of a two-link manipulator underscores the practicality of this approach, illustrating how end-effector configuration can be elegantly derived using Lie groups and Lie algebras.

References

1. Brockett R. W. Robotic manipulators and the product of exponentials formula. Springer, 2005, Vol. 58, pp. 120-129.
2. Murray R.M., Li Z., Sastry S.S. Mathematical Introduction to Robotic Manipulation. Boca Raton, Florida, CRC Press, 1994. pp. 35-42.
3. Sun P., Li Y., Chen K. Generalized Kinematics Analysis of Hybrid Mechanisms Based on Screw Theory and Lie Groups Lie Algebras. Chin. J. Mech. Eng. Vol. 34. 2021. p. 3.

Моделирование кинематики манипуляторов с использованием групп Ли и алгебр Ли

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Аннотация. Целью данного исследования является описание метода моделирования кинематики роботизированных устройств с использованием групп Ли и алгебр Ли. Элементы группы Ли могут быть использованы для описания обобщенного движения твердых тел в трехмерном евклидовом пространстве, элементы алгебры Ли являются бесконечно малыми генераторами таких движений. В статье представлена формула произведения экспонент, описывающая кинематику последовательного манипулятора. Формула произведения экспонент показывает зависимость конфигурации конечного звена от углов вращательных пар и элементов алгебры Ли, описывающих их пространственную конфигурацию. Приведен пример расчета прямой кинематики двухзвенного манипулятора.

Ключевые слова: алгебры Ли, группы Ли, кинематика, манипуляторы, многотельные системы, теория винтов.

УДК 621.81.09

Prerequisites for creating a system for forecasting costs in milling furniture decor elements

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Abstract
The paper presents the general concepts of processing materials used in decoration by milling. The development of a cost prediction system for milling decorative furniture elements is driven by the need to optimize expenses and improve production efficiency. Key factors affecting cost are analyzed, including material, tooling, cutting modes, and equipment wear. The implementation of automated forecasting will help minimize losses, enhance planning, and increase cost estimation accuracy, significantly improving the economic efficiency of furniture manufacturing.
Keywords: woodworking, milling, decor, cutters, economic feasibility.

Introduction

Processing wood materials by milling is one of the most common methods. In production conditions, machining centers, CNC machines, and general-purpose machines are used.

Milling is a process of blade processing of a material with a rotary main cutting motion at a constant radius of its trajectory and feed motion (GOST 25761-83). In this case, the workpiece allowance is removed by successively cutting off individual sickle-shaped chips. Costs for milling decorative furniture elements may include several key factors [1].

Materials and methods

There are two types of cutters – diamond and carbide. Carbide cutters are a monolithic or prefabricated tool that is turned on CNC grinding machines from cylindrical metal rods. The cutting part of the products is made of tungsten and cobalt, which determines their wear resistance and strength.

Diamond cutters are cutters that are harder than carbide ones, thanks to diamond plates, and stronger due to the steel shank. They are especially advantageous in large-scale production and can show greater durability. With careful handling, they can be sharpened repeatedly. Careful handling is, first of all, the absence of impacts in the work. But the comparatively low heat resistance of diamond also requires attention: too small feeds can lead to overheating and breakage of the cutter [1].

Materials: the cost of wood, plywood or other materials from which the elements will be made. This depends on the selected grade and quality of the material.

When milling decorative elements, various materials are used, each of which has its own characteristics, properties and purpose. Here are the main ones:

1. Wood:

- Solid wood (such as oak, ash, pine, birch) is often used for frame structures and visible parts of furniture.

- Plywood: Lightweight and durable material used as a base for various furniture elements, as well as in furniture cases.

- MDF (Fine fraction): Used to create smooth surfaces and is convenient for milling complex shapes.

2. Laminated boards: These are MDF or chipboard (chipboard) covered with a decorative layer, often used to make furniture fronts.

3. Glued laminated timber: Widely used to create strong and durable structures, such as tables and chairs.

4. Acrylic and Plastic: These materials are used to create modern furniture elements and decorative details due to their lightness and variety of shapes.

5. Glass and composite materials: Often used in combination with other materials to create original and stylish solutions.

The choice of materials depends on the design, purpose of the furniture and the desired performance characteristics. Let's take a closer look at chipboard and MDF. The surface quality of chipboard has a rougher structure compared to MDF, so the surface after milling may be less smooth.

Chipboard is more difficult to mill than MDF due to its heterogeneity. Due to which, problems such as chipping and "tearing out" of the material subsequently arise. This is especially true if milling is performed at high speed. LMDF is more difficult to mill than regular MDF due to the presence of a laminated layer that can be damaged. Milling tools must be sharpened, properly selected, and the right cutting modes selected to avoid damaging the laminated layer. Dull or poor-quality tools can leave burrs, chips, and unevenness on the surface. Insufficient cooling can lead to overheating of the tool, which can reduce the quality of processing [1].

Electricity consumption for equipment operation, especially if these are high-performance machines.

Results

Creating software for calculating the cost of milling requires knowledge of the basics of programming and an understanding of the principles of working with data. Below is an example Python script that calculates the cost of milling based on several input parameters.

```
def calculate_cost(time, material_cost, labor_rate):
A function for calculating the cost of milling.
:param time: Time spent on processing (in hours)
:param material_cost: Cost of material (in rubles per cubic meter)
:param labor_rate: Labor rate (in rubles per hour)
:return: Total cost of milling (in rubles)
# Surface area of the workpiece
surface_area = 10 # m^2 (example value)
# Volume of material removed
volume_removed = 0.01 * surface_area # m^3 (example value)
# Cost of material
material_cost_total = material_cost * volume_removed
# Labor costs
labor_cost = time * labor_rate
```

```
# Total cost
total_cost = material_cost_total + labor_cost
return total_cost
# Usage example
time_spent = 2 # hours
material_price = 5000 # rubles/cu.m
labor_rate_per_hour = 1000 # rubles/hour
cost = calculate_cost(time_spent, material_price, labor_rate_per_hour)
print(f"The total cost of milling is {cost:.2f} rubles.")
```

This script takes three parameters: the time spent on the job, the material cost, and the labor rate. It calculates the total cost of the milling operation, given the surface area of the workpiece, the volume of material removed, and the labor cost (man-hours).

Conclusion

It should be noted that the calculation of the cost of woodworking in furniture production can be implemented in any specialized software environment, but we used the open domestic software Python - the most popular among IT specialists on the market.

References

1. Wood processing by milling / Ed. I. G. Glebov. - Ekaterinburg: Publishing house of USLTU. lit., 2007. - 196 p.
2. Digital mechanical engineering [Electronic resource, multimedia]: textbook / M. N. Krasnyansky, V. G. Mokrozub, V. A. Nemtinov, M. V. Sokolov et al. - Tambov: Publishing center of FSBEI HE "TSTU", 2023 - 267 p.
3. Digital mechanical engineering / M. N. Krasnyansky, V. G. Mokrozub, V. A. Nemtinov, M. V. Sokolov [et al.]. Textbook – Tambov: Publishing center of the Federal State Budgetary Educational Institution of Higher Education “Tambov State Technical University”, 2024. – 266 p.

Предпосылки создания системы прогнозирования расходов при фрезеровании элементов декора мебели

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Аннотация. В работе представлены общие понятия обработки материалов, которые используются при декорировании, методом фрезерования. Создание системы прогнозирования расходов при фрезеровании элементов декора мебели обусловлено необходимостью оптимизации затрат и повышения эффективности производства. Анализируются ключевые факторы, влияющие на себестоимость: материал, инструмент, режимы резания и износ оборудования. Внедрение автоматизированного прогнозирования позволит минимизировать потери, улучшить планирование и повысить точность оценки затрат, что значительно повысит экономическую эффективность мебельного производства.

Ключевые слова: деревообработка, фрезерование, декор, фрезы, экономическая целесообразность.

УДК 519.612

The frame model of knowledge representation

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Abstract
The article discusses the concept of a knowledge representation frame model and its use in creating a database. The semantic network is characterized as a form of knowledge representation in the form of a set of concepts and relationships between them in a certain subject area, where three characteristic levels are distinguished. Special attention is paid to the development of frames in the form of description frames and a semantic network.
Keywords: frame, frame description, frame model, semantic network, slot, terminal slot.

Introduction

Marvin Minsky introduced the concept of frames as a way to organize knowledge in 1975, describing them as "data structures for representing typical situations." These structures encompass a diverse range of information about objects and occurrences anticipated within a specific situation, along with guidelines on how to utilize the information embedded within the frame. Frames are comprised of numerous situation-specific characteristics, termed slots, each with its own associated meaning. Generally speaking, a frame is defined by a frame name accompanied by a series of slots [1].

The concept of frames offers a broad framework for representing knowledge, with various specific implementations of this framework being developed. To illustrate, let's examine the frame model of knowledge representation used in the FRL (Frame Representation Language) system. Within this system, a frame is conceptualized as a structured entity composed of the following elements:

<FN, <SN, IP, DTP, SV, D, <X>*, where FN — frame name; ИSN — slot name; IP — the inheritance pointer; DTP — data type pointer; SV — slot value; D — daemon; <X>* — a sequence of arbitrary length elements <X>.

A frame's name acts as its distinctive identifier within a specific frame system, serving as the key to referencing it.

The slot name acts as a unique slot identifier within the frame. Some slots may be defined for intra-system purposes or reflect information common to any knowledge hierarchies [2]. For example, in the FRL system, the DEFINEDON slot stores the date of the frame definition, and the ISA slot indicates which class the frame belongs to.

The inheritance pointer is used in hierarchical frame systems to indicate how information contained in upper-level frame slots can be inherited by the corresponding lower-level frame slots.

The inheritance pointer is used in hierarchical frame systems to indicate how information contained in upper-level frame slots can be inherited by the corresponding

lower-level frame slots.

The system includes such types of inheritance as:

U (unique) — the value of the lower-level frame slot is not related to the value of the corresponding slot of the parent frame;

S (same) — the value of the slot of the child frame must match the value of the corresponding slot of the parent frame;

R (range) — the value of the slot of the child frame must be in the range specified in the corresponding slot of the parent frame;

O (override) — the default slot value of the child frame is determined by the value of the corresponding slot of the parent frame (as in the S case), but when explicitly set, it is determined by this value (as in the U case).

Inheritance enables the retrieval of data from parent frames, making it a valuable output mechanism in the frame system.

The data type pointer serves as a clear indicator of the type of data stored in the slot. The slot value is determined by the data type pointer.

A distinctive aspect of frame systems is the capacity to store not only data in slots, but also procedures, which are referred to as attached procedures. This feature allows frames to encompass both declarative and procedural knowledge.

There are different gradations of frames. Let's use one of them. Highlight the description frames (elements) and role frames (bundles).

Frame F can have a hierarchical structure

F = [<N1, V1>, ..., < Nn, Vn>]

where N1, ..., Nn is the slot name; V1, ..., Vn is the slot value. Each such pair is called a slot. Links to other frames are possible.

Here are some examples: frame description

[<machines>, <lathes, 70>, <milling machines, 20>];

[<resistor>, <nominal value, x1>, <power, x2>, <accuracy class, x3>, <design type, x4>, <GOST, x5>], where x1...x5 are variables taking different values;

The role frame is [<shipment>, <lathes, 70>, <where, Moscow>, <where, St. Petersburg>, <mode of transport, railway>].

There are also concepts of a sample frame (prototype, without entered data), called an intensive description, a frame instance with corresponding specific data, or an extensional description.

In another gradation, the following frames are distinguished: frames-structures (objects, concepts), frames-roles (object behavior), frames-scenarios (interaction of related processes) and frames-situations (influence of the external environment).

A daemon is a specific type of attached procedures that are automatically triggered by some typical event associated with a given slot. The main types of demons are:

IF-NEEDED — it is started if its value is not defined at the time of accessing the slot.;

IF-ADDED — runs when a new value is written to the slot.;

IF-REMOVED — starts when the slot value is erased.

Therefore, the management of output in frame systems is regulated through the use of inheritance, associated procedures, and background processes. The concept of frames

served as a crucial theoretical foundation for the development of object-oriented programming.

However, due to the unique nature and intricacy of the programming language, frames have limited practical application. Furthermore, they are not compatible with MLV techniques.

Each frame can be considered as a semantic network consisting of highlighted vertices and connections. The upper level of the frame represents the corresponding concept, and the subsequent levels represent terminal slots that contain specific values [4].

Conclusion

Summing up, we can say that we have given an idea of the principles of the frame model for knowledge representation and its application in developing a knowledge repository. Frames in the form of description frames and a semantic network were developed and presented for the chosen subject area.

References

1. Pamanin M.Ju., Zajceva T.V. Razrabotka frejmovoj modeli predstavlenija znanij v vybrannoj predmetnoj oblasti. Cifra. Informacionnye tehnologii i telekommunikacii. 2024. № 1 (1).
2. Jarahmedov G.A. O frejmovyh modeljah predstavlenija matematicheskih znanij. V sbornike: Izbrannye voprosy nauki XXI veka. Sbornik nauchnyh statej. Nauchnyj red. N.O. Beraja. Moskva, 2019. S. 110-114.
3. Kamynina M.A., Kanaev A.K., Oparin E.V. Postroenie frejmovoj modeli predstavlenija znanij v intellektual'noj sisteme podderzhki prinjatija reshenij sistemy upravlenija set'ju taktovoj setevoj sinhronizacii. Available from: https://cyberleninka.ru/article/n/postroenie-freymovoy-modeli-predstavleniya-znaniy-v-intellektualnoy-sisteme-podderzhki-prinyatiya-resheniy-sistemy-upravleniya-setyu (Accessed 10.03.2025). (Rus)
4. Belous E.S., Kudinov V.A., Zhelnin M.Je Sovremennye modeli predstavlenija znanij v obuchajushhih sistemah. Available from: https://cyberleninka.ru/article/n/sovremennye-modeli-predstavleniya-znaniy-v-obuchayuschih-sistemah (Accessed 10.03.2025). (Rus)

Фреймовая модель представления знаний

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Аннотация. В статье рассматривается понятие фреймовой модели представления знаний и ее использовании при создании базы данных. Дана характеристика семантической сети, как формы представления знаний в виде совокупности понятий и отношений между ними в некоторой предметной области, где выделяются три характерных уровня. Особое внимание уделяется разработке фреймов в виде фреймов-описаний и семантической сети.

Ключевые слова: семантическая сеть, слот, терминальный слот, фрейм, фреймовая модель, фрейм-описание.

УДК 57-74

Optimization of structural designs using genetic algorithms

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Abstract
This article presents the development of a method for optimizing building structures, considering load requirements and external impacts to reduce costs. The method is based on an approach of utilizing genetic algorithms, enabling a comprehensive consideration of design variables and constraints.
Keywords: cost efficiency, genetic algorithms, loads, optimization, structural design

Introduction

In modern conditions, structural designs are created with consideration of numerous factors, including cost efficiency, resilience to external impacts, and compliance with load requirements. Traditional methods used in engineering practice often face challenges in achieving a comprehensive optimization of all structural parameters. Therefore, new approaches are being developed, such as methods based on evolutionary algorithms, which are capable of automating the design process and accounting for multiple variables. Moreover, these algorithms provide flexibility in adapting to complex constraints, such as material limitations and dynamic load conditions. By utilizing advanced computational models, engineers can evaluate a wider range of potential solutions in a shorter time frame. This not only improves the accuracy of design decisions but also enhances the sustainability and economic viability of construction projects. Such advancements reflect the ongoing shift toward more data-driven and efficient design methodologies in the field of engineering. The goal of this work is to derive a formula for the optimization of building structures.

Optimization of Structural Designs Using Genetic Algorithms

Existing software tools, such as Autodesk Inventor, SCAD, and Hilti PROFIS, offer opportunities for calculating individual characteristics of building structures. Each application has its specific features: Autodesk Inventor is used for 3D modeling and analyzing basic mechanical properties, SCAD for strength and stability calculations, and Hilti PROFIS for anchor and joint calculations. These programs enable engineers to perform a segmented analysis of different aspects of the designed structure, but they are not capable of performing comprehensive optimization, considering all load, economic, and operational factors simultaneously.

To address these issues, genetic algorithms, which are highly suitable for discrete optimization of structures, have started being applied in construction practice. Earlier, the application of this method was considered in the study by Rajeev S. and Krishnamoorthy C.S. in their work 'Discrete Optimization of Structures Using Genetic Algorithms' [1] where they explored the application of genetic algorithms for optimizing structural

designs. Their research highlighted the effectiveness of genetic algorithms in handling complex optimization problems in construction, providing valuable insights into the methodology and its practical applications. Genetic algorithms are an evolutionary modeling method that simulates natural selection, allowing for the creation and refinement of design solutions through constant selection, crossover, and mutation of variants. This method enables engineers to find optimal design solutions even under numerous constraints, such as cost minimization and meeting strength and reliability requirements. The optimization method based on genetic algorithms involves several key stages. First, a population of possible solutions is initialized, where each individual represents a potential design solution. Then, a fitness function is calculated for each individual, determining its compliance with specified optimization criteria, such as minimum cost or weight of the structure. Next, crossover is applied to combine favorable characteristics of different solutions, and mutation introduces random changes in some parameters to broaden the search. This process continues until an optimal solution is found that meets the specified load and structural requirements. To construct a mathematical model implemented using genetic algorithms, it is necessary to define discrete design variables, such as section dimensions and element lengths. The genetic algorithm approach can also incorporate multi-objective optimization, allowing engineers to balance conflicting requirements, such as minimizing both cost and material usage while ensuring structural safety. Furthermore, the flexibility of genetic algorithms enables the adaptation of the model to various types of structures, ranging from simple beams to complex frameworks, ensuring broad applicability in real-world construction projects. By leveraging the evolutionary nature of these algorithms, it is possible to continuously improve design solutions through iterative refinement, ultimately leading to more efficient and cost-effective structural designs. Additionally, all constraints and impacts must be considered, including strength and rigidity requirements under various loads. Unlike traditional methods, where calculations and parameter selection are sequential, the use of genetic algorithms allows for simultaneous consideration of all parameters, resulting in improved design quality and adaptability to operational conditions. This method allows engineers to explore a wide range of design variations by iteratively refining solutions based on predefined optimization criteria. By incorporating constraints such as strength, rigidity, and economic feasibility, the algorithm ensures that all critical factors are addressed simultaneously. Furthermore, the use of discrete variables, such as profile dimensions and material properties, enables the modeling of highly customized design scenarios that align with practical construction requirements. Additionally, the optimization process aims to minimize the total cost of the structure, which is a function of parameters such as length, width, and the applied force F. The total cost consists of several components: the cost of longitudinal and transverse profiles, as well as additional expenses, such as U-shaped frames. The selection of profiles is represented by variables subject to specified constraints, ensuring that available resources and operational requirements are accounted for. This approach enhances the precision of cost evaluation for each structural element, significantly improving the economic efficiency of the solutions.

The optimization problem can be mathematically formulated as follows:

$$min_{\gamma,\beta,M} f(F, length, width) = min_{\gamma,\beta,M} (2\gamma C + M(\beta C + addit)$$

Where γ and β are the selection variables, C represents the cost per unit length of profiles, M is the number of transverse profiles, and *addit* accounts for additional expenses. This mathematical model allows for a systematic and comprehensive optimization process.

Conclusion

The use of genetic algorithms for optimizing structural designs represents a transformative step in engineering practice. By enabling the simultaneous consideration of diverse structural parameters this approach provides an efficient pathway to achieve cost-effective, stable, and robust solutions. Its ability to adapt to evolving project requirements further solidifies its relevance in modern construction.

Unlike traditional methods, genetic algorithms emphasize a comprehensive understanding of the interplay between design constraints and external conditions, fostering innovative and resilient designs. Their adaptability allows for seamless recalibration as project specifications change, ensuring continued relevance across diverse scenarios. Additionally, by optimizing material usage and minimizing waste, this methodology contributes to sustainable construction practices, reducing the industry's environmental impact. Looking ahead, the integration of genetic algorithms with advanced machine learning techniques could revolutionize decision-making in structural design. These technologies may enable automated, multi-stage optimization processes, significantly enhancing the precision and economic efficiency of engineering solutions. Such advancements could redefine the landscape of construction, promoting both innovation and sustainability in future projects.

References

1. Rajeev, S.; Krishnamoorthy, C. S. Discrete Optimization of Structures Using Genetic Algorithms. Journal of Structural Engineering, 1992, Vol. 118, Issue 5, pp. 1233-1250.

Оптимизация строительных конструкций с использованием генетических алгоритмов

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Аннотация. В статье представлена разработка метода оптимизации строительных конструкций с учетом нагрузок и внешних воздействий для снижения затрат. В качестве основы метода выбран подход на базе генетических алгоритмов, позволяющий комплексно учитывать проектные переменные и ограничения.

Ключевые слова: генетические алгоритмы, нагрузки, оптимизация, строительные конструкции, экономическая эффективность.

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Wireless network technical devices

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Abstract
The article discusses the features of the implementation of technical means of wireless information transmission networks. The use of wireless information transmission networks is an integral part of society and is a complex of software and hardware solutions for fast and convenient information exchange.
Keywords: system, network, access, antenna, antenna array, radiation pattern.

Introduction

Recent years have seen an increase in the use of wireless broadband access systems (BBA), which offer connections with transmission speeds higher than 1.544 Mbit/s (T1) or 2.048 Mbit/s (E1).

Offering reasonably priced choices for constructing broadband access networks in order to distribute various kinds of content is the main objective of putting networks based on broadband wireless access systems into operation. Thus, broadband wireless access devices use radio frequencies between 2 and 60 GHz.

Wireless broadband access systems provide the following advantages: fast installation of subscriber equipment, regardless of its location within the coverage area; minimal costs for the system operator when adding more subscribers in the coverage area; guaranteed high quality of service within the coverage area; and simple network reconfiguration for a subscriber within the sector's coverage area without additional costs for laying a fixed communication line. Therefore, to implement all of the service possibilities of wireless broadband access systems, incredibly efficient antenna systems are needed. The efficiency of these systems depends on antenna-feeder devices [1].

Antenna-feeder devices are designed to transport data in radio engineering systems that use the free propagation of radio waves. The antennas in these systems are only used to emit electromagnetic waves. Transmitting or receiving antennas are antennas that are connected to either the transmitter or the receiver. In order to move energy from the generator to the antenna or from the antenna to the receiver, antennas mostly depend on a feeder, sometimes referred to as a transmission line. There are numerous requirements for antennas in contemporary radio engineering systems, but two are particularly important:

1) The pattern-based distribution of electromagnetic power in space is known as directivity of action. In some circumstances, it is necessary to focus radiation or perform radio reception within a relatively limited angular sector, or "beam." In other circumstances, it is desirable to provide constant antenna operation in all directions. To provide a narrow beam, the antenna must be many times larger than the operating wavelength of the radio system.

2) Low electromagnetic power losses from the antenna's conductors and dielectrics heating up must accompany radio reception or radiation; in other words, the antenna must be extremely efficient [2].

Making sure antennas have the required system noise immunity is the first consideration in antenna design. In a variety of operational contexts, this is essential for preserving efficient communication and performance. Developing antennas with high gain and few side lobes is necessary to achieve this degree of noise protection. By concentrating energy in a particular direction, high-gain antennas strengthen signals and raise transmission quality overall.

Several aspects of the antenna radiation pattern must be taken into account in order to control side lobes. There is no set amount of side lobes that are considered acceptable; rather, it depends on the particular application and the kind of interference that is present. Unwanted signals may be picked up by side lobes, which could interfere with transmission. Their placement in respect to the major maximum, which denotes the principal direction of signal transmission, must thus be carefully considered. The antenna's ability to reject interference from undesirable directions can be improved by improving this connection.

In addition, the radiation pattern's dip depth, sometimes known as “zeros”, is another crucial factor. The antenna does not transmit energy at these zeros, therefore signals from those directions are essentially nullified. These zeros must be positioned carefully throughout the design phase to offset particular sources of interference. Furthermore, it is critical to manage side lobes during scanning, particularly in dynamic situations where interference may fluctuate over time. The antenna's performance and dependability are improved by its capacity to modify its response to changing circumstances.

Furthermore, the kind of interference present affects the requirements for side lobe management. For example, compared to pulsed interference, continuous wave interference could require distinct design considerations. Another important factor is the interference's intensity; more interference might necessitate stricter control techniques to preserve signal integrity. Another thing to think about is spatial positioning, since the antenna's and the interference sources' locations can have a big influence on performance.

The design and functionality of the antennas must change in tandem with the interference environment. This flexibility is essential to guaranteeing that the antennas will continue to function at their best in a variety of circumstances. Engineers can create antennas that not only satisfy the necessary noise immunity requirements but also improve the general efficacy and efficiency of wireless communication systems by concentrating on these factors: gain, side lobe control, radiation pattern optimization, and interference adaptation. Thus, the creation of sophisticated antennas is essential to the success of contemporary telecommunications since it permits dependable connections in settings that are becoming more dynamic and complicated.

The power line, sometimes referred to as the feeder path, is essential to an antenna system's overall operation because it makes it easier for electromagnetic energy to move between the generator and the antenna. For the antenna to function effectively, whether it

is sending or receiving signals, this connection is necessary. The system's overall performance is greatly impacted by the feeder path's features and design.

An effective feeder must have low losses, which is one of its main needs. The strength of the transmitted signal or the quality of the received signal may be weakened as a result of feeder losses that lower the amount of power supplied to the antenna. Thus, reducing these losses is essential to maximizing the antenna system's efficiency. This is frequently accomplished by choosing suitable building materials and methods that improve conductivity and lower resistive losses.

Furthermore, the feeder must not emit any electromagnetic interference. The system may experience noise and interference if the feeder itself starts to emit undesired radiation, jeopardizing the integrity of the signals being sent or received. In order to avoid this, feeders are usually made with particular insulation and shielding to keep electromagnetic energy inside the conductor and guarantee that it moves straight to or from the antenna without leaking.

Another key part of feeder design is impedance matching. The input resistance of the antenna must be equal to either the transmitter's output circuit or the receiver's input circuit. To optimize power transfer and reduce reflections that may arise from an improper match, proper impedance matching is crucial. Standing waves along the feeder may result from reflected power, which could harm the transmitter or receiver and result in more losses.

The power line or feeder path of an antenna system is an important component that directly affects its effectiveness and efficiency. The feeder enhances the overall performance of the antenna device by ensuring low losses, preventing unwanted radiation, and achieving the proper impedance matching. As technology advances, the importance of feeder design optimization becomes increasingly evident as it is needed to ensure the seamless operation of modern communication systems. With careful engineering and design considerations, the feeder may significantly improve the reliability and caliber of wireless communication. [3]

Results and discussion

The use of multi-frequency antenna arrays is the most sophisticated and practical way to guarantee dependable wireless communication in the quickly changing technical environment of today. By allowing signals to be transmitted and received over many frequency bands, these arrays provide a number of benefits that increase the adaptability and capacity of communication systems. These antennas can efficiently handle various signal types by functioning over many frequencies, supporting a wide range of applications from satellite links to mobile communications.

However, there are some difficulties in putting multi-frequency antenna arrays into practice. Complex diagram-forming algorithms are needed to maximize their performance and adjust to the dynamic character of real-world situations. These algorithms need to take into consideration a number of variables, including signal deterioration, interference, and shifting ambient circumstances. Consequently, intelligent algorithms have taken on a more significant role in this industry.

Neural networks, which simulate how the human brain processes information, are among the most promising methods. Large volumes of data may be analyzed by these networks, which can also spot patterns that conventional approaches might miss. Neural networks can be trained using machine learning approaches to optimize the operation and configuration of multi-frequency antenna arrays, enabling real-time adaptation to changing conditions. In wireless communication systems, this flexibility is essential to sustaining high performance and dependability levels.

Furthermore, the need for sophisticated solutions like multi-frequency antenna arrays becomes more urgently as the need for wireless communication keeps increasing, especially with the emergence of the Internet of Things (IoT) and smart gadgets. Meeting the demands of contemporary consumers requires the capacity to accommodate more connections at once while preserving speed and quality.

Conclusion

Cognitive algorithms, especially neural networks, in conjunction with multi-frequency antenna arrays, constitute a substantial breakthrough in wireless communication. In addition to addressing present issues, this collaboration puts the sector in a position to satisfy expectations in the future. The continuous development and improvement of these systems will be crucial in determining the direction of connectivity in the future as technology develops further, allowing for smooth communication across several platforms and applications.

References

1. Ziganurova R.A. Osobennosti provodnyh i besprovodnyh setej, a takzhe setej sledujushhego pokolenija [Features of wired and wireless networks, as well as next-generation networks]. Research and Development Center "Technical Innovations", 2023, Vol.№ 14, pp 14-18. (Rus)
2. Nazarov S.N., Brezhnev D.V., Keriemov E.I., Nazarov A.S. Issledovanie gibridnyh setej besprovodnoj peredachi informacii s ispol'zovaniem metodov teorii setej ocheredej [Study of hybrid wireless information transmission networks using queueing network theory methods]. DSPA: Voprosy primenenija cifrovoj obrabotki signalov [DSPA: Issues of Digital Signal Processing Applications], 2012, Vol.№ 2, Issue 1, pp 151-153. (Rus)
3. Ponachugin A.V., Ivanova S.U., Kurakina E.A. [Possibilities of wireless access networks in modern society[. Dnevnik nauki, 2020, Vol.№ 6, Issue 42, Available from: www.dnevniknauki.ru (Accessed 12.12.2024) (Rus)

Технические средства беспроводных сетей

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Аннотация. Рассмотрены особенности реализации технических средств беспроводных сетей передачи информации. Применение беспроводных сетей передачи информации является неотъемлемой частью жизни общества и представляет собой комплекс программных и аппаратных решений для быстрого и удобного обмена информацией.

Ключевые слова: система, сеть, доступ, антенна, антенная решётка, диаграмма направленности.

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Information support for visualization of the evaporation process in the digital world

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Abstract
This article presents the development of information support for the implementation of a process visualization system. We decided to choose the Unity 3D game engine. In this work we analyzed the features of the chosen tools, identified its advantages and proposed solutions to some problems that may arise in the process of implementing our idea.
Keywords: database; information support; tables; Unity 3D.

Introduction

In today's fast-changing and rapidly developing world, it is becoming increasingly difficult for organizations to find effective methods for training new employees. The trainings take a lot of time and money, and their effectiveness does not always satisfy the employer. There are many approaches to training: from traditional formal trainings and structured lectures to innovative methods, such as simulating the process in virtual reality. The latter methods allow companies to solve problems mentioned above to some extent and to make the training process more modern, accessible and transparent.

The main objectives of this study are to find and select a platform, which will be used for software development; to choose and create a database in which evaporator data will be stored. Scientific novelty of this study lies in the fact that we offer a new form of training for employees of sugar production enterprises, as well as the absence of similar works in this field.

Various technologies and tools are used to develop software that visualizes industrial processes and helps train new employees. One of the most popular approaches is using a virtual reality to create three-dimensional models and simulate real life working experience.

Developing software that will train new employees plays important part in improving production efficiency and accelerating the training process.

The most promising solution is to create a digital one-to-one copy for each needed technical equipment and machine. However, creating such copies requires a large amount of time and resources, so the most proficient variant will be using some kind of simulations for these objects.

Training new employees in the virtual world is one of the innovative approaches that is becoming increasingly popular. This method is used by managers of organizations of various sizes: from small businesses to large companies with offices in different cities. Virtual world allows you to train employees using the latest technologies and special software, helps easily demonstrate the necessary processes (to the management of the

current company) and interactively practice skills and test knowledge (to new or existing employees) without leaving home.

Development of visualization of the evaporation process is impossible without support systems. To implement our software product, various types of support systems were used, such as: mathematical, information, linguistic, software, technical and methodological support system. Below we will take a look at the information support in more detail.

When creating a program to visualize the evaporation process in the digital world, information support is of great importance. The program should be developed for the Windows platform, because it is the most common operating system. The interface should be simple and visually attractive, understandable to any user. These things are necessary to trivialize learning process. The Unity 3D game engine may meet such requirements.

What is unity?

The user manual by A. V. Kornilov states: "Unity is a powerful application development environment for all types of devices and platforms" [1]. The main language for writing code in this environment is the object-oriented programming language C#.

A project in Unity is divided into scenes (levels) - separate files containing their own sets of objects, scenarios and settings. Scenes can contain both models and empty objects - objects that do not have a model ("null"). The application is being developed using the combination of such scenes.

In the program, you can move along the 3D plain with evaporators placed on it. The evaporators can be examined them from both the outside and the inside. In addition, it is possible to turn on the 2D mode to view the input and output parameters (temperature, pressure and dry substances) in the text form.

The next step in a development process is the database creation.

The database is necessary to store the parameters of the evaporators. In our case, the input and output data of the evaporators are stored in a json text file.

It is worth noting that when the program is launched, a check is made for data integrity. If there has been changes in the files, the backup data is loaded from the code. However, if the input and output data of the evaporators remains unchanged, then it is loaded from the json text file.

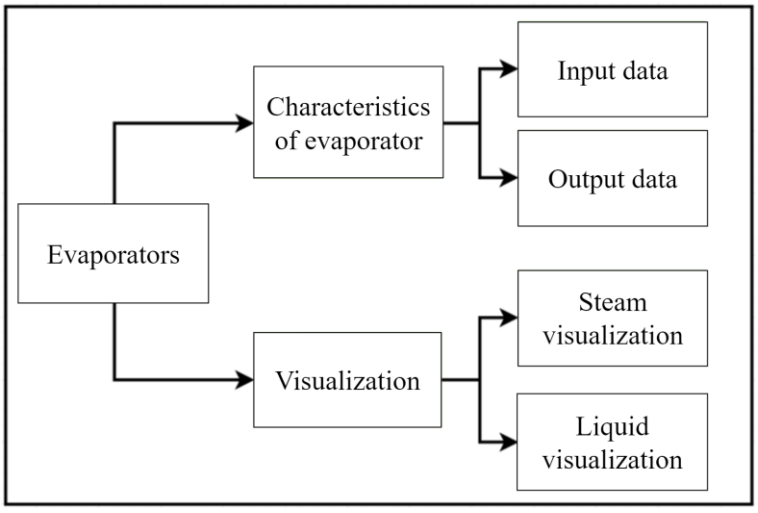

Figure 1 – Infological model of databases

Figure 1 shows the infological model of databases. During the development process, it is necessary to pay attention to the number of evaporators, their characteristics and how visualization is implemented. The information stored in the application is used for nine evaporators. Each evaporator displays input and output state of pressure, temperature, and dry matter. The application database should store these values for each evaporator.

Designing the logical structure of a database goes through the steps of converting the initial info-logical model into a data model and the verification of converted values, that consists of parameters' constraints and format checks.

The application interface has the easily accessible table with the data of evaporators for convenience that can be hidden. In addition, it is possible to add the functions of observing 3D models of evaporators from any angle (360°), approaching objects to take a closer look and moving away from them in isolation. This will allow seeing evaporators and their input and outputting data in more detail.

To avoid the overlapping of text and object textures, text is automatically being rotated depending on the current user's location. In the future, it will be necessary to add a mathematical model that will allow the user to set an input states and get the output data from it.

Conclusion

To summarize, we will draw the following conclusion: Unity is ideal for implementing the visualization of the evaporation process in the modern world. This game engine provides ease of use due to a comfortable interface, contains essential features that allow viewing the necessary information in both 2D and 3D mode, prevent textures and text overlap, allow user camera rotation and positioning. The set goal was achieved, all tasks were implemented.

References

1. Kornilov, A.V. UNITY. Polnoe rukovodstvo, 2-e izdanie [Unity. Complete leadership]. Saint Petersburg, Nauka i tekhnika, 2021. 496 p. (Rus)

Информационное обеспечение для визуализации процесса выпаривания в цифровом мире

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Аннотация. В данной статье представлена разработка информационного обеспечения для реализации системы визуализации технологических процессов. Нами было принято решение о выборе игрового движка Unity 3D. В работе были проанализированы особенности программы, выявлены её преимущества, а также предложены решения некоторых проблем, которые могут возникнуть в процессе реализации нашей идеи.

Ключевые слова: база данных, информационное обеспечение, таблицы, Unity 3D.

УДК 681.518

Specificity of information support of engineering and technical departments

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Abstract
The article focuses on the relationship between the quality of engineering and technical services and the overall success of the enterprise. During the analysis and subsequent systematization of requirements and restrictions in the implementation of information support systems, the main goal of the study is revealed - the introduction of specialized support systems for technical personnel aimed at reducing the time spent on emergency and scheduled repair work, as well as improving the coordination of the actions of departments.
Keywords: Efficiency of engineering and technical services, information support system, repair automation, structure of identification objects.

Introduction

The main task of engineering and technical departments is to restore and maintain the operability of production processes to minimize production downtime. When performing this task, engineering and technical services have to cope with the unpredictability and complexity of emerging requests, with an ever-increasing volume of work.

The difficulties of maintaining the efficiency of enterprise maintenance services are considered in the works of many specialists: Shklovsky E.I., N. Cooper, Kafarov V.V. and others. A large pool of works notes a direct relationship between the efficiency of the enterprise and the quality of services provided to production by engineering and technical services: setting the goal of implementing information support systems, increasing the efficiency of the engineering and technical services of the enterprise, using the implementation of mechanisms that ensure a reduction in the time frame for emergency and scheduled work on technical maintenance and repair of enterprise equipment [1, 2].

Formalization of requirements for the information support system of engineering and technical services of the enterprise

When organizing an information support system, it is necessary to take into account both the requirements for functionality and the possibility of further scaling of this system by the enterprise personnel. In order to ensure unification of the software and hardware complex used at the enterprise, it is proposed to develop an information support system as a module to the control system already used in production, allowing for localization of information within the enterprise, organizing the distribution of roles and preserving the ability of the engineering and technical personnel of production to supplement information on changes made to the technological and technical equipment, without increasing the requirements for the qualifications of the personnel servicing the system [3].

To organize the structure of information support objects, it is necessary to divide it into levels from the enterprise in general as the first level of the organization, up to the final actuators and technical means at the final level, with mandatory observance of a direct sequential hierarchy corresponding to the rule from the general (upper level) to the

particular (lower level), according to the scheme shown in Figure 1:

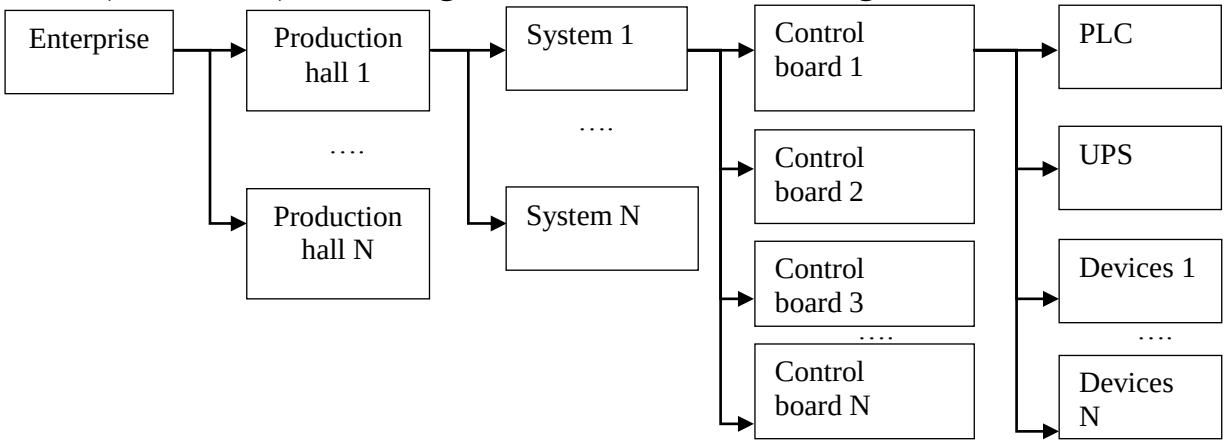

Figure 1 - Proposed structure for the distribution of levels of objects of the information support system.

To implement access to objects, it is necessary to provide a mechanism for viewing the mnemonic diagrams of the object by means of remote access using visual identification technology, allowing the address of the required object to be fixed inside itself and read using auxiliary devices.

To comply with information security requirements, it is necessary to provide for the delimitation of user rights when using remote access systems and to necessarily limit the ability to visit process control structures, leaving the user with only the functions of viewing and entering messages into a special acknowledged log [1, 3].

Aggregating the requirements provided for information support of the engineering and technical service, a diagram of the functioning of the system of the following type is presented (Fig. 2):

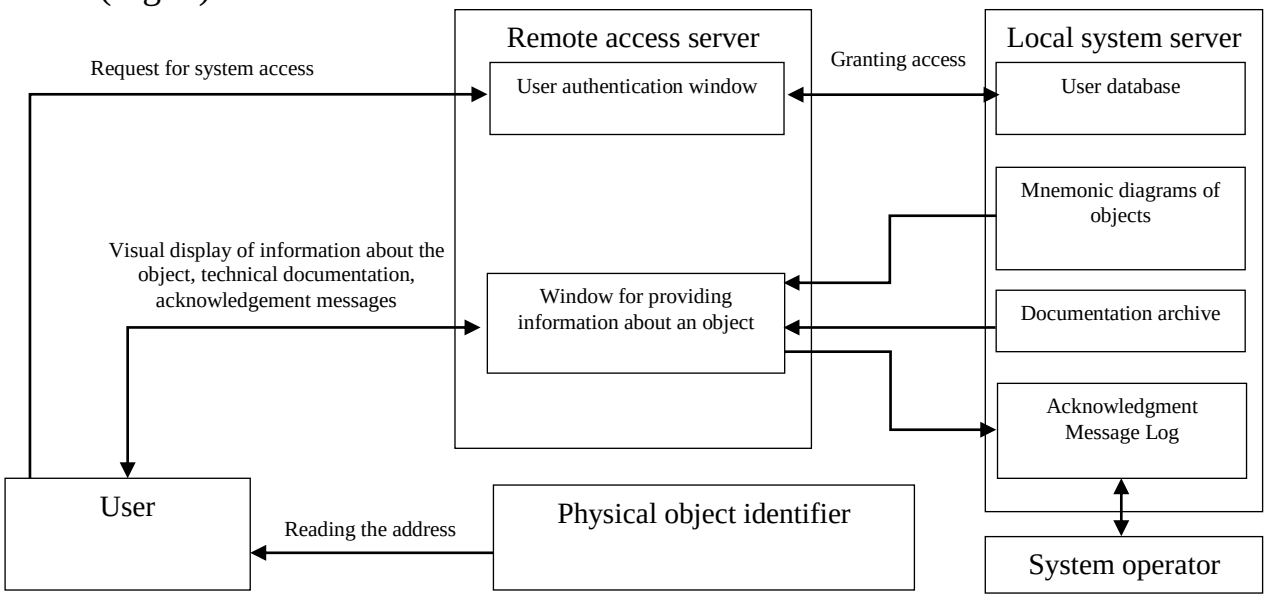

Figure 2 - Target structure of the functioning of the information support system.

As follows from the requirements and figures presented above, the implementation of the information support system for the engineering and technical services of the enterprise can be reduced to the task of automating the provision of technical documentation of a clearly identifiable object [3, 4].

Conclusion

The analysis and formalization of the requirements for the implementation of the information support system for the engineering and technical departments of the enterprise were carried out to improve their efficiency.

As the analysis showed, the requirements for the implementation of the information support system are reduced to the automation of the provision of technical documentation of a clearly identifiable object in accordance with the developed operating scheme.

References

1. Vasin S.A., Ancev V.Y., Inozemcev A.N., Pushkin N.M. Informacionnaya podderzhka sistem upravleniya kachestvom izgotovleniya mashin [Information support of quality management systems for machine manufacturing]. Tula, TSU, 2002. 428 p. (Rus)
2. Bulatova A.S. Ehkonomika [Economics]. Moscow, BEK, 2013. pp. 156-203. (Rus)
3. Elizarov I.A. Tekhnicheskie sredstva avtomatizacii. Programmno-tekhnicheskie kompleksy i kontrollery [Technical means of automation. Software and hardware complexes and controllers]. Tambov, TSTU, 2004. 126 p. (Rus)
4. Matvejkin V.G. Primenenie SCADA-sistem pri avtomatizacii tekhnologicheskikh processov [Application of SCADA systems in automation of technological processes]. Moscow, Mashinostroenie, 2000. 176 p. (Rus)

Специфика информационного сопровождения инженерно-технических подразделений

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Аннотация. Статья акцентирует внимание на взаимосвязи между качеством услуг инженерно-технических служб и общим успехом предприятия. В ходе анализа и последующей систематизации требований и ограничений при реализации систем информационного сопровождения, раскрывается основная цель исследования — внедрение специализированных систем поддержки технического персонала, направленных на сокращение временных затрат на выполнение аварийных и плановых ремонтных работ, а также на улучшение координации действий подразделений.

Ключевые слова: автоматизация ремонта, система информационного сопровождения, структура объектов идентификации, эффективность инженерно-технических служб.

УДК 004

Adaptive Kalman filter application for information and measurement system with variable structure

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Abstract
Improving the accuracy of measurements and increasing the reliability of the information and measuring system under conditions of changing system topology is an urgent task in many technological processes. The purpose of this work was to develop a model of the adaptive Kalman filter for an information and measuring system with a variable structure. The adaptive Kalman filter is based on the classical Kalman filter and is implemented in the Python programming language. As a result, a model of the adaptive Kalman filter was developed and practically implemented.
Keywords: dynamic topology, information and measurement systems, Kalman filter, measurement accuracy, state prediction, variable structure.

Introduction

Variable structure information and measurement systems are widely used in various fields, including industrial automation, environmental monitoring, and medical research. These systems have a dynamically changing topology, which is caused by the movement of sensors, changes in their number, unstable communication and failure of elements. This approach causes problems with measurement accuracy, as data may arrive with delays, contain gaps, or be noisy [1].

To solve these problems, it is necessary to apply methods that can adapt to changes in the network structure and compensate for data loss.

This research is aimed at creating an adaptive Kalman filter for information and measurement systems with variable structure.

The purpose of creating an adaptive Kalman filteris is to improve the measurements accuracy and reliability of the information and measurement system in the context of changing the system topology [3].

Materials and methods

The Kalman filter is an effective recursive filter that evaluates the state vector of a dynamic system using a number of incomplete information.

The algorithm works in two stages: prediction and correction.

Prediction:

1. The prediction of the state of the system

$$\hat{x}_{\bar{k}} = F\hat{x}_{k-1} + Bu_{k-1}$$

where

$\hat{x}_{\bar{k}}$ is the prediction the current state of the system

F is the state transition matrix (dynamic model)

$\hat{x}_{k-1}$ is the state of the system at the last moment in time

B is the matrix of application of the control action

u_{k-1} is the control action at a past point in time

2. The prediction of the error matrix

$$P_{\bar{k}} = FP_{k-1}F^T + Q$$

where

P_{k-1} is an error at a previous point in time

Q is covariance of process noise

Correction:

1. The Calculation Kalman gain

$$K_k = P_{\bar{k}}H^T(HP_{\bar{k}}H^T + R)^{-1}$$

where

H is a measurement matrix that displays the ratio of measurements and states

R is measurement noise covariance

2. Updating the estimate based on the measurement z_k

$$\hat{x}_k = \hat{x}_{\bar{k}} + K_k(z_k - H\hat{x}_{\bar{k}})$$

z_k is current time measurement

3. Updating the error matrix

$$P_k = (I - K_kH)P_{\bar{k}}$$

where

I is the identity matrix [2].

When using the Kalman filter as an adaptive algorithm for an information and measurement system with a variable structure, changes in the matrices of the system F, B, and H. The filter should automatically update the parameters to correct predictions and improve measurement accuracy.

The task:

Adaptive application of the Kalman algorithm for an AIS with a variable structure using the example of a system with alternating temperature sensors.

The program code:

```
import numpy as np
import pandas as pd
# Parameters
n_steps = 10 # Number of time steps
n_sensors = 5 # Number of sensors
true_temperature = 20 # Initial temperature
process_noise = 0.1 # Process noise
measurement_noise = 0.5 # Measurement noise
delta_T = 0.1 # Temperature change
# Initializing data
time = np.arange(1, n_steps + 1)
true_temps = np.zeros(n_steps)
measurements = np.zeros((n_steps, n_sensors))
# Generate true temperature with noise
true_temps[0] = true_temperature
for t in range(1, n_steps):
    true_temps[t] = true_temps[t-1] + delta_T + np.random.normal(0, process_noise)
# Generate measurements from sensors with noise
for t in range(n_steps):
    for i in range(n_sensors):
        measurements[t, i] = true_temps[t] + np.random.normal(0, measurement_noise)
```

```
# Initializing the Kalman filter
x_hat = np.zeros(n_steps)# Temperature estimation
P = np.ones(n_steps) * 10 # Initialization of covariance (confidence in the estimate)
R = np.ones(n_sensors) * measurement_noise**2 # Measurement noise
Q = process_noise**2 # Process noise
# Simulating alternate sensor disconnection
sensor_order = np.array([0, 1, 2, 3, 4])# How to disable sensors
# Applying the Kalman Filter
for t in range(1, n_steps):
 # Forecast (prediction)
 x_hat[t] = x_hat[t-1] + delta_TT # Simple forecast
 P[t] = P[t-1] + Q # Forecast error
    # Determining which sensors are active at step t
 active_sensors = np.setdiff1d(np.arange(n_sensors), sensor_order[(t-1) % n_sensors])#
Disabling one sensor
 k = len(active_sensorssensors)# Number of active sensors
    # Average measurement noise for active sensors
    R_active = np.mean(R[active_sensors])
 # Kalman coefficient
    K_t = P[t] / (P[t] + R_active)
    # Updating the filter for active sensors
    measurement_residual = np.sum(measurements[t, active_sensors] - x_hat[t-1])
    x_hat[t] += K_t * measurement_residual
    # Updating the covariance
    P[t] = (1 - K_t) * P[t]
# Creating a table with results
data = {
    'Time': time,
    'True Temperature': true_temps,}
# Adding sensor measurements and Kalman filter estimation
for i in range(n_sensors):
    data[f'Sensor {i+1}'] = measurements[:, i]
data['Kalman Estimate'] = x_hat
# Converting to DataFrame
df = pd.DataFrame(data)
# Displaying the table
print(df)
```

Explanation:

1. The system consists of five alternating ambient temperature sensors. Four sensors are used in each step.

2. The initial temperature $T_0 = 20$ changes in increments of $\Delta T = 0{,}1$, adding random noise to the Q process.

3. The measurements from the sensors are generated by adding random noise R with a normal distribution, creating data for each sensor.

4. The Kalman filter updates the temperature estimate at each step, using only those sensors that are currently active.

5. After that, the cycle repeats.

Results and discussions

An adaptive Kalman filter model has been developed and practically implemented, which contributes to improving the measurement accuracy and reliability of the information and measurement system in the context of changing the system topology.

The program execution result:

	Time	True Temperature	Sensor 1	Sensor 2	Sensor 3	Sensor 4	Sensor 5	Kalman Estimate
0	1	20.000000	20.254386	18.964538	19.918406	19.458188	19.939979	0.000000
1	2	20.124834	20.147410	19.961655	20.109758	19.233061	19.462794	76.947988
2	3	20.092368	20.496917	20.198719	20.497068	19.712685	20.064544	-37.342782
3	4	20.428909	20.148801	19.993361	20.286009	20.155718	20.021595	43.672728
4	5	20.470721	20.601462	19.839604	20.958577	19.693739	21.268118	17.844846
5	6	20.673154	20.307393	20.184870	19.917702	20.095263	20.253030	20.166346
6	7	20.805833	20.796158	20.280668	20.768410	21.167100	20.546214	20.729444
7	8	20.814413	21.422042	20.651653	20.652019	21.593824	20.652177	21.119544
8	9	20.833237	21.079378	20.890659	19.875667	20.588581	21.111401	21.059532
9	10	20.803761	20.316594	20.477763	21.106532	21.116234	21.041973	20.910526

Thus, we get a table with true temperatures, readings of each sensor and temperature estimates by the Kalman filter.

It is recommended to use an adaptive Kalman filter for an information and measurement system with a variable structure to maintain the stability and operation of the measurement system, compensate for changes in the structure and prevent loss of accuracy.

Conclusion

The usage of an adaptive Kalman filter in variable structure information and measurement systems is an effective solution to compensate for data loss and improve measurement accuracy under dynamic conditions. This approach can be applied to a wide range of tasks, ensuring their stable and reliable operation.

References

1. Kazakov I.E. Statisticheskaya dinamika sistem s peremennoj strukturoj [Statistical dynamics of systems with variable structure]. – Moscow: Nauka, 1977. (Rus)
2. Lemeshko O.V. Fil'tr Kalmana. Teoreticheskie osnovy i prakticheskoe primenenie [Kalman filter. Theoretical foundations and practical application] // Bulletin of the Magistracy. 2014. No. 6-1 (33). (Rus)
3. Stepanov O.A. Osnovy teorii ocenivaniya s prilozheniyami k zadacham obrabotki navigacionnoj informacii. Ch.2. Vvedenie v teoriyu fil'tracii [Fundamentals of estimation theory with applications to problems of processing navigation information. Part 2. Introduction to filtration theory]. State Scientific Center of the Russian Federation JSC "Concern" Central Research Institute "Elektropribor", 2012. – 417 p. (Rus)

Адаптивное применение фильтра калмана для информационно-измерительной системы с переменной структурой

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Аннотация. Улучшение точности измерений и повышение надежности информационно-измерительной системы в условиях изменения топологии системы является актуальной задачей во многих технологических процессах. Целью данной работы являлось разработать модель адаптивного фильтра Калмана для информационно-измерительной системы с переменной структурой. Адаптивный фильтр Калмана выполнен на основе классического фильтра Калмана и реализован на языке программирования Python. В результате была разработана и практически реализована модель адаптивного фильтра Калмана.

Ключевые слова: динамическая топология, информационно-измерительные системы, переменная структура, прогноз состояния, точность измерений, фильтр Калмана.

УДК 004.588

Support subsystem for design and visualization the digital shadow of the aquarium ecosystem

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Abstract
The purpose of this work is to improve the quality of the process of creating new aquariums, and to obtain knowledge for the benign maintenance of the life of the aquarium ecosystem.
To achieve the goal, it is necessary to complete the following tasks: to analyze modern approaches to creating an aquarium ecosystem by online store customers; to develop an object-oriented model of the subsystem for designing and visualizing the digital shadow of the aquarium ecosystem; to implement the support of the subsystem for designing and visualizing the digital shadow of the aquarium ecosystem; to test the operation of the subsystem for designing and visualizing the digital shadow of the aquarium ecosystem.
The object of the study is the mathematical and algorithmic support of the subsystem for designing and visualizing the digital shadow of the aquarium ecosystem. The subject of the study is to improve the quality of the process of starting a new aquarium.
Keywords: database, information support, MySQL, Unity Editor.

Introduction

In the modern world, digitalization is becoming an integral part of various business sectors, and retail is no exception. Online stores actively use modern information technologies to improve the efficiency of their activities and improve the quality of customer service. In the context of the development of the digital economy and the penetration of digital shadow technologies into various areas of business, the task of creating a decision support subsystem for the effective management of the aquarium assortment within the online store becomes relevant.

According to modern surveys, 11% of people in Russia keep an aquarium. At the same time, creating a sustainable ecosystem is a non-trivial task that requires deep knowledge in the field of aquarium keeping, which is often lacking among customers of online stores.

In addition, the digital shadow of the aquarium ecosystem allows you to simplify the process of analyzing and creating aquariums based on research data, as well as avoid errors that lead to the destruction of the ecosystem, which, in practice, means the death of the inhabitants and the loss of the aquarium by the client. It is the minimization of such errors that we will consider the quality of aquarium design.

Part of the mathematical and algorithmic support of the digital shadow of the aquarium ecosystem is the design and visualization subsystem. It will allow you to preliminarily evaluate the appearance of the aquarium, both from a visual point of view and from the point of view of the correctness of their filling, which will allow you to most rationally place the inhabitants.

The purpose of this work is to improve the quality of the process of composing new aquariums, and to gain knowledge for the benign maintenance of the life of the aquarium ecosystem.

Applied technologies

The server part uses a combination of the MySQL database management system and the general-purpose PHP scripting language; the Unity engine and the C# programming language were used to develop the mobile application.

PHP is a server-side programming language responsible for the backend, the part of the product that the user does not see. For example, a website or application sends requests to different services: a database - it will confirm the availability of information about the user, payment gateways - they will return a response from the bank about the payment, a logistics service - it will inform that the goods are in stock, and so on.

In programming, a database is an ordered set of structured data. Simply put, a database is a file or a collection of files that stores systematized information about one project.

MySQL is one of the database management systems or simply DBMS. In simple words, a program with which a database is created and controlled.

SQL is a declarative programming language (structured query language used to create, process and store data in relational databases.

Unity is a free cross-platform engine created by Unity Technologies in 2005. The advantage of choosing this engine is its cross-platform nature. It is used to create modern applications for platforms such as PC, Android, iOS, PlayStation, Xbox, Nintendo Switch. Unity is also used to create VR and AR projects. The editor is especially useful for processes with iterative improvement, such as prototyping or testing cycles [1].

It uses program code written in C# as its source code.

C# is a programming language from Microsoft. Initially, it was created for Windows projects, but now it is a truly universal language: it is used to write games, mobile and desktop applications, web services, neural networks and even graphics for metaverses.

Mathematical and algorithmic support for the digital shadow of the aquarium ecosystem allows you to simulate the required number of aquariums, for each of which you can form the best model. With this software, the user can track models of future aquariums, which will also allow collecting information about them. Based on the received models, the quality and speed of aquarium design will improve.

The user selects from the list of inhabitants that he wants to add to the selected aquarium.

First, the application checks the compatibility of the inhabitant selected by the user, after which the application checks it for compatibility and if it is not compatible, the user selects another inhabitant, then displays its addition, after which it sends a request to the server, which sends data with the new inhabitant to the server database. After adding a new inhabitant, the server makes a request to update the database list. After which the server replenishes the application database with the updated list.

When switching to the "Inhabitants" tab, the user will be provided with a list of inhabitants from the database, each of which has its own characteristics and requirements. The user can add inhabitants to the aquarium if the compatibility check system allows it. Each inhabitant has a list of inhabitants that are incompatible with it. An example would be that guppies cannot get along with predators. When trying to add incompatible species to the aquarium, the application will display a warning that the inhabitants are

incompatible. Also, depending on the specified parameters of the inhabitant and the dimensions of the aquarium, the permissible number of inhabitants in the aquarium will depend. If you try to exceed the limit of inhabitants, the application will also issue a warning. For more convenient use of the application, the user can study the information about each inhabitant. This will allow you to come to warnings less often and learn faster. For the benign presence of an inhabitant in the aquarium, the quantity and quality of water, the oxygen level are also important. These characteristics depend on the number of inhabitants, the size of the aquarium, the amount of water.

Conclusion

As a result of solving the above problems, a subsystem has been developed, which is a tool for fast and high-quality composition of an aquarium. The aquarium is formed on the basis of research data entered into the database. The application generates fairly accurate results using the function of checking the compatibility of inhabitants with each other, flora, amount of water and other parameters, and also displays them. The designed architecture of the subsystem for constructing and visualizing the mathematical and algorithmic support of the digital shadow of the aquarium ecosystem is easily scalable and allows for effective testing of the developed subsystem. Scalability is achieved due to the object-oriented approach used in designing the subsystem models.

References

1. Hawking, D. Unity in Action. Multimedia Development in C#. – St. Petersburg.: Piter, 2023. - 448 p.

Обеспечение подсистемы конструирования и визуализации цифровой тени экосистемы аквариума

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Аннотация. Целью данной работы является повышение качества процесса составления новых аквариумов, и получение знаний для доброкачественного поддержания жизни аквариумной экосистемы. Для достижения цели необходимо выполнить следующие задачи: провести анализ современных подходов к созданию экосистемы аквариумов клиентами интернет-магазина; разработать объектно-ориентированную модель подсистемы конструирования и визуализации цифровой тени экосистемы аквариума; реализовать обеспечение подсистемы конструирования и визуализации цифровой тени экосистемы аквариума; протестировать работу подсистемы конструирования и визуализации цифровой тени экосистемы аквариума. Объектом исследования является математическое и алгоритмическое обеспечение подсистемы конструирования и визуализации цифровой тени экосистемы аквариума. Предметом исследования является повышение качества процесса заведения нового аквариума.

Ключевые слова: база данных, информационное обеспечение, MySQL, Unity Editor.

УДК 004.946

Development of an intelligent environment selection system for virtual simulators

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Abstract
An approach to developing an intelligent system for selecting the environment, mechanics and objects is described. The basic principles and concepts for generating simulators and interactive objects for virtual simulators are considered.
Keywords: Adaptive training**,** virtual reality, virtual simulators, intelligent systems.

Introduction

In the modern world, the use of virtual simulators for training staff and improving their skills is playing an increasingly important role. During the development of virtual simulators, a huge amount of time is spent building the level and arranging interactive objects for the user. This article discusses an approach to creating an algorithm for automated creation and selection of an environment [1].

A virtual simulator is a simulation of a real object in a virtual environment, the interaction scenario with which is included in the training program.

With the help of a virtual reality helmet, the user can be completely transported to the field of activity to further gain work experience and prepare for the operation of a real object. Also, to interact with the digital world, in addition to the virtual helmet, there are joysticks for simulating hands [2].

Interactive objects

When designing an intelligent system, it is important to consider several key aspects that will help to create a realistic environment. The main tasks when placing interactive objects are optimization of spatial arrangement, logical interaction of objects with the user and adaptation of objects depending on the user's level of experience:

1. Contextual placement of objects is required to create deeper immersion, objects must logically correspond to scenarios and training goals.

2. Using areas of high interest, interactive objects should be placed in places where the user needs to concentrate within the training scenario

3. Scenario-aware contextual layout is used to ensure that interactive objects can only appear in specific scenarios that match the training objective.

4. Testing and optimization of object placement; the system should provide the ability to test various object placement schemes in order to identify the most effective and user-friendly ones.

5. Placement of interactive objects is the most important component of creating an effective virtual simulator. An intelligent placement system must take into account the context, user level, and the ability to dynamically adapt (Fig. 1).

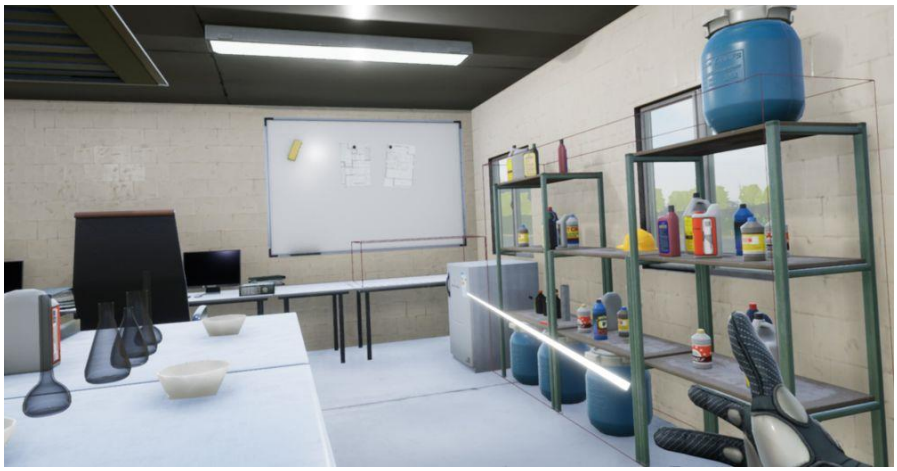

Figure 1 – Example of object generation

Environment generation

To generate the environment of virtual simulators, it is important to create a realistic, adaptive and interactive environment that will help the user to fully immerse themselves in the learning process. The goal of such a system is not just to imitate real space, but also to flexibly change it depending on the context, tasks and level of training of the user. The main principles are:

1. Contextualization and realism, the system should create an environment that matches the theme of the simulator and the learning objectives. This approach requires taking into account many factors, including textures, lighting, sound ambiance, weather and time conditions. The more realistic the environment, the easier it is for the user to apply the acquired skills in real life.

2. Weather and time conditions represent a system that must change weather conditions and time of day to train in a variety of conditions that simulate real situations. This helps prepare the user for how conditions change during actual work.

3. Modular environment for changing scenarios to create the maximum number of scenarios, the environment can be modular and easily changed. This allows you to create a variety of training tasks based on one virtual space and adapt the simulator to the specific needs of the user.

4. Progressive complication of the environment, as you complete training or complete certain tasks, the system can add complex elements of the environment (Fig. 2).

Figure 2 – Level generation example

Conclusion

Creating an intelligent environment for virtual simulators requires a balance between realism, interactivity and adaptability. Such a system, taking into account many factors, helps the user not only learn certain skills, but also develop the ability to respond to complex, unpredictable conditions. With the help of an adaptive environment, virtual simulators become a universal and effective tool for training in conditions close to reality.

The proposed classification allows us to systematize the process of selecting interactive objects, environments and mechanics for virtual simulators.

Acknowledgements

The study was carried out with the financial support of the Ministry of Science and Higher Education of the Russian Federation within the framework of the project "Development of an immersive virtual reality interaction system for professional training based on an omnidirectional platform" (124102100628-3).

References

1. Dedov D., Nikolykin M., Kruglov V., Nikitnikov Yu. Optimization of the software architecture of the virtual training system for warehouse workers training, AIP Publishing, 2023, Vol. 2910. Issue 1.
2. Nikitnikov, Yu. V. Razrabotka virtual'nogo trenazhera dlya obucheniya deystviyam ministrov po chrezvychaynym situatsiyam pri vozniknovenii pozharov v zakrytykh pomeshcheniyakh [Development of a virtual simulator for training employees of the Ministry of Emergency Situations in extinguishing fires in enclosed spaces] 2023, pp. 358-360. (Rus).

Разработка интеллектуальной системы выбора окружения для виртуальных тренажеров

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Аннотация. Описан подход к разработке интеллектуальной системы выбора окружения, механик и объектов. Рассмотрены основные принципы и концепции при генерации тренажеров и интерактивных объектов для виртуальных тренажеров.

Ключевые слова: Адаптивные тренировки, виртуальная реальность, виртуальные тренажеры, интеллектуальные системы.

УДК 004.5

Formalization of the parameters of the virtual simulator interface

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Abstract
The article is devoted to the development of a virtual simulator interface for professional training of miners in the mining industry. The relevance of the study is due to the need to minimize the risks of training in real conditions, where the high "cost of error" threatens the safety of personnel and the economic efficiency of enterprises. The work presents a detailed interface model, including the formalization of its elements and parameters.
Keywords: interface; virtual simulator; specialist training; formalization of interface parameters.

Introduction

Modern technologies have penetrated very closely into many areas of human activity, one of them is the professional training of specialists in the mining industry. This industry is associated with increased risks and difficult working conditions, which makes the safety and professionalism of miners critically important characteristics. In this context, virtual simulators can be effectively used in cases where training in real conditions is difficult or poses a danger to the health and life of students, for example, the elimination of the consequences of emergencies. Virtual simulators consist of many different components, such as: interface, control algorithm, interface for interaction with other components. This article will present the main interface of the program in more detail.

Materials and methods

When designing an interface, you should initially define the set of elements it will consist of. Define the essence of the interface – the set $E = \langle e_1, e_2, ..., e_n \rangle$ that stores all elements in the amount of n. Each element is characterized by 7 parameters $e_i = \left\{ p_x^e, p_y^e, s_x^e, s_y^e, color^e, cont, selected \right\}$, where p_x^e, p_y^e – pixel coordinates that indicate the overall position of an element, s_x^e, s_y^e – the dimensions of the element, the width and height of the element, $color^e$ – the color of an element that corresponds to the RGB color model, that is, the color is characterized by 3 parameters $color^e = \left\{ R^e, G^e, B^e \right\}$, where R^e, G^e, B^e – red, green and blue color meanings, $selected$ – logical variable that determines whether the current item is selected, $cont$ – the content of the element, under this value there can be either text or an image. Note that the description provided can be expanded taking into account the three-dimensionality of the interface, however, despite the presence of conditionally three-dimensional interfaces, the image output on them is carried out on flat screens with a two-dimensional coordinate system.

The text contained in the element is also characterized by several parameters $cont = \left\{ text, font, s^{cont}, color^{cont} \right\}$, where $text$ is text that describes the purpose of the element or describes the category that the element contains, $font$ contains the font in which the text

is written, s^{cont} is font size, $color^{cont}$ is text color.

Each element e_i sets E can be a container $e_i \to E_j$, which contains other elements collected into a specific group (category) $E_j = \{e_i, e_l, ..., e_m\}$ in quantity m. For each such set there is a connection c_i, which links a parent, namely a subset, to its descendants or elements $c_i^j : e_i \to E_j$. It should also be noted that in order to organize elements into a group based on similar characteristics, it is necessary to solve the clustering problem.

The following parameters are additionally set:

- cursor position $K = \left(p_x^k, p_y^k\right)$, where p_x^k, p_y^k – cursor coordinates, which denotes both the position of the mouse cursor and the position of any other control element, such as a controller;
- the dimensions of the entire application interface $I = \left(s_x^l, s_y^l\right)$, where s_x^l, s_y^l the dimensions of the interface in width and height.

One of the important criteria for assessing the created interface is the calculation of the access time to this element. It is based on calculating the minimum access values to all interface elements and performing subsequent transformations: either averaging the obtained values, or choosing the maximum value among all, which reflects the pessimistic option (the longest path to performing the action). In this study, a calculation based on averaged values of the minimum access time was selected:

$$T = \frac{\sum_{i=1}^{n} T(e_i)}{n}. \quad (1)$$

The algorithm for calculating the minimum access time to an element is presented in the following form. The time to select an element e_i from a variety E points are calculated using the sum of times obtained by Fitts' law and the Hick-Hyman law [1]:

$$T(e_i) = T_F(e_i, K) + T_H(e_i). \quad (2)$$

Fitts' Law is a predictive model of human movement that is primarily used in human-computer interaction. It relates movement time to the precision of the movement and to the distance of movement: the further or more precisely the movement is performed, the more correction is required to perform it, and accordingly, the longer it takes to make that correction:

$$T_F(e_i, K) = a_1 + b_1 \log_2\left(\frac{D(e_i, K)}{s} + 1\right). \quad (3)$$

a_1 and b_1 – these are the delay and acceleration constants, respectively, which depend on the choice of input device (e.g. computer mouse), usually determined empirically using regression analysis. $D(e_i, K) = \sqrt{\left(p_x^e - p_x^k\right)^2 + \left(p_y^e - p_y^k\right)^2}$ – Euclidean distance between the cursor point and the center of the element. $S = s_x \cdot s_y$ – area of an element.

The Hick-Hyman law describes the time it takes for a person to make a decision based on possible options:

$$T_H(e_i) = a_2 + b_2 \cdot \log_2(m_i + 1), \quad (4)$$

a_2 and b_2 are constants that describe individual user perception characteristics, such as the delay before completing a task and the individual decision speed factor. m_i is the time spent on selecting an element at the current level, so to select an element located in a certain nesting, the following formula works:

$$T(e_i) = T(e_j) + T(e_i). \quad (5)$$

Conclusion

The development of an effective and convenient interface for a virtual simulator requires a comprehensive approach that will take into account all the components used in it. The interface model presented in this paper allows us to determine the variable parameters for the criteria of an effective interface

Acknowledgements

The article was carried out with the financial support of the Ministry of Science and Higher Education of the Russian Federation within the framework of the project "Development of an immersive virtual reality interaction system for professional training based on an omnidirectional platform" (FEMU-2024-0005).

References

1. Popov A. A., Kuzmina A. O. Software application for determining conditions of the human-computer interaction using Fitts' and Hick's Laws // International Multi-Conference on Industrial Engineering and Modern Technologies (FarEastCon). IEEE, 2019. pp. 1-6.

Формализация параметров интерфейса виртуального тренажера

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Аннотация. Статья посвящена разработке интерфейса виртуального тренажера для профессиональной подготовки шахтеров в горнодобывающей отрасли. Актуальность исследования обусловлена необходимостью минимизировать риски обучения в реальных условиях, где высокая «цена ошибки» угрожает безопасности персонала и экономической эффективности предприятий. В работе представлена детальная модель интерфейса, включающая формализацию его элементов, параметров.

Ключевые слова: интерфейс; виртуальный тренажер; обучение специалиста; формализация параметров интерфейса.

УДК 004.946

Human interaction tools with virtual objects

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Abstract
This article describes existing technologies and methods for organizing user interaction with virtual reality objects. The approach based on additional equipment and the use of computer vision are considered. The pros and cons of various approaches to human motion capture for use in virtual reality are also considered.
Keywords: VR, motion capture, interactions in VR

Introduction

Over time, virtual reality technologies are actively developing and finding a variety of new areas of application: from the entertainment segment (VR games) to specialized medical VR simulators.

If, when developing games, due to the need to support the maximum number of devices (increase the potential target audience), it is necessary to limit oneself to a standard set of user input devices (VR headset and controllers) when developing specialized VR simulators, there are no such restrictions.

The main disadvantage of the standard set of devices for interacting with VR (Helmet + controllers) is the limitation of the set of input data on user actions. Information on the position of the user's head and hands in space may be insufficient in some simulators (for example, if direct interaction with virtual reality objects is required using fine motor skills of the hands). There are many different approaches to solving such specific problems.

Hardware-based approach

One way to expand the input data on user actions is to use additional equipment. At the moment, there is a wide range of different VR equipment, let's consider it in more detail. If additional information is required on the position of large limbs in space, one option is to use motion capture trackers (for example, HTC VICE Tracker, Figure 1A). If fine motor skills (fingers' movements) need to be captured, special gloves can be used (Figure 1B). If full-body motion capture is required, the optimal method is to use a motion capture suit (Figure 1C).

A B C

Figure 1 - Motion capture equipment for VR simulators

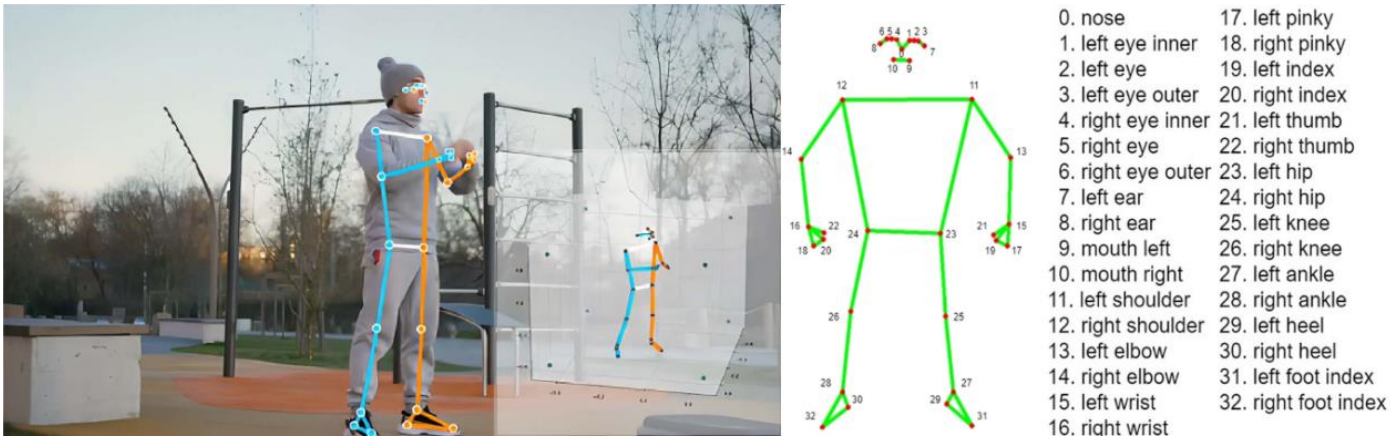
However, using additional equipment to capture user motion has its drawbacks, expressed both in availability (price, availability in stores) and in the uniqueness of the software. When using additional equipment in VR simulator projects, it is also necessary to take into account the unique API (Application Programming Interface) of each device, which is especially difficult if several types of devices are used simultaneously.

Neural network-based approach

An alternative to using additional equipment is to use computer vision technology to capture motion.

A direct analogue of using a motion capture suit is to use a stream of images from an external camera (standing at a distance and facing the user) and process them using any neural network for capturing human body motion (for example, Mediapipe, Figure 2A).

Such computer vision neural networks, as a rule, output an array of points with coordinates in the {x, y, z} format (Fig. 2b). To interpret data in virtual reality simulators for visualization of the body of a virtual avatar, you can use the Shepperd method [1] and apply vectors and rotations to the corresponding bones of the 3D character model.



A B

Figure 2 – Mediapipe neural network (Body tracking mode)

Using an external camera with image processing using motion capture neural networks is free from problems associated with the availability of special VR equipment, since this method only requires a web camera (or several web cameras to increase the accuracy of capture), but the need to work with a unique software interface remains, since each neural network has its own unique API.

In turn, a similar approach can also be used to capture hand movements [2,3]. Since most virtual reality helmets are equipped with cameras on the body, they can be used to capture hand movements. To do this, it is enough to run images from the helmet cameras through a similar neural network (for example, Mediapipe, Fig. 3).

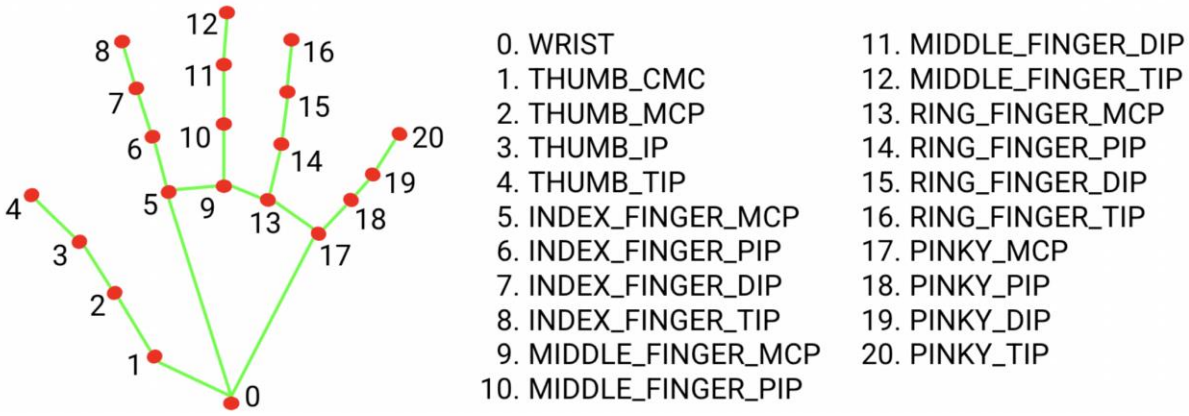


Figure 3 – Tracking hand points using Mediapipe (Hands tracking mode)

Some virtual reality helmets (for example, Oculus Quest) already contain similar functionality for hand capture within their software, which can already be used in VR simulators without using third-party neural networks.

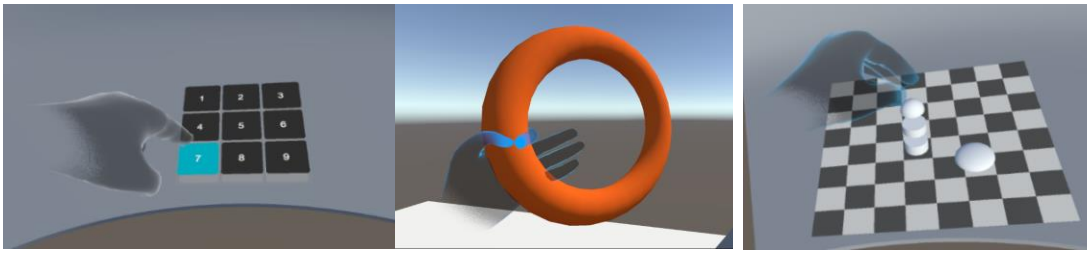


Figure 4 – Interaction with VR objects using fine motor skills

A common problem with using computer vision technology for motion capture against competitors is the accuracy of positioning the points recognized in the image (especially depth coordinates). To solve this problem, several cameras and triangulation methods are usually used.

Conclusion

The choice of the capture method and means depends on many conditions: the required amount of data, capture accuracy, budget, limitations of the target operating system, complexity of implementation in a specific application, etc. Before developing each VR simulator that requires capturing the user's limbs, the preferred method can be determined using the above list of conditions.

Acknowledgements

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References
1. Sarabandi S., Thomas F. Accurate computation of quaternions from rotation matrices //International Symposium on Advances in Robot Kinematics. – Cham: Springer International Publishing, 2018. – С. 39-46.
2. Obukhov A. et al. Modeling of Nonlinear Dynamic Processes of Human Movement in Virtual Reality Based on Digital Shadows //Computation. – 2023. – Т. 11. – №. 5. – С. 85.
3. Shiltsin M.A., Surkova E.O., Arkhipov A.E. Integratsiya tekhnologiy virtual'noy real'nosti i komp'yuternogo zreniya pri zakhvate dvizheniy ruk [Integration of Virtual Reality and Computer Vision Technologies in Hand Motion Capture]. Novye informatsionnye tekhnologii i sistemy (NITiS-2022), 2022, pp. 89-92. (Rus)

Средства взаимодействия человека с виртуальными объектами

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Аннотация. В данной статье описываются существующие технологии и методы организации взаимодействия пользователя с объектами виртуальной реальности. Рассматриваются подход, основанный на дополнительном оборудовании и использовании компьютерного зрения. Также рассматриваются плюсы и минусы различных подходов к захвату движения человека для использования в виртуальной реальности.
Ключевые слова: взаимодействия в VR, виртуальная реальность, захват движения

УДК 004.021

Pattern thinking path for CNC Machines program development

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Abstract
The article presents promising method of CNC Machines control programs development as program-templates. It is based on pattern thinking that natural for human. An example of the functioning of one of the programs and a vector of development of direction are shown. The niche of the method being developed in the field of development Control Programs for CNC machines is marked.
Keywords: CNC Machine programs; development; pattern thinking; program-templates.

Introduction

Patterns are a fundamental part of the human experience of everyday and professional life. The word "pattern" describes reusable solution for the problem. Everything from walking to job duties is built on patterns. Human is woven of patterns. And since that's the case We face the challenges and get experience. When you're looking for patterns, you're applying your past experiences and what you know to a new set of circumstances, even if those circumstances don't look the same [1]. Good terms will be repeated worst will be consigned to oblivion. And since that's the case, I think the natural way of CNC program development is template usage.

The aim of this work is to look at the experience of programming machines with CNC from the point of view of the pattern thinking for further processing it into practical program-templates using macro programming tools.

Interim results are presented in the example of one of the program templates. The method development path is defined - a library of such programs, which will allow the method to take a solid position among existing ones.

Patterns in CNC Programs case

We found out that the origins of pattern-based thinking are in human nature. That means recognizing common issues or scenarios. Civil engineer named Christopher Alexander first used the term pattern-based thinking for the first time. Alexander wrote, "Each pattern describes a problem which occurs over and over again in our environment, and then describes the core of the solution to that problem, in a way that you can use this solution a million times over, without ever doing it the same way twice." [2] So, the pattern-based thinking is the practice of approaching a problem by analyzing it, likening it to past experience, and applying the solutions of that experience to our current circumstances. Approaching problem solving in the same way lets you jump past a lot of long theorizing and move straight towards developing a solution.

Templates save time and resources. Templates exist, are created and used for this. The templates are actually everywhere in the development of CNC machines control programs. The world's leading CNC systems (FANUC, DMG MORI and SIEMENS) provide built-

in software (MANUAL GUIDE, CELOS and POWERMILL) to build NCP (Numerical Control Program) from block types. What are these like templates? The same approach in CAM systems. Tools and methods NX, Fusion 360, SprutCAM - are sets of templates. The programmer configures the most suitable ones for his task.

Take this natural path of pattern thinking and take another step. Move to where any of the previously mentioned methods are not effective. Move towards high-level patterns, those that describe the whole detail, whose geometric parameters are formalized. Typical parts such as drive chain sprocket or servo gear are complex and not available for onboard programming. Programming them with CAM systems requires efforts to create a new model for each sample even with small changes. After applying all tools to the new model program-template is devoid of shortcomings of the above approaches. To obtain NCP for the production of a drive chain sprocket wheel arbitrary characteristic with an arbitrary number of teeth on it from any material is sufficient one program-template. The results of which can be found in the following Fig. 1

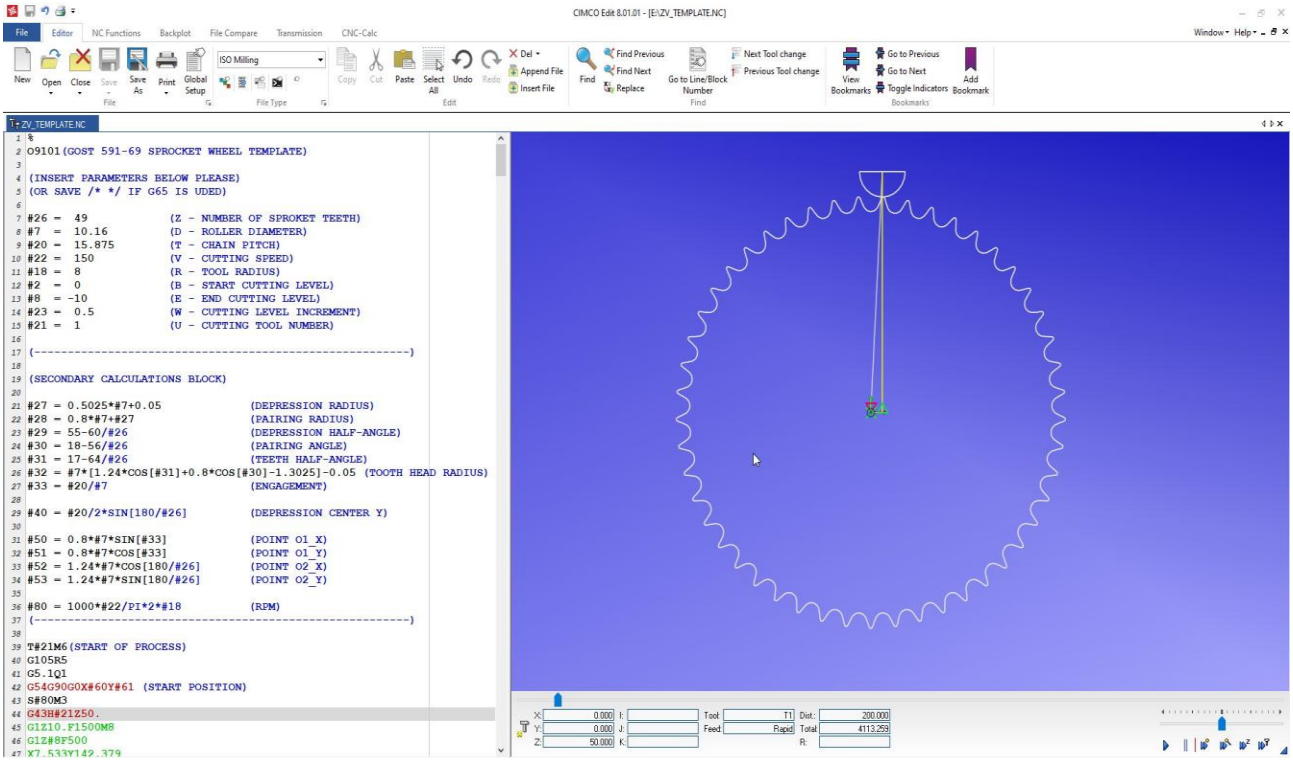

Figure1 - Program-template of sprocket wheel implementation for Z=49

Most industrial enterprises are adopting digital methods in preparing production and reducing time for programming to be successful in competitive struggle [3]. The direction of the programs-templates has its niche in development and will be demanded. Having an extensive library of templates, easily accessible, even a visual description in the accompanying documentation will make the use of such template programs preferable to manual programming or using CAM systems. The POWERMILL, MANUAL GUIDE and CELOS toolset is easily reproduced within the created library for easy completion of template-based NCP by elementary operations sets.

To create such templates, it will be necessary to classify and structure the existing experience. Everything possible to be used repeatedly should be formed of procedures for further transformation into a macro-program template. It is a specially designed control program in a system-friendly format. For this we use macro programming available to modern CNC systems. There is the possibility to operate variable values, set of arithmetic and logical functions, unconditional and conditional transitions. The distinctive feature of a macro program is the possibility to transfer arguments into it. We get both a ready to run on the machine program, if you put the necessary parameters, and embedded in a more voluminous process procedure with arguments.

Conclusion

The natural way of CNC program development is template based. Analysing of the repeated positive experience of manufacturing various machine-building parts on CNC machines and using macro programming, it is possible to create a library of software templates that complement existing methods of NumericalControlProgram creation.

References

1. Will Harris. What's pattern-based thinking, and what does it have to do with design systems? Available from: https://www.knapsack.cloud/blog/pattern-based-thinking (Accessed 23.11.2024). (Rus)
2. Alexander C., Ishakawa S., Silverstein M. A Pattern Language: Towns, Buildings, Construction. Oxford, Oxford University Press, 1977. 1171 p.

Применение шаблонного мышления к разработке программ для станков с ЧПУ

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Аннотация. В работе описывается перспективная методика разработки управляющих программ для станков с числовым программным управлением – программ-шаблонов, а также демонстрируется естественность этого подхода, основанного на шаблонном мышлении. Показаны пути развития и определена ниша разрабатываемого метода среди инструментов разработки управляющих программ.

Ключевые слова: программы для станков с ЧПУ; программы-шаблоны; разработка; шаблонное мышление.

УДК 34-4414

Automatisierung der Interaktion der Verwaltung der kleinen Siedlungen mit der Bevölkerung

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Zusammenfassung
Die Dorfverwaltung ist das Exekutiv-Verwaltungsorgan der ländlichen Siedlung. Eine wichtige Rolle spielt die Gewährleistung der Entwicklung der Landwirtschaft, die Umsetzung der staatlichen Politik auf lokaler Ebene, die Koordinierung der Arbeit verschiedener Branchen und die Unterstützung der ländlichen Bevölkerung. Für die produktive Arbeit der lokalen Regierung ist es wichtig, den Leuten zuzuhören und die Menschen zu hören, die sich direkt für Veränderungen zum Wohle des Volkes interessieren. Probleme, die ein angenehmes Leben auf dem Territorium der ländlichen Siedlung behindern, sollten schnell gelöst werden. Der Einsatz von Informationstechnologien für die Kommunikation zwischen Verwaltung und Bürgern kann die Effizienz und Benutzerfreundlichkeit der Kommunikation erheblich verbessern. In diesem Zusammenhang wurde ein Webportal für die Verwaltung «Portal für die Interaktion der Verwaltung kleiner Siedlungen mit der Bevölkerung» entwickelt, das es der Verwaltung ermöglicht, sich der Probleme bewusst zu sein, die in dem ihnen untergeordneten Gebiet auftreten, und ihre Aufzeichnungen zu führen. Für die Entwicklung des Webportals werden standardmäßige und allgemein anerkannte Entwicklungswerkzeuge verwendet: HTML, CSS, PHP und JavaScript, MySQL-Datenbankverwaltungssystem, die Anwendung von phpMyAdmin für die Verwaltung von MySQL-DBMS.
Schlüsselwörter: die Dorfverwaltung, die Verwaltung, IT-Marktes, Informationssystemen.

Die Dorfverwaltung ist das Exekutiv-Verwaltungsorgan der ländlichen Siedlung, das mit Befugnissen zur Lösung von Fragen von lokaler Bedeutung ausgestattet ist [3].

Die lokale Selbstverwaltung fungiert als eine der wichtigsten demokratischen Institutionen, die die Verwirklichung der Rechte der Bürger auf Siedlungsebene sicherstellen. Eine wichtige Rolle spielt auch die Gewährleistung der Entwicklung der Landwirtschaft, die Umsetzung der staatlichen Politik auf lokaler Ebene, die Koordinierung der Arbeit verschiedener Branchen und die Unterstützung der ländlichen Bevölkerung. Das System der Kommunalverwaltungen umfasst zwangsläufig ein repräsentatives Organ, dessen Mitglieder durch die Abstimmung gewählt werden [1].

Die Verwaltung der ländlichen Siedlung unterstützt die Rechtsstaatlichkeit, die Verbesserung des Territoriums und die Lösung der häuslichen Probleme der Bevölkerung, was ein wichtiger Indikator für die Arbeit der Verwaltung ist. Außerdem ist die Dorfverwaltung verpflichtet, ihre Aktivitäten zu überwachen und den höheren Behörden und der Bevölkerung Bericht zu erstatten. Die Kontrolle ermöglicht es, Fehler und Mängel zu erkennen und zu korrigieren sowie Transparenz und Offenheit der Verwaltung zu gewährleisten. Durch die Zusammenarbeit mit anderen Behörden, wie Gemeinden, Behörden und Organisationen, gewährleistet die Verwaltung des ländlichen Raums die effektive Verwaltung und Entwicklung des ländlichen Raums.

Die Verwaltung der ländlichen Siedlung sollte den Menschen, die auf dem Territorium dieser Siedlung leben, nahe sein [3]. Für die produktive Arbeit der lokalen Regierung ist es

äußerst wichtig, den Menschen zuzuhören und die Personen zu hören, die sich direkt für Veränderungen zum Wohle des Volkes interessieren. Probleme, die das angenehme Leben auf dem Territorium der ländlichen Siedlung behindern, sollten schnell gelöst werden. In diesem Fall führt die fehlende Kommunikation der Bevölkerung mit der Verwaltung oft zu einem langwierigen Prozess der Lösung von Fragen und hat negative Auswirkungen auf ihre Beziehungen [2].

Die Analyse des IT-Marktes von Systemen für die ländliche Verwaltung ermöglicht es, die wichtigsten Trends in diesem Bereich zu erkennen und die aktuelle Wettbewerbssituation und Entwicklungsmöglichkeiten zu bewerten.

Die Dorfverwaltung hat spezifische Bedürfnisse und Aufgaben, die mit Hilfe von Informationstechnologien optimiert werden können.

Derzeit gibt es mehrere Unternehmen, die sich auf die Entwicklung und Implementierung von Systemen für die ländliche Verwaltung spezialisiert haben. Zum Beispiel kann man solche Software wie: BARS-Budget, «ADC-Finanzen», «Kontur-External», «ADC-Planung» nennen.

Die Analyse des IT-Marktes hat gezeigt, dass es trotz der Verfügbarkeit von Informationssystemen zur Automatisierung der Verwaltung keine Softwareprodukte gibt, die die Interaktion der Verwaltung mit der Bevölkerung sicherstellen. Der Einsatz von Informationstechnologien für die Kommunikation zwischen Verwaltung und Bürgern kann die Effizienz und Benutzerfreundlichkeit der Kommunikation erheblich verbessern. Die Bevölkerung wird in der Lage sein, ohne das Verwaltungsgebäude zu besuchen, Probleme in der Siedlung über die Website zu melden. Für die effektive Arbeit der Verwaltung ist der Einsatz von Informationstechnologien ebenfalls bequem, da der Kommunikationsprozess mit den Bürgern sowie die Erfassung von Anfragen erheblich erleichtert und beschleunigt wird [1].

In diesem Zusammenhang ist ein Webportal für die Verwaltung «Portal für die Interaktion der Verwaltung kleiner Siedlungen mit der Bevölkerung» entwickelt, das es der Verwaltung ermöglicht, die Probleme, die in ihrem untergeordneten Gebiet auftreten, zu berücksichtigen und zu protokollieren. Die Bevölkerung wiederum wird in der Lage sein, alle Probleme der Verwaltung schnell zu melden und Antworten darauf zu erhalten.

Die Analyse der Aktivitäten der Verwaltung ermöglichte es, die grundlegenden Anforderungen zu bestimmen, denen das vorgeschlagene Portal entsprechen sollte: übersichtliche Benutzeroberfläche, Eingabe von Anfragen aus der Bevölkerung, Speicherung und Verarbeitung von Informationen zu Anfragen, d.h. Protokollierung, Eingabe von Antworten seitens der Verwaltung, Datensicherheit.

Die Funktionalität des angebotenen Webportals ist im Vergleich zu anderen bereits vorhandenen Websites und Informationssystemen gering. Es sollte jedoch die enge Ausrichtung dieses Portals berücksichtigt werden. Außerdem wird das System im Rahmen der Abschlussqualifizierungsarbeit kostenlos entwickelt [4].

Das Webportal ist für die Verwendung durch die Verwaltung und die Bewohner des Landratsamtes von Lipov im Bezirk Pichaevo des Gebiets Tambow vorgesehen. Damit es für die Bevölkerung und die Verwaltung des Landratsamtes einfacher ist, die Funktionalität des Portals zu verstehen, wird eine einfache und übersichtliche Schnittstelle

verwendet. Das Webportal verfügt nur über die erforderlichen Tools, mit denen man sich beim Erstellen und Senden von Kundenvorgängen und beim Buchen von Kundenvorgängen schnell navigieren kann.

Für die Entwicklung des Webportals werden standardmäßige und allgemein anerkannte Entwicklungstools verwendet. Betrachten wir alle Entwicklungswerkzeuge im Detail.

Für die Entwicklung eines Webportals wurde als Sprache für die Erstellung von Webseiten die Sprache HTML ausgewählt, die die Grundlage für die Erstellung von Webseiten darstellt. Es ist mit allen Geräten kompatibel, hat viele Vorteile, ist einfach zu erlernen. Zum Erstellen von Websitestilen wird die CSS-Sprache verwendet, mit der man einen Stil an strukturierte Dokumente anhängen kann. Außerdem werden die Sprachen PHP und JavaScript verwendet, die die Integration in HTML und CSS ermöglichen, um ein Webportal zu erstellen [4]. MySQL ist als Datenbankverwaltungssystem ausgewählt, da es sich um ein kostenloses DBMS handelt und außerdem einfach zu bedienen ist. Die kostenlose Anwendung von phpMyAdmin wird für die Verwaltung des MySQL-DBMS ausgewählt [2].

Literaturverzeichnis

1. Bokenchina, L.K. Perspektivy razvitiya social'noj sfery sela / L.K. Bokenchina. – Almaty: Vestnik universiteta Turan, 2016. – 110 S. (in Russ.)
2. Burceva, E.V. Bazy dannyh: ucheb. posobie / E.V. Burceva, A.V. Platenkin, I.P. Rak. – Tambov: Izdatel'skij centr FGBOU VO «TGTU», 2023 // FGBOU VO «TGTU» Obrazovatel'nye internet-resursy TGTU: [sajt]. – URL: https://www.tstu.ru/r.php?r=obuch.book.elib1&id=7 (data obrashcheniya: 17.05.2024). (in Russ.)
3. Zotov, V.B. Sistema municipal'nogo upravleniya / V.B. Zotov. – Sankt-Peterburg: Piter, 2013. – 364 s. (in Russ.)
4. Rak, I.P. Osnovy razrabotki informacionnyh sistem: ucheb. posobie / I.P. Rak, A.V. Platyonkin, A.V. Terekhov. – Tambov: Tambovskij Gosudarstvennyj Tekhnicheskij Universitet, EBS ASV, 2017. – 98 s. (in Russ.)

Автоматизация взаимодействия администрации малых населенных пунктов с населением

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Аннотация. Сельская администрация является ключевым исполняющим органом сельского поселения, отвечающим за развитие сельского хозяйства и реализацию государственной политики на местном уровне. Ее важнейшая задача - координация работы различных отраслей и поддержка сельского населения. Для эффективного местного самоуправления необходимо учитывать мнения граждан, заинтересованных в положительных изменениях. Для решения существующих проблем нами был разработан веб-портал «Портал взаимодействия администрации малых населенных пунктов с населением», который улучшит коммуникацию между администрацией и жителями. Портал позволит администрации оперативно выявлять и учитывать возникающие проблемы на своей территории. Для разработки веб-портала использовались стандартные и общепризнанные средства разработки: язык HTML, язык CSS, языки PHP и JavaScript, система управления базами данных MySQL, приложение PhpMyAdmin для администрирования СУБД MySQL.
Ключевые слова: сельская администрация, администрация, ИТ-рынок, информационная система.

УДК 004.93

Development of software for a robotic locomotor therapy system

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Abstract
Robotic complexes are widely used for rehabilitation of patients who have undergone various traumas and surgeries, neurological diseases and diseases of the musculoskeletal system. The paper describes the software developed to simplify the interaction of medical specialists with the robotic complex for locomotor rehabilitation. The paper also presents a description of the robotic complex used in the study, overall structure of the software and principle of interaction of its components are reviewed. The functionality provided by the software is described.
Keywords: locomotor therapy, musculoskeletal rehabilitation, software, robotic systems.

Introduction

Robotic locomotor therapy systems are devices that mimic human limb movements. Such systems are widely used for rehabilitation of patients who have suffered a stroke, various injuries and surgeries, neurological and musculoskeletal diseases [1]. The use of robotic systems can make the process of patient rehabilitation more efficient and safer [2,3].

The flexibility of the rehabilitation process is one of the main advantages of this approach [3]. In this paper, we propose software for working with the rehabilitation system. This software allows simplifying user (doctor or health worker) interaction with the system and gives the opportunity to adjust its necessary parameters in accordance with the individual patient's characteristics and condition.

The software includes a system driver and a client application with a user interface implemented in the Python programming language.

General system description

Complete rehabilitation system, used in our work, consists of personal computer (PC) on which the software is deployed and hardware including: manipulators, patient lift/lowering system, treadmill and a controller that interprets the commands that come from the software.

Interaction with the hardware is carried out via Wi-Fi network by means of TCP-connection using our developed data exchange protocol. The conceptual diagram of interaction is shown in the Fig. 1.

To prepare the locomotor therapy system for a session with a patient, the user needs to select a pre-trajectory file in the following format CSV (Comma-Separated Values). We obtain this trajectory by taking readings from a person using a motion capture system. After loading the preliminary trajectory from the software on the computer into the controller memory of the rehabilitation system, the controller calculates the final trajectory and sends a ready signal.

In addition to the above functionality, proposed software provides the ability to send service mode commands to debug the system and check its performance. In order to ensure patient safety during training while using the system, procedures for regular and emergency system

shutdown were implemented. A normal stop is performed after sending a corresponding command by the computer operator, an abnormal stop occurs when a signal is received from the limit switches, which means that a link has exceeded the maximum permissible deflection angle in one of the directions.

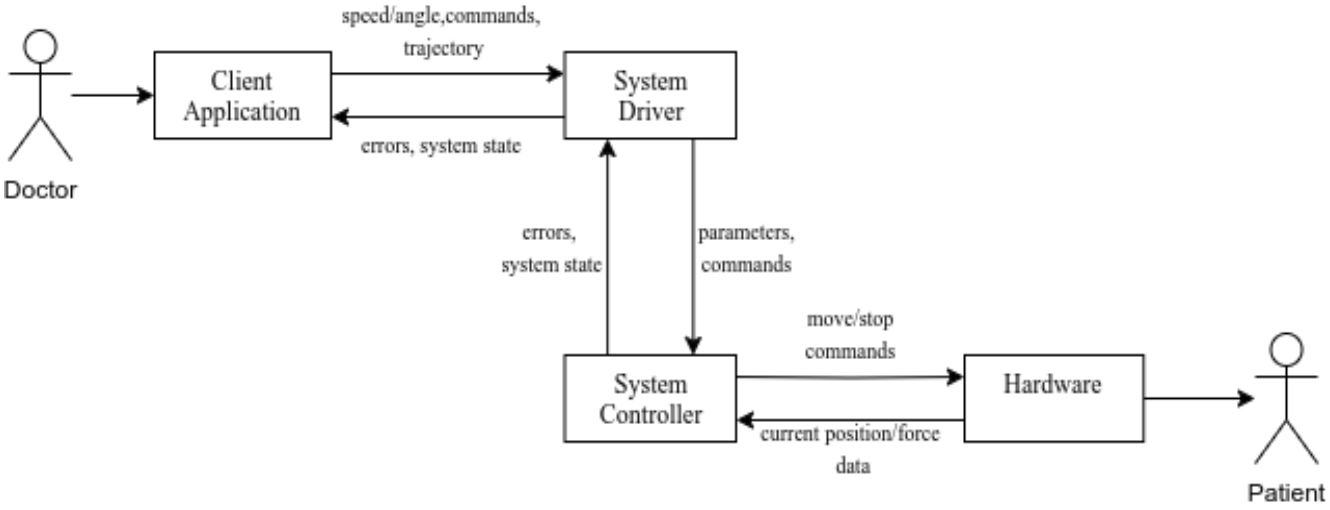

Figure 1 - Conceptual diagram of the system

System driver

The logic of interaction with the robotic system controller is implemented in the system driver. The driver is used as a library that is plugged into the client application project. The driver software code includes both basic classes that can be used to interact with any remotely connected device using the protocol we have developed, and components used to control the system itself. The general control protocol for such devices includes various types of packets, designations of operating modes, settings and commands, error codes. Individual operating parameters and commands are used to work with the robotic system. The driver also contains implementations of procedures for connecting to device, loading data, sending a request to device and waiting for a response from it.

Client application

An interface implemented using the PyQt5 framework has been developed for user interaction. The entire interface functionality is divided into two main tabs: "Training" and "Service mode". In the first tab, the user is given access to work in automatic mode, selecting and loading the trajectory. The second tab is used for internal system testing and debugging, allowing the user to set coefficients and control the robotic arm links manually.

During the application development process, the "Model View Controller" design pattern is selected. The chosen approach allowed delegating system events to different levels: display - interface, controller - driver and models. Interaction between the levels takes place through the pyqt-signals mechanism, which allows for an upward flow of commands.

Conclusion

In this paper, a description of the software used to control the robotised locomotor therapy system was presented. The considered software is divided into two components: system driver and client application, each responsible for specific tasks. The presented software architecture allows minimising the number of errors in the system operation and simplifies its debugging.

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References

1. Warutkar V., Dadgal R., Mangulkar U. R. Use of Robotics in Gait Rehabilitation Following Stroke: A Review. Cureus., 2022, Vol 14, Issue 11.
2. Kotov E. A., Druk A. D., Klypin D. N. Razrabotka ekzoskeleta nizhnih konechnostej cheloveka dlya medicinskoj reabilitacii [Development of a human lower limb exoskeleton for medical rehabilitation]. Omskij nauchnyj vestnik, 2021, Vol 4(178), pp 91-97. (Rus)
3. Pool D. et al. Locomotor and robotic assistive gait training for children with cerebral palsy. Developmental Medicine & Child Neurology, 2021, Vol. 63, Issue, pp 328-335.

Разработка программного обеспечения для роботизированной системы локомоторной терапии

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Аннотация. Роботизированные комплексы широко используются для проведения восстановительной реабилитации у пациентов, перенёсших различные травмы и операции, неврологические заболевания и заболевания опорно-двигательной системы. В статье приведено описание программного обеспечения, разработанного для упрощения взаимодействия медицинских специалистов с роботизированным комплексом для локомоторной реабилитации. Также в работе представлено описание роботизированного комплекса, использованного в исследовании, рассмотрена общая структура ПО и принцип взаимодействия его компонентов. Описан функционал, который предоставляет данное программное обеспечение.

Ключевые слова: локомоторная терапия, опорно-двигательная реабилитация, программное обеспечение, роботизированные системы.

УДК 004.4'277.4

Information system for creating and editing guitar score

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Abstract
This paper presents the development of an information system for creating and editing guitar parts for music schools. The cross-platform Unity 3D engine was chosen as the main working environment. For the server part the choice was made in favor of PHP and MySQL database. Tasks to be solved: 1) Analysis of existing solutions; 2) Selection of tools for realization of information system
Keywords: Information system, Unity 3D, C#, MySQL, PHP.

Introduction

In the modern world, information technologies have a significant impact on various spheres of human activity, including music education. Creation and editing of scores play an important role in the learning process of students of musical educational institutions. In the context of studying guitar playing the use of information systems that promote the quality formation and development of musical performance skills becomes especially important. Under the quality of formation and development of skills or quality of training, in this case, we mean the value inverse to the time of mastering the corresponding skills at some given level.

Interactive tools and software for creating and editing guitar scores are becoming an integral part of students' learning and practice. They provide an opportunity for prompt checking by the teacher, as well as making the necessary adjustments to build a more competent vector of student's development. Therefore, the development of specialized information systems that take into account the peculiarities of guitar performance and teaching is an urgent problem of modern music education.

It is also important to realize that during training, the teacher always checks homework, independent work and other achievements of students. Accordingly, to simplify this process, an information system that combines all the necessary functionality would be suitable.

The situation on the current market offers information systems for creating scores, but they do not take into account the specifics of the educational process and are not effective for the realization of communication between teacher and student.

Such an information system should include the possibility of reviewing, supplementing, or otherwise assisting the teacher, and the storage, revision, or maintenance of the score by the student. It would also have the obvious merit of allowing the teacher to create a score for the students as an example of a well-crafted piece.

Such monitoring of the work would make it much easier to master such a complex discipline. That in turn will give additional motivation for further development without losing interest in the subject. The usefulness of this information system will not be finished at the stage of full completion of the course. In the future, the user gets the

opportunity to work together remotely at a convenient moment with other people. Thus, by facilitating the process of creating scores, productivity in creating them will be greatly enhanced. Since there will no longer be a need for paper-based work.

Defining the technology stack

The client part of the application is implemented using Unity engine and object-oriented language C#. The server part uses the classic combination of general-purpose scripting language PHP and DBMS MySQL.

In 2005, the company Unity technologies presented the first version of the engine, which was originally conceived for Mac computers. However, an update released in August of the same year allowed working on Windows. Over time, the multiplatform nature of this engine was 25 different environments to run programs developed in it. This flexibility allows you to change the platform under which the development takes place as needed. Obviously, among the 25 proposed platforms there are necessary Android and iOS. Also in favor of choosing this technology is the fact that Unity has a very large community, which is constantly creating various frameworks and utilities for this environment [1].

C# is an object-oriented programming language from Microsoft, created in 1998, belonging to the family of C-like languages. It is often called a “cleaned up version of Java”, with it has about 75% similar syntactic features, 10% C++ heritage, 5% Visual Basic and the remaining 10% is the realization of developers' own ideas. This language is the main language when developing on the Unity engine. Where it is translated into C++ when compiling a program [2]. Since C# is a younger language, its annual trend of increasing popularity could not but affect the speed of its development. With each version of the language, developers add new and new functionality, trying to achieve perfection in the convenience of development.

This language has all the qualities of an object-oriented language, namely inheritance, encapsulation, polymorphism. These powerful development tools are usually combined with interfaces, and their implementation in C# is one of the best. The only disadvantage that can be ot-marked is the priority focus on the Windows platform, which does not matter when developing on Unity.

PHP is a kind of golden standard in the development of the server side of the application. This is not surprising, because its original purpose is the development of personal web pages. Nowadays, it is one of the most demanded programming languages for the back-end part of the program. According to the TIOBE ranking, PHP is among the top 10 languages in terms of usage by developers. It is supported by many providers and for its history has grown more than one library that simplifies interaction with it. Working with HTTPS authorization, processing files uploaded to the server, automatic extraction of POST and GET-parameters and many other things are implemented thanks to this language.

MySQL is a free relational database management system. One of the most widespread DBMS on the market, it has proved itself by stability and simplicity of work

for many years of use by developers. It is actively supported and developed, has API for working with many programming languages (including PHP), and is an excellent solution for medium and small projects, such as the information system for creating and editing guitar parts for students of secondary and higher musical educational institutions.

Conclusion

Ultimately, the chosen set of technologies fully satisfies the goals of the information system. The relevance of the tools - will become a reliable foundation for supporting and extending the functionality. The main advantages of the developed information system are its intuitive interface, wide functionality and the possibility to personalize settings for specific user needs. This approach allows students to study, create and perform music on guitar more effectively, improving the quality of education and stimulating creative development.

References

1. Harryson F. Izuchaem C# cherez razrabotku igr na Unity. Saint Petersburg, 2022. 512 p. (Rus) ил.
2. Rukovodstvo Unity [The global pharmaceutical industry]. Available from: https://docs.unity3d.com/ru/530/Manual/index.html. (Rus)

Информационная система для создания и редактирования гитарных партитур

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Аннотация. В данной статье представлена разработка информационной системы для создания и редактирования гитарных партий для музыкальных учебных заведений. В качестве основной рабочей среды был выбран кроссплатформенный движок Unity 3D. Для серверной части выбор был сделан в пользу PHP и базы данных MySQL. Решаемые задачи: 1) Анализ существующих решений; 2) Выбор инструментов для реализации информационной системы
Ключевые слова: Информационная система, Unity 3D, C#, MySQL, PHP.

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Application of OS-level virtualization in deception technology

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Abstract
This article explores the use of containerization for deploying information security systems based on deception technology. The relevance of this topic is driven by the increasing number of cyberattacks and the limitations of traditional security methods. The advantages of containerization are examined, including lightweight deployment, fast startup, scalability, and portability. The study presents practical examples of container-based deception techniques, such as docker-ssh-honey – a fake SSH server designed to log brute-force attempts – and T-Pot, a distributed platform for managing multiple honeypots. Experimental testing has demonstrated that containerization significantly simplifies the deployment and configuration of deception systems, reduces overhead costs, and enhances cyberattack detection efficiency. The findings confirm the applicability of containerization in deception-based security systems.
Keywords: deception technology, hardware virtualization, honeypot, information security, OS-level virtualization.

Introduction

The idea of deception technology comes from the so-called «honeypot» – a primitive false information resource for identifying unauthorized access to an information system. Deception technology expands upon this idea to include centralized management, monitoring, automated deployment, and integration with other security solutions. Organizations can use deception-based security systems to supplement traditional defenses with proactive measures, allowing for early detection of attackers instead of only containing their damage. Moreover, such systems can be used as a «last line of defense» when other security measures have failed to identify an intrusion or where there are insider threats.

In general, deception systems are complex to build and run due to the need to properly decide on the kind of traps to place, setting them up, and ensuring they can run cross-platform, portable, and easy to install. Some techniques involve emulating entire OS, while others focus on individual services you would find in your environment. The first approach needs to boot a complete OS with the aid of VMs and is resource greedy. In the second case, it is possible to install traps directly alongside real services on network nodes. But then the question arises about the possibility of quickly deploying traps with the required configuration in heterogeneous networks of distributed information systems with nodes based on different OS and architectures, where the complexity of optimal resource allocation is described by Mazalov, Yakovlev and Alekseev in the article «Development of an analytical model for optimizing resource allocation across nodes of distributed information systems» [1]. In this case, a suitable solution is to use containerization – virtualization at the operating system level, which allows isolating applications and their dependencies in separate, lightweight environments running on a common OS kernel [2].

OS-level virtualization in deception technology

Any organization is limited by hardware resources. In order to divide these resources at different levels, virtualization is used. Virtualization enables the creation of virtualized hardware resources, allowing entire OS instances to operate independently on shared infrastructure. This is achieved through hardware-assisted virtualization technologies such as AMD-V and Intel VT, which provide near-native performance and allow for full OS emulation. Such virtualization is often used in deception technology to deploy traps that emulate complete operating systems.

However, not all deception techniques or software solutions require the overhead of full OS virtualization. In many cases, fast deployment times and portability are critical, particularly for deception traps. OS-level virtualization, commonly referred to as containerization, addresses these needs by allowing software to run in isolated OS environments – containers – where only the necessary dependencies, libraries, and configurations are included. Dependencies refer to external components (other programs, services, or modules) required for an application's operation. Libraries contain pre-written code that applications utilize to perform various functions. Configuration settings define how an application operates. Since an entire OS instance is not required for each application, containerization improves portability across OS environments with the same kernel or when using virtualization. This capability is particularly important for deception-based security systems, as it enables rapid and flexible deployment of traps across various nodes.

The use of containerization for deception-based security systems is a well-established and successful approach [2]. Many standalone honeypots and entire deception management platforms are built on this foundation. Notable examples include docker-ssh-honey and T-Pot.

The docker-ssh-honey honeypot is an open-source fake SSH server designed to listen for incoming SSH connections and log IP addresses, usernames, and passwords used in brute-force attacks [3]. Initially known as SSH Honeypot, it requires a specific set of libraries – libssh, OpenSSL, libjson-c, and libpcap – for installation. Containerization enables it to be deployed with the necessary environment and dependencies pre-configured.

T-Pot is a comprehensive distributed deception system supporting more than 20 types of honeypots and multiple visualization tools. It utilizes Docker and Docker Compose to deploy and manage multiple honeypots simultaneously, maximizing hardware resource utilization [4].

Conclusion

The analysis demonstrates that containerization is a highly effective solution for deploying deception-based security systems due to its lightweight nature, rapid startup times, and portability. It facilitates the automated deployment of decoy targets in heterogeneous networks while enabling scalability, system isolation, and reduced deployment overhead. Practical examples such as docker-ssh-honey and T-Pot highlight the advantages of containerization in simplifying the setup and configuration of deception

environments. This study confirms the applicability of containerization in addressing the challenges of automated deployment and management of deception-based security mechanisms in corporate networks.

References

1. Mazalov A.N., Yakovlev A.V., Alekseev V.V. Razrabotka analiticheskoj modeli optimizacii razmeshcheniya resursov po uzlam raspredelennyh informacionnyh system [Development of an analytical model for optimizing resource allocation across nodes of distributed information systems]. Vestnik Voronezhskogo instituta MVD Rossii, 2020, No. 4, pp. 55-62. (Rus)
2. Besplatnyj syr v Docker – kak podnyat' sotni setevyh lovushek na odnoj mashine [Free cheese in Docker - How to run hundreds of network traps on a single machine]. Available from: https://habr.com/ru/companies/bastion/articles/583796/ (Accessed 25.02.2025). (Rus)
3. Docker-ssh-honey. Available from: https://github.com/random-robbie/docker-ssh-honey (Accessed 25.02.2025)
4. T-Pot – The All In One Multi Honeypot Platform. Available from: https://github.com/telekom-security/tpotce (Accessed 25.02.2025)

Применение контейнеризации в технологии киберобмана

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Аннотация. В статье исследуется применение контейнеризации для развертывания систем защиты информации, основанных на технологии киберобмана. Актуальность проблемы обусловлена ростом числа кибератак и ограничениями традиционных методов защиты. Рассматриваются преимущества контейнеризации: легковесность, быстрый запуск, масштабируемость и переносимость приложений между узлами с различными операционными системами. В работе приводятся примеры практического применения контейнерных технологий для создания ложных целей, такие как docker-ssh-honey – ложный SSH-сервер для регистрации попыток подбора учетных данных, и T-Pot – распределенная платформа для управления множеством ловушек. Экспериментальное тестирование показало, что использование контейнеров значительно упрощает установку и настройку ловушек, снижает накладные расходы и повышает эффективность обнаружения кибератак. Полученные результаты подтверждают применимость контейнеризации в системах защиты информации на основе технологии киберобмана.

Ключевые слова: аппаратная виртуализация, информационная безопасность, программная виртуализация, технология киберобмана.

УДК 519.612

Die Relevanz der Entwicklung intelligenter Systeme für die Analyse der Effizienz von Unternehmen

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Zusammenfassung

Der Beitrag diskutiert die Relevanz der Entwicklung intelligenter Systeme für die Analyse der Effizienz von Unternehmen. Die Hauptprobleme im Zusammenhang mit der Verarbeitung großer Datenmengen und der unzureichenden Integration von Informationssystemen sind beschrieben. Bestehende Softwarelösungen, ihre Vor- und Nachteile sind analysiert und Richtungen zu deren Verbesserung im Rahmen des Einsatzes von Technologien des maschinellen Lernens aufgezeigt. Moderne Unternehmen generieren täglich riesige Mengen an Informationen, die aufgrund des Mangels an effektiven Verarbeitungs- und Analysetools ungenutzt bleiben. Durch die Implementierung intelligenter Leistungsanalysesysteme können Sie die Datenverarbeitung automatisieren, Muster erkennen und Empfehlungen zur Verbesserung der Leistung geben. Moderne Technologien wie maschinelles Lernen spielen bei der Erstellung solcher Systeme eine Schlüsselrolle, wodurch sowohl quantitative als auch qualitative Faktoren berücksichtigt werden können.

Schlüsselwörter: intelligente Systeme, Softwarelösungen, Verbesserung der Leistung, maschinelles Lernen.

Relevanz der Forschung

Das Wachstum der von Unternehmen generierten Daten erfordert den Einsatz neuer Ansätze für deren Verarbeitung und Analyse. Die Fragmentierung der Data Warehouses, die Verwendung verschiedener Formate und der geringe Grad ihrer Integration erschweren es, sich ein ganzheitliches Bild vom Zustand des Unternehmens zu machen.

Von besonderer Bedeutung sind intelligente Performance-Analysesysteme, die nicht nur die Ursachen von Abweichungen identifizieren, sondern auch mögliche Trends vorhersagen können. So ermöglicht beispielsweise die Analyse des Zustands von Anlagen und Produktionsindikatoren die Vorhersage von Ausfällen, und die Clusterung der Mitarbeiter nach Leistungsstufen hilft bei der Entwicklung von Weiterbildungsprogrammen.

Die Komplexität bei der Entwicklung solcher Systeme nimmt jedoch zu, wenn es darum geht, den menschlichen Faktor zu berücksichtigen. Viele Analyseplattformen konzentrieren sich ausschließlich auf quantitative Metriken, was ihre Fähigkeiten einschränkt. Ein umfassender Ansatz, der die Analyse indirekter Signale aus der Unternehmenskommunikation, Kundenfeedback und anderen Quellen umfasst, kann die Genauigkeit von Schlussfolgerungen erheblich verbessern [2].

Analyse bestehender Lösungen

Es gibt viele Softwareprodukte auf dem Markt, um die Effizienz von Unternehmen zu analysieren. Betrachten wir die beliebtesten von ihnen.

Tableau

Tableau ist einer der Marktführer auf dem Gebiet der Datenvisualisierung. Das System ermöglicht die Integration von Daten aus mehreren Quellen und bietet leistungsstarke Tools für die Erstellung interaktiver Berichte. Tableau verfügt jedoch nicht über integrierte Prognose- und Trendanalysealgorithmen, sodass Benutzer ihre eigenen Modelle entwickeln müssen. Dies erhöht den Zeit- und Ressourcenaufwand und erschwert es, schnelle Entscheidungen zu treffen [3].

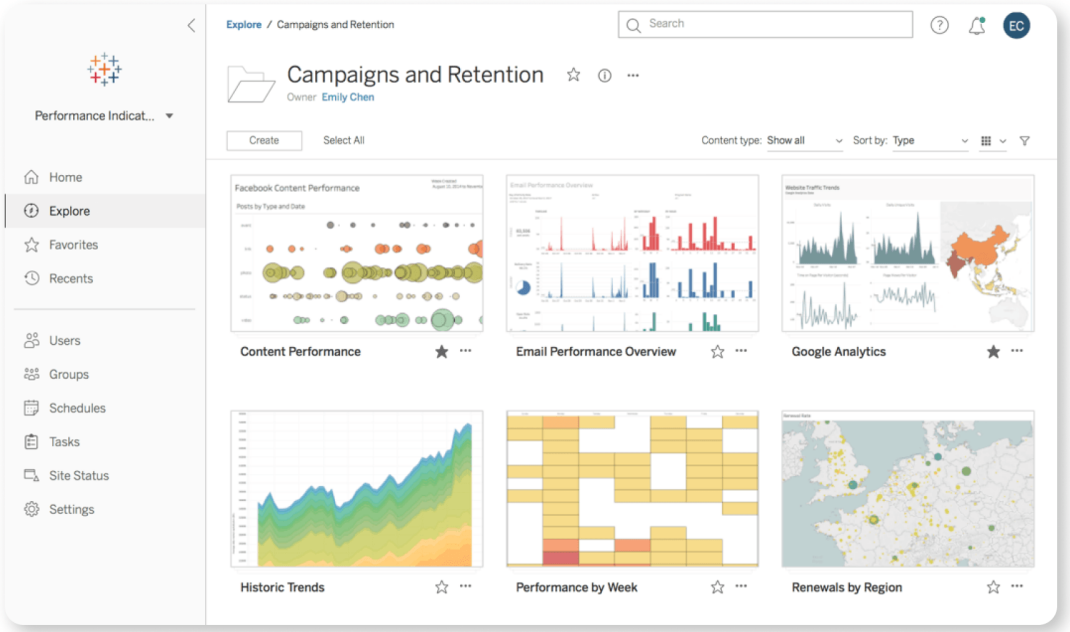

Abb. 1. – Tableau

Power BI (Microsoft)

Power BI ist eine umfassende BI-Plattform, die in das Microsoft-Ökosystem integriert ist. Zu seinen Vorteilen gehört die Erstellung praktischer Dashboards und Berichte. Das System verfügt jedoch nur über eine begrenzte Flexibilität bei der Anpassung von Analysemodellen an einzigartige Geschäftsprozesse, was seine Effektivität für Unternehmen mit nicht standardmäßigen Prozessen verringert [4]. Richtungen zur Verbesserung intelligenter Systeme.

Um die Effizienz intelligenter Systeme zur Analyse der Arbeit von Unternehmen zu verbessern, können folgende Bereiche unterschieden werden:

Integration von maschinellem Lernen.

Der Einsatz von Algorithmen des maschinellen Lernens ermöglicht es Ihnen, die Datenanalyse zu automatisieren, verborgene Muster zu identifizieren und zukünftige Ereignisse vorherzusagen [1]. Zum Beispiel die Vorhersage von Geräteausfällen oder die Segmentierung von Mitarbeitern nach Leistungsstufen.

Einfachheit der Benutzeroberfläche und Visualisierung.

Durch die Vereinfachung der Schnittstellen für analytische Systeme und die Erhöhung der Sichtbarkeit von Visualisierungen werden Benutzer ohne tiefgreifende Kenntnisse in der Lage sein, mit der Plattform zu arbeiten und Daten effektiv zu interpretieren.

Modularität und Anpassungsfähigkeit.

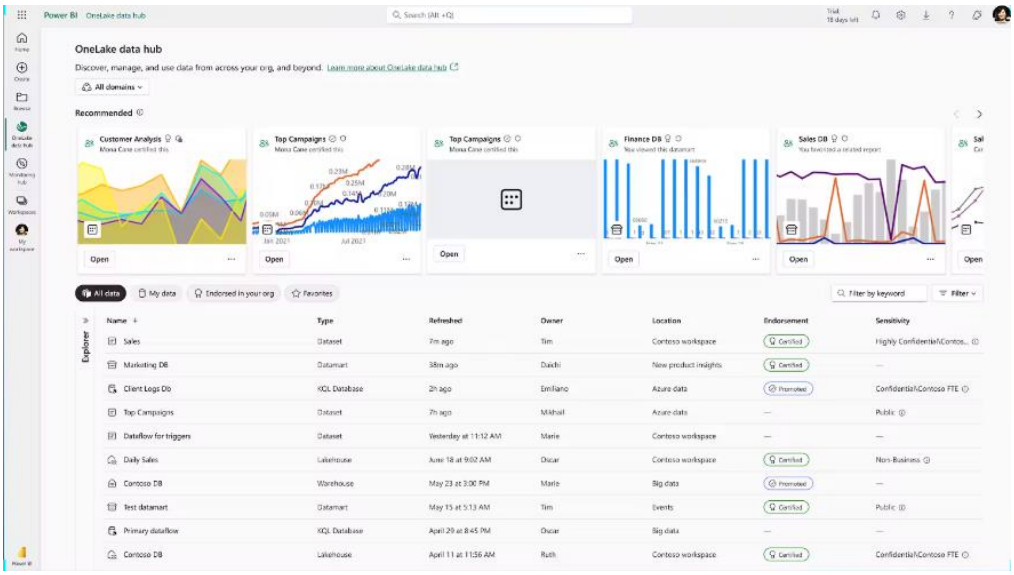

Abb. .2 – Power BI

Die Entwicklung modularer Systeme, die an einzigartige Geschäftsprozesse angepasst werden können, gewährleistet deren Flexibilität und Effizienz.

Echtzeit-Analyse.

Die Implementierung von Echtzeit-Datenanalysen wird es Unternehmen ermöglichen, schneller auf Veränderungen zu reagieren und fundierte Entscheidungen zu treffen.

Unter Berücksichtigung des Faktors Mensch.

Durch die Integration von Daten aus der Unternehmenskommunikation, wie Chats, E-Mails und Kundenfeedback, können emotionale und soziale Aspekte berücksichtigt werden. Dies ermöglicht eine umfassendere Analyse und verbessert die Genauigkeit der Empfehlungen.

Intelligente Leistungsanalysesysteme werden zu einem wichtigen Instrument zur Verbesserung der Wettbewerbsfähigkeit und Nachhaltigkeit von Unternehmen. Moderne Technologien, einschließlich des maschinellen Lernens, eröffnen neue Möglichkeiten, die Datenanalyse zu automatisieren und die Entscheidungsfindung des Managements zu unterstützen.

Lösungen auf dem Markt, wie Tableau und Power BI, haben ihre Grenzen aufgrund des Fehlens integrierter prädiktiver Algorithmen, der Komplexität der Dateninterpretation und der mangelnden Anpassungsfähigkeit an die individuellen Bedürfnisse des Unternehmens.

Um maximale Effizienz zu erreichen, müssen sich neue Systeme auf die Integration von maschinellem Lernen, Benutzerfreundlichkeit, Modularität und die Berücksichtigung emotionaler Faktoren konzentrieren. Dies wird die Schaffung von Plattformen ermöglichen, die in der Lage sind, Daten in Echtzeit zu verarbeiten und die Entscheidungsfindung auf allen Managementebenen zu unterstützen.

Literaturverzeichnis

1. Gol'cman A.V., «Mashinnoe obuchenie v biznese: teoreticheskie aspekty i prakticheskoe primenenie». Saint

Petersburg, Piter Publ, 2020. (in Rus.).
2. Sidorov N.G., «Analiz bol'shih dannyh v sistemah upravleniya predpriyatiem». Moscow, Nauka Publ., 2019. (in Rus.).
3. Oficial'naya dokumentaciya ot Tableau Software (https://www.tableau.com). (Data obrashcheniya 23.12.2024). (in Rus.)
4. Oficial'nyj sajt Microsoft Power BI (https://powerbi.microsoft.com). (Data obrashcheniya 24.12.2024). (in Rus.)

Актуальность разработки интеллектуальных систем анализа эффективности работы предприятий

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Аннотация. В статье рассматривается актуальность разработки интеллектуальных систем анализа эффективности работы предприятий. Описаны основные проблемы, связанные с обработкой больших объёмов данных и недостаточной интеграцией информационных систем. Проанализированы существующие программные решения, их преимущества и недостатки, а также выделены направления для их совершенствования в контексте применения технологий машинного обучения. Современные предприятия ежедневно генерируют огромные объёмы информации, которые остаются неиспользованными из-за отсутствия эффективных инструментов обработки и анализа. Внедрение интеллектуальных систем анализа эффективности работы позволяет автоматизировать обработку данных, выявлять закономерности и предоставлять рекомендации для повышения производительности. Современные технологии, такие как машинное обучение, играют ключевую роль в создании подобных систем, позволяя учитывать как количественные, так и качественные факторы.

Ключевые слова: интеллектуальные системы, программные решения, повышение производительности, машинное обучение.

УДК 69.001.5

Energy-saving materials in construction

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Abstract
The purpose of this study is to analyze modern energy-saving materials used in construction, their properties, and their impact on reducing energy consumption. The research highlights the role of thermal insulation, phase-change materials, and innovative coatings in improving energy efficiency. The implementation of these materials significantly reduces heat loss, lowers operational costs, and contributes to sustainable development. The study also examines international practices and the economic feasibility of energy-saving technologies.
Keywords: energy-saving materials, thermal insulation, phase-change materials, sustainable construction.

Introduction

Modern construction is increasingly focused on improving energy efficiency and sustainable development, driven by the need to reduce heat loss, optimize operational costs, and minimize environmental impact. According to research, the construction industry and building operations account for over 40% of global energy consumption, making the search for innovative insulation and energy-saving solutions a priority. The implementation of modern insulation technologies can reduce this figure by 20–30%, playing a crucial role in lowering carbon emissions and enhancing overall energy efficiency [1]. Additionally, integrating renewable energy sources into construction further enhances sustainability and reduces reliance on fossil fuels.

A significant area of focus in this field is the development and application of energy-efficient building materials, including thermal insulation, phase-change materials, and innovative coatings [2]. Thermal insulation materials are particularly important, as up to 60% of heat loss occurs through external building structures such as walls, roofs, and windows. Among the most widely used insulation materials are mineral wool (0.032–0.040 W/(m·K)), polystyrene foam (0.030–0.038 W/(m·K)), and aerogels (0.013 W/(m·K)). The latter, despite offering superior thermal performance, are limited by their high cost.

Phase-change materials (PCMs) represent another innovative approach to energy efficiency. These materials store and release heat as they change phase, contributing to a stable indoor temperature, reducing temperature fluctuations, and decreasing the load on heating and cooling systems. This is particularly relevant for buildings with extensive glass facades [3]. Advancements in nanotechnology have also led to the development of high-performance coatings that reduce heat transfer. Reflective coatings, designed to minimize surface heating by reflecting solar radiation, and thermoceramic paints, which form a barrier against infrared radiation, contribute to improved insulation and energy efficiency.

Materials and methods

This study is based on a review of existing literature and an analysis of innovative energy-efficient materials used in modern construction. The research incorporates data from peer-reviewed articles, industry reports, and experimental studies on thermal insulation, phase-change materials (PCMs), and high-performance coatings. The properties of commonly used insulation materials, such as mineral wool, polystyrene foam, aerogels, and vacuum insulation panels, are compared in terms of thermal conductivity and cost efficiency. Additionally, the study examines case studies of energy-efficient buildings and evaluates the economic feasibility of implementing these materials in residential and commercial construction [4]. Furthermore, the research explores the impact of climate conditions on material performance and the long-term benefits of integrating these technologies into modern building practices.

Results and discussion

A significant area of focus in energy-efficient construction is the development and application of advanced insulation materials. Thermal insulation plays a crucial role, as up to 60% of heat loss occurs through external building structures such as walls, roofs, and windows. Commonly used insulation materials include:

Mineral wool (0.032–0.040 W/(m·K)), polystyrene foam (0.030–0.038 W/(m·K)), aerogels (0.013 W/(m·K)), and vacuum insulation panels (<0.004 W/(m·K)) are among the most effective insulation materials. However, despite their high thermal efficiency, aerogels and vacuum insulation panels remain costly, which limits their widespread adoption [1].

Phase-change materials (PCMs) are another innovative solution, allowing buildings to store and release heat efficiently. These materials contribute to stable indoor temperatures and reduce the load on heating and cooling systems, making them particularly beneficial for buildings with large glass facades. Nanotechnology advancements have also led to the development of high-performance coatings, such as reflective coatings and thermoceramic paints, which further enhance insulation and reduce heat transfer [2].

Several successful projects illustrate the effectiveness of these technologies. The Edge building in Amsterdam incorporates photovoltaic panels and an intelligent facade system, reducing energy demand. Germany's Passivhaus program promotes the construction of ultra-low-energy buildings, while Sweden integrates fiberboard panels with PCMs, reducing heating costs by up to 40% [3].

Economic analysis reveals that although initial investments in energy-efficient materials can be substantial, they yield long-term savings. For instance, insulating a multi-apartment building can reduce annual heating costs from 250,000 RUB to 150,000 RUB, with an insulation cost of 1,000,000 RUB, resulting in a payback period of approximately 10 years [4]. Additionally, government subsidies and tax incentives can further shorten the payback period, making these investments more attractive.

Conclusion

The development and adoption of energy-efficient materials are essential for modern construction, reducing energy consumption, enhancing living comfort, and minimizing environmental impact. Global experience demonstrates that implementing innovative energy-saving technologies is both economically viable and environmentally responsible. Future advancements, including vacuum insulation panels, smart glass, and energy-generating coatings, will further optimize building energy consumption and contribute to sustainable urban development.

Collaboration between researchers, engineers, and policymakers will be key to accelerating the widespread implementation of these solutions. As global energy demand continues to rise, investing in energy-efficient construction is necessary to mitigate climate change, foster economic growth, and improve public health and quality of life. Additionally, governmental incentives and regulatory frameworks play a crucial role in promoting sustainable construction practices, ensuring a widespread transition to energy-efficient building solutions.

References

1. Flory B., Abraham E., De La Cruz J.A., Chandrasekar V.S., et al. Aerogel from sustainably grown bacterial cellulose as a thermal insulation film for building envelopes // *arXiv preprint*. 2022. arXiv:2201.00449. Available at: https://arxiv.org (accessed: 18.03.2025).
2. Aimbetova I.O., Suleimenov U.S., Kambarov M.A., et al. Thermophysical properties of phase-change heat-accumulating materials used in construction // *Advances in Modern Natural Science*. 2018. No. 12–1. pp. 9–13.
3. SovTechnoStroy. The most promising energy-saving enclosing structures in modern energy-efficient construction practice. Available at: https://sovtehnostroy.ru (accessed: 18.03.2025).
4. Energy saving in construction. *Electro-Expo*. Available at: https://elektro-expo.ru (accessed: 18.03.2025).

Энергосберегающие материалы в строительстве

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Аннотация. Целью данного исследования является анализ современных энергосберегающих материалов, используемых в строительстве, их свойств и их влияния на снижение потребления энергии. В исследовании подчеркивается роль теплоизоляции, материалов с фазовым переходом и инновационных покрытий в повышении энергоэффективности. Внедрение этих материалов значительно снижает потери тепла, снижает эксплуатационные расходы и способствует устойчивому развитию. В исследовании также рассматривается международная практика и экономическая целесообразность энергосберегающих технологий.

Ключевые слова: энергосберегающие материалы, теплоизоляция, материалы с фазовым переходом, устойчивое строительство.

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Implementation of artificial intelligence in construction industry

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Abstract
This paper discusses the process of artificial intelligence (AI) implementation in the construction industry, its benefits, current trends, and development prospects. Special attention is paid to design automation, the use of neural networks for data analysis, the introduction of robots on construction sites, and the management of construction processes with AI. Key challenges such as the high cost of technology, shortage of skilled professionals, and safety issues are also analyzed. It concludes with a forecast of the impact of AI on construction efficiency, quality, and sustainability in the coming years.
Keywords: automation, BIM, cloud computing, construction costs, digitalization, efficiency, innovation.

Introduction

In today's world, artificial intelligence (AI) technologies are rapidly developing and finding applications in various industries, including construction. The introduction of AI into the construction industry is improving process efficiency, reducing costs, and improving quality control and safety on sites. Design automation, resource management, risk prediction, and the use of robots on construction sites are just some of the areas where AI is already having a significant impact.

The application of AI is particularly relevant in the growing demand for fast and high-tech buildings, and in the context of clever construction based on big data analytics and the Internet of Things (IoT). This report discusses the key areas of AI implementation in the construction industry, its benefits, challenges and development prospects [1].

1. Transforming the construction industry through AI

The construction industry, traditionally associated with physical labor, has been rapidly transformed by new technologies in recent years. One of the key drivers of this transformation has been artificial intelligence (AI). With its help, many aspects of construction - from design to quality control - are becoming more efficient, predictable, and cost-effective. At first glance, it may seem that AI technologies are the domain of the giants of the construction market. But practice shows that even small companies are beginning to implement intelligent systems to automate tasks related to data analysis, cost forecasting and logistics management [2].

2. Application of AI in the construction industry.

2.1) Design and generative modeling.

The application of artificial intelligence in construction ranges from architectural design to construction site management. Already today, AI is proving its effectiveness with real-world examples, making work faster, more accurate, and safer. Modern architectural firms are actively using AI to create detailed building models. Systems such as Autodesk Revit or Rhino with the Grasshopper plug-in use generative design algorithms that take into account thousands of factors, from climate conditions to budget. This allows

architects to create optimal designs with minimal time investment.

2.2) Logistics and supply chain optimization.

On construction sites, AI is helping to manage the delivery of materials and machinery. Services like Gectaro optimize logistics processes, from selecting suppliers to monitoring delivery. For example, the system analyzes traffic congestion data and predicts delivery times, reducing the likelihood of downtime. This allows companies to make significant cost savings.

2.3) Security monitoring and risk detection.

AI solutions such as Smartvid.io use cameras and sensors to monitor construction site processes. The systems are able to detect safety violations, predict potential emergencies, and ensure strict quality control. The implementation of such technologies significantly reduces risks for workers and raises standards of work performance. Construction companies can benefit from automation tools such as Gectaro.

Based on all of these examples, it is clear that artificial intelligence has already made its way into the construction industry. The use of such solutions gives companies a competitive advantage, reducing costs and improving the quality of work. More and more market players are realizing that to ignore the potential of AI is to miss out on growth opportunities. Those who are implementing these technologies now are laying a solid foundation for future success. Artificial intelligence is being applied to virtually every aspect of the construction process.

Here are the main areas in which AI has already proven to be an indispensable tool:

1. AI algorithms analyze a large amount of data related to the supply of materials, transportation, and labor. For example, AI-based systems help to:

- predict delivery delays and minimize their impact;
- optimize delivery routes, which is especially important for large facilities with complex logistics;
- calculate material requirements, avoiding surpluses or shortages.

2.4) Project management and foresight

Safety Monitoring. Using cameras and sensors, AI systems analyze worker behavior and facility conditions. These technologies detect violations in real-time: lack of protective equipment, being in hazardous areas, and other risks. The use of AI-equipped drones enables rapid inspection of high-rise structures, minimizing risks to employees. Quality control of materials and work. AI is able to analyze construction materials, identifying defects at the supply stage. In addition, intelligent systems can check the accuracy of construction works by checking them against the design documents. Project management and planning. AI-based software products help predict risks and build schedules for tasks. With their help, project managers can make informed decisions based on current data and predictions [3].

Benefits of implementing AI:

- Cost reduction. Process optimization reduces errors and material overruns. Companies reduce costs by utilizing resources efficiently.
- Improved accuracy and quality of work. AI algorithms minimize the impact of human error, ensuring accurate compliance with project requirements.

Challenges of AI implementation:

- High implementation cost. Buying software, hardware, and staff training requires a significant investment, which can be a challenge for small businesses.

- Skills shortage. Working with AI requires specialists, which are still scarce in the labor market [4].

Despite the challenges, the benefits of AI outweigh. Those companies that are already betting on new technologies today are gaining a serious competitive advantage.

Conclusion

Artificial intelligence is no longer a gimmick and is becoming a tool that should be in every construction company's arsenal. Examples of successful use of AI show that its implementation allows not only to solve actual tasks, but also to lay the foundation for further business growth. This platform helps optimize logistics, simplifies interaction with suppliers, and minimizes downtime. Such tools are becoming a necessity in an increasingly competitive environment.

References

1. Bock T., Linner T. Robot-Oriented Design: Design and Management Tools for the Deployment of Automation and Robotics in Construction. - Cambridge: Cambridge University Press, 2016. 320 p.

2. Eastman, C., Teicholz, P., Sacks, R., Liston, K. BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers, and Contractors. – New Jersey: John Wiley & Sons, 2011. – 640 p.

3. Gorodetsky A.E., Grushnin A.A.. Iskusstvenniy intellect v injenernikh sistemakh [Artificial Intelligence in Engineering Systems]. -Moscow: Bauman Moscow State Technical University Publishing House, 2020. 415 p. (Rus)

4. Pan Y., Zhang L. Roles of artificial intelligence in construction engineering and management: A critical review and future trends. Automation in Construction. 2021. P. 103–120. Amsterdam.

Внедрение искусственного интеллекта в строительной отрасли

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Аннотация. В данной статье рассматривается процесс внедрения искусственного интеллекта (ИИ) в строительной отрасли, его преимущества, современные тенденции и перспективы развития. Особое внимание уделено автоматизации проектирования, использованию нейронных сетей для анализа данных, внедрению роботов на строительные площадки, а также управлению строительными процессами с помощью ИИ. Также анализируются ключевые проблемы, такие как высокая стоимость технологий, нехватка квалифицированных специалистов и вопросы безопасности. В заключение приводится прогноз влияния ИИ на эффективность, качество и устойчивость строительства в ближайшие годы.

Ключевые слова: автоматизация, искусственный интеллект, облачные вычисления, строительство, цифровизация, экономия, эффективность.

УДК 624.059

Consideration of brick production quality in the repair of brick walls of historic buildings

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Abstract
The questions of influence of brick production peculiarities on repairing brick walls of historical buildings of provincial cities are considered. The necessity of taking into account the influence of brick production processes in the 19th century on their experimental qualities when repairing brick walls is shown.
Keywords: brick buildings, historical development, repair and construction works.

Historic buildings are generally defined as buildings with a service life of more than 100 years. Such buildings, as a rule, have value as elements of historical buildings. Most of them are also objects of cultural heritage and for this reason require their preservation through timely and quality repair works [1, 2, 3]. The efficiency and quality of repair works depends on the system of taking into account the structural solutions and current technical condition of the buildings under repair when developing design documentation [4]. It is also necessary to take into account the impact on the building of the state of improvement of the existing urban development. A typical example of the need for such consideration during repairs is brick walls of historical buildings. The choice of repair works in this case is determined by

the peculiarities of brick production in the period of the 19th and early 20th centuries.

The quality of brick production in the 19th century depended on all stages of brick manufacture, including the choice of clay and additives to enhance its quality and ensure porosity formation during firing, moulding and drying of bricks. The disadvantage of firing was that the temperature distribution in the kiln was very uneven and, consequently, the bricks were fired unevenly. All bricks fired in floor kilns were divided into 5 grades, namely "iron", "semi-iron", "red", "scarlet", "white" (raw), based on the quality of firing. After culling, three main grades were used: iron, red and scarlet.

Brick grade was determined by the sound and appearance of the fracture. Iron was used for foundations. It was black, strong and moisture-resistant brick. Red had a bright red colour on chips and damage. Striking a "red" brick produced a ringing, single tone sound. These indicators showed that the bricks were of good quality. Scarlet (pale) bricks had a pale red colour on chips due to insufficient baking. When struck, a sound was formed, these signs indicated that the quality of the bricks was poor and therefore their use should be limited. The division of bricks into grades was taken into account in the construction of buildings. "Red" bricks, as the strongest and most frost-resistant bricks,

were used for external walls, while the weaker and less frost-resistant "scarlet" bricks were used for internal walls and partitions.

In the second half of the 19th century, brick firing, including in the Tambov region, began to be carried out in ring kilns. In ring kilns, the uniformity of brick firing was significantly improved. However, as before, bricks were divided into three main grades.

A distinctive feature of the 19th century bricks is their rather low strength. The strength of "iron" could correspond to the mark M50-M75. "Red" brick had a strength within the mark M50. The strength of "scarlet" bricks did not exceed M30÷M35 marks. In this regard, when repairing damaged exterior masonry should be made to replace the exterior destroyed bricks with new bricks that have a strength corresponding to the mark M50. The new bricks must have the same body structure as the bricks they replace, especially in terms of porosity and strength.

A distinctive feature of 19th century bricks, which is of great importance for the reliable operation of brick walls, is the formation of a stronger protective "crust" on the outer surface of the bricks during the firing process. Its presence protects the bricks during the operation of the building from environmental damage and thus increases the longevity of the masonry walls. Therefore, when cleaning walls from dust and dirt, mechanical cleaning methods such as sandblasting, which destroy the crust, are strongly discouraged.

Much attention was paid to the choice of clay in the production of bricks. Four types of clay were used for making bricks in this period: white, yellow, red and blue. Blue and red clay were the most "convenient" for making bricks. However, as blue clay was less common and more expensive, the practice in provincial towns was to use red clay in brick making. This, in particular, is evidenced by the quality of bricks in the walls of buildings built in Tambov in the 19th century. In Tambov Province, due to its size, the quality of clay varied considerably between different deposits and, consequently, this may have influenced the quality of brick production in its different districts.

The homogeneity and uniformity of the brick body is very important for the quality of the brick. In the 19th century, fine charcoal ground into dust was used to form pores in bricks. This consistency of the pore-forming additive made it possible to obtain small, uniformly distributed pores of the same size during firing. This is particularly different in brick buildings built in Tambov in the 19th century.

The way bricks were moulded in the nineteenth century had a significant influence on their quality. Brick moulding in the 17th and early 19th centuries was done manually. Closer to the second half of the 19th century, mechanical brick moulding was introduced in Russia. Bricks with mechanical moulding had a regular shape with clear sharp edges and the same dimensions regardless of where they were produced. The mechanical moulding method was used in the 19th century brickworks in Tambov for the production of bricks used in historic buildings. The quality of the bricks also indicates that they were dried in drying chambers using good quality ventilation. The quality of drying greatly influenced the quality of the last stage of brick manufacture, namely firing. Until the middle of the 19th century in Tambov province bricks were mainly fired in "floor" kilns using charcoal. A "crust" was formed. Its presence protects the bricks during the operation of the building from environmental damage and thus increases the longevity of the masonry walls.

Therefore, when cleaning dust and dirt, mechanical cleaning methods such as sandblasting, which destroy the crust, are strictly forbidden.

All of the 19th century brick manufacturing processes discussed above, due to their imperfections and peculiarities, had a significant impact on the performance of bricks and masonry walls in general. For this reason, during the operation of 19th century brick buildings and when carrying out renovation and repair work, all of the above features of brick manufacture should be taken into account, namely their structure, strength characteristics and the presence of a protective layer on their surface. The structure and strength of the new bricks used in wall repairs should be close to the bricks of the masonry being replaced.

References

1. Seregin S.I. Otsenka vozmozhnosti sohraneniya zhilyh zdaniy G. Tambova, imeyuschih status nedvizhimyh obektov kulturnogo naslediya [Assessment of the possibility of preserving residential buildings of Tambov having the status of immovable objects of cultural heritage]. Aktualnye problemy gorodskogo stroitelstva : Sbornik trudov Vserossiyskoy nauchno-tehnicheskoy konferentsii, 2020, p. 79-84.(Rus)
2. Andrianov, K.A. Organizatsiya obsledovaniya i provedeniya remontno-stroitelnyh rabot - osnova sohraneniya obektov kulturnogo naslediya v istoricheskoy zastroyke Tambova [Organisation of inspection and repair and construction works - the basis for the preservation of cultural heritage objects in the historical building of Tambov]. Sovremennaya nauka: teoriya, metodologiya, praktika : Materialy IV Vserossiyskoy natsionalnoy nauchno-prakticheskoy konferentsii, 2022, p. 113-115. (Rus)
3. Zhabina A.S., Seregin S.I., Kryukova A.A., Ledenev V.I. Gradostroitelnye, ekologicheskie, sotsialnye i tehnicheskie problemy istoricheskoy zastroyki Tambova i puti ih resheniya [Urban planning, environmental, social and technical problems of the historical building of Tambov and ways to solve them]. Ustoychivoe razvitie regiona: arhitektura, stroitelstvo, transport: Materialy VII-oy Mezhdunarodnoy nauchno-prakticheskoy konferentsii, 2020, p. 129-132. (Rus)
4. Matveeva, I. V. Konstruktivnye resheniya ustroystva metallicheskih poyasov v kirpichnyh stenah istoricheskih zdaniy i ih uchet v protsesse restavratsii [Structural solutions of metal belts in brick walls of historical buildings and their consideration in the restoration process]. Ustoychivoe razvitie regiona: arhitektura, stroitelstvo, transport: Materialy 5-y Mezhdunarodnoy nauchno-prakticheskoy konferentsii Instituta arhitektury, stroitelstva i transporta, 2018, p. 329-333. (Rus)

Учет качества производства кирпичей при ремонте кирпичных стен зданий исторической застройки

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Аннотация. Рассматриваются вопросы влияния особенностей производства кирпичей на выполнение ремонтов кирпичных стен исторической застройки провинциальных городов. Показана необходимость учета при ремонте кирпичных стен влияния процессов производства кирпичей в XIX веке на их экспериментальные качества.

Ключевые слова: историческая застройка, кирпичные здания, ремонтно-строительные работы.

УДК 004.896

Construction of houses drawings using computer vision

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Abstract
The purpose of this study is to create a system for analyzing and constructing drawings, which will greatly simplify the design process. Using neural network algorithms, we intend to automate the stages associated with the creation of architectural and design solutions. This, in turn, will increase the efficiency and speed of the work of architects and engineers. This system will help to improve the quality of design during the construction of houses, minimizing the human factor and errors.
Keywords: drawing, neural networks, pattern recognition.

Introduction

The development of drawings is the main stage in the design of houses. The process of creating house drawings is structured and includes several stages: conceptualization, design and visualization. Software tools that help to implement this process are used in all modern construction companies.

As a solution to stage in the design of houses, it is proposed to use neural networks for pattern recognition (computer vision).

The system for creating drawings using computer vision (SCDUCV) is an analogue of existing BIM (Building Information Model) design programs. This approach involves the use of computer vision technologies to recognize sketch elements and transfer them into a virtual environment, where information is analyzed and corrected, after which a drawing and three-dimensional visualization are formed.

The use of neural networks is a common feature of modern systems. They are often found in the image creation and editing applications.

Technology review

SCDUCV uses the OpenCV library, which is designed for computer vision and image processing. It is one of the most popular libraries in the field and provides a wide range of tools and functions to perform various tasks.

For the correct operation of the system, it was proposed to divide the functionality into separate modules: the pattern recognition module, the size recalculation module and the drawing module.

A highly efficient and complex neural network model called Faster R-CNN (Convolutional neural Network based on regions) is used for the pattern recognition module. This advanced model has been retrained on specially prepared versions of drawings, which significantly improves its ability to identify and classify various objects in graphical data accurately and quickly [1].

The training sample consisted of more than 1,000 carefully selected images, each of which was carefully marked with appropriate elements that needed to be found in subsequent drawings. These key elements have been divided into several main classes, such as: window openings, doorways, walls, etc.

A prerequisite for the correct operation of this module is different variations of the drawings. Since the standards for displaying walls, windows and other elements differ from company to company, it is necessary to take these features into account [2].

The possibility of repeated training was also provided. This feature is necessary to improve the quality of pattern recognition in drawings. Based on the results of the first sample, the program analyzes new data sets, after which it corrects its behavior and improves predictions.

After finding all the elements in the sketch, the data is transferred to the size recalculation module. The main task of this module is to ensure that the found elements are not torn from each other and have the correct dimensions in thickness and length. At this stage, it is important to identify and correct all errors, as they can lead to serious problems in the future. For example, if you use the processed data for the 3D model building module, then problems may arise when calculating the final cost, or the building will not pass the strength test. The new data is recorded in a separate file, after which it is transferred to the drawing module.

The last module of the system performs several tasks at once. The main part creates a two-dimensional drawing based on the data obtained from the recalculation module using the Pillow graphics library. This library provides convenient tools for image processing and allows you to create algorithms for the image of non-standard geometric shapes. A functional for building a three-dimensional visualization is also being developed, in which it will be possible to change the material that will be used for building a house.

The PyCharm development environment was used to develop the system. An example of the application's work is shown in Fig. 1.

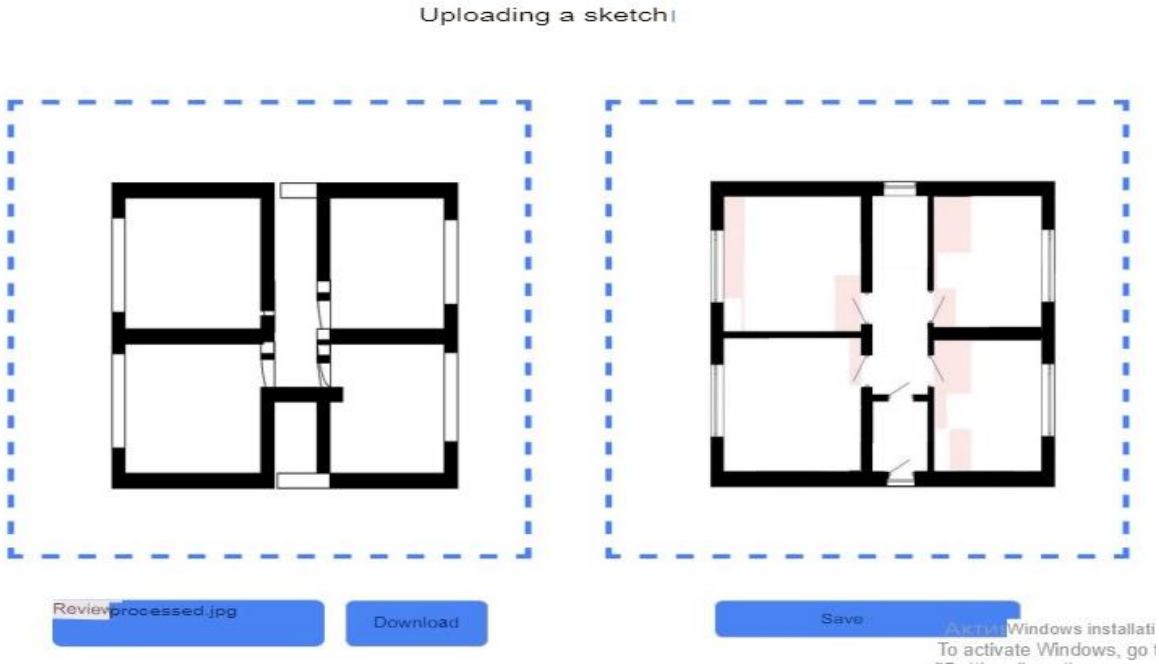

Figure 1- Example of the application's work

To work successfully with this system, you need to follow a few simple steps. First of all, you need to click on the button labeled "Overview". As a result of this action, a file

selection window will open in which you will be prompted to find and select the appropriate file of the bitmap image that you want to upload for processing. After you select the desired file, do not forget to click on the "Upload" button. This step starts the process of uploading your image to the system.

Next, you will need to wait a little while for all the modules to process your sketch. At this time, the uploaded image is analyzed and transformed. When the process is completed, you will see the result of the processing. The original image will be displayed on the left so that you can compare it with the updated version. This processed result will appear to the right of the original. This will allow you to see the changes and assess how successfully your image has been transformed.

Conclusion

The use of neural networks for the design of houses is under development and requires more time to implement, since some elements, for example, the construction of a drawing, require more accurate calculations. In the future, the function of building a 3D model based on the received drawing will be developed and added. In addition, the following functions will be added: choosing the material for construction, changing the house plan with subsequent recalculation of elements, calculating the total cost and selecting materials to minimize it. It is also necessary to improve the quality of recognition and the algorithm of construction.

References

1. Mikhailin S. Object Detection. Raspoznavaj i vlastvuj [Objetc Detection. Recognize and rule] Available from: https://habr.com/ru/companies/jetinfosystems/articles/498294/ (Accessed 20.11.2024). (Rus)

2. Litovka Yu. V. Poluchenie optimal'nyh proektnyh reshenij i ih analiz s ispol'zovaniem matematicheskih modelej. Uchebnoe posobie [Obtaining optimal design solutions and their analysis using mathematical models. Tutorial]. Tambov, TGTU, 2006. 98 p.(Rus)

Построение чертежей домов с использование компьютерного зрения

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Аннотация. Целью данного исследования является создание системы анализа и построения чертежей, которая позволит значительно упростить процесс проектирования. Используя алгоритмы нейронных сетей, мы намерены автоматизировать этапы, связанные с созданием архитектурных и конструктивных решений. Это, в свою очередь, повысит эффективность и скорость работы архитекторов и инженеров. Данная система будет способствовать улучшению качества проектирования при строительстве домов, минимизируя человеческий фактор и ошибки.
Ключевые слова: нейронные сети, построение чертежей, распознавание образов.

УДК 624.138.9

Effects of reinforcement on the strength and deformability of sandy foundation

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Abstract
This paper presents the results of laboratory tests of rigid models of surface foundations on a sandy base reinforced with horizontally placed unplasticized polyvinyl chloride sheets. A complex multifactor analysis of the influence of the reinforcement embedment depth, its dimensions and the density of the backfill soil on the deformation and strength characteristics of the foundation was performed.
Keywords: reinforcement element, soil reinforcement, stamp, vertical displacement.

Introduction. The foundation is one of the most critical and expensive structures. Prices for its erection vary from 20% and in some structures (towers, chimneys) the cost reaches up to 50% of the total price of the building or structure.

Recently, the load on bases and foundations has been increasing due to the increase in the span of the building, the number of storeys, and the influx of heavier equipment. It is necessary to use territories that were previously unsuitable for construction. It is not possible to use these territories without means of special engineering preparation.

Reinforcement of soils is extremely promising. Soil reinforcement is the improvement of physical-mechanical, strength and deformation characteristics of the foundation by creating a composite material consisting of reinforcement, perceiving shear and tensile forces and soil matrix, perceiving compressive forces. New reinforcement materials, theories of calculation of reinforced soil structures are being developed. Therefore, in order to improve the normative and technical base, it is necessary to carry out complex experimental studies of the influence of reinforcement on the non-substantial-strength characteristics of foundations.

Experimental studies of the influence of reinforcement on the deformation and strength characteristics of foundations are reflected in the works of such authors as V.M. Antonov [1], O.V. Khryanina [2], A.B. Ponomarev [3], D.A. Tatiannikov [4], V.I. Kleveko [4].

Methodology of experiments. The tests were carried out in metal trays with dimensions 69×54×66(h) and 182x101,5x85,5(h) cm of the Soil Mechanics Laboratory of TSTU. The transfer of the central vertical load (P) from the knife to the conditional foundation was performed by placing the weights on the hangers of the lever systems placed on the trays. The ratios of the lever force arms (transmission ratios) were 1:6 and 1:10. Sandy soil with densities of $\rho_1 = 1.54\ \frac{g}{cm^3}$ and $\rho_2 = 1.68\ \frac{g}{cm^3}$ was used as a natural base. A round die of diameter $D_{st} = 100$ mm with a smooth contact surface acted as a model of the conditional foundation. The soil was placed layer by layer in layers not more than 5 cm thick. Each layer was compacted by hand tamping with the sole dimensions of 22x22x0.8 cm. The backfill density was measured by varying the number of tamping blows on 1 trail. The value of soil density was measured by the cutting ring method. After

compaction of the last topsoil layer was completed, the stamp was placed and the required equipment was installed.

Determination of settlement (S) in the whole range of loads was carried out by two indicators of hour type ICH-10 placed on two diametrically opposite ends of the die. They were attached to the reference frame. The precipitation value was calculated as the arithmetic mean of the readings of the two indicators. Each stage was maintained until the precipitation was conditionally stabilized at 0,1 mm/hour. The number of loading stages was taken not less than 10. The experiments were considered to be completed if soil failure occurred or the settlement reached $[S_u] = 10$ mm. ($0{,}1D_{st}$). Sheets of unplasticized polyvinyl chloride opaque, unpainted or painted, manufactured by pressing method were used as reinforcing elements. Sheet sizes: 100x150, 150x150, 200×200, 250×250 mm, sheet thickness is 6 mm, density $\rho = 1.38\ \frac{g}{cm^3}$. The sheet vinyl plastic was located at a distance (h_s) from the bottom of the die. To compare and search for optimal reinforcement variants, the depth of burial was varied from $0{,}1D_{st}$ to $0{,}5D_{st}$, i.e. from 1 to 5 cm. Physical and mechanical characteristics of sheet vinyl plastic are given in Table 1. The scheme of the pilot plant is presented in Fig. 1.

Table 1. Physical and mechanical characteristics of vinyl plastic sheets

No.	Characteristics	Significance
1	Density g/cm^3	1.38
2	Tensile strength, MPa	55
3	Compressive strength, MPa	100
4	Bending strength, MPa	90
5	Relative elongation at break, %	20
6	Tensile modulus of elasticity (MPa)	2, 600

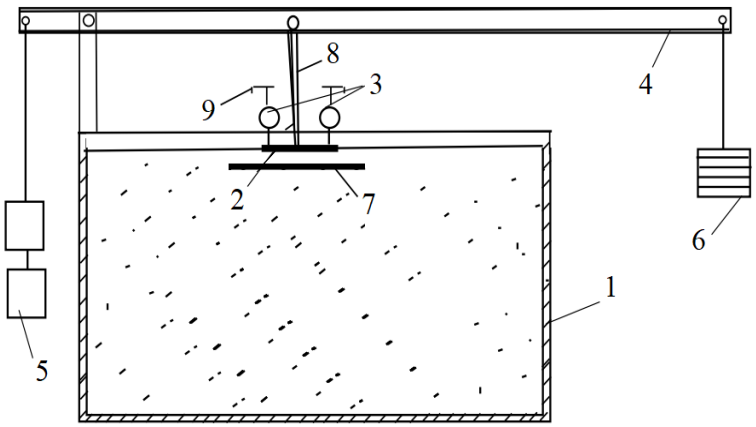

Figure 1 - Diagram of the pilot plant:
1 – metal tray, *2* – stamp, *3* – hour indicators, *4* – lever, *5* – counterweight, *6* – cargoes, *7* – reinforcing element, *8* – lever blade, *9* – reference frame

The results of experiments to determine the effectiveness of vinyl plastic reinforcement by reducing the absolute values of die settlements for a 200x200 mm sheet at density $\rho_1 = 1.54\ \mathrm{g/cm^3}$ are shown in Fig. 2, 4 and at density $\rho_2 = 1.68\ \mathrm{g/cm^3}$ in Fig.3, 5. The effectiveness of reinforcement was evaluated by the coefficient $k_s = s_{unr}/$

s_r is the ratio of die settlements on unreinforced and reinforced base at equal values. Table 2 shows the values of efficiency coefficients on the values of settlement and strain modulus for reinforced and unreinforced foundation at 60 kPa pressure.

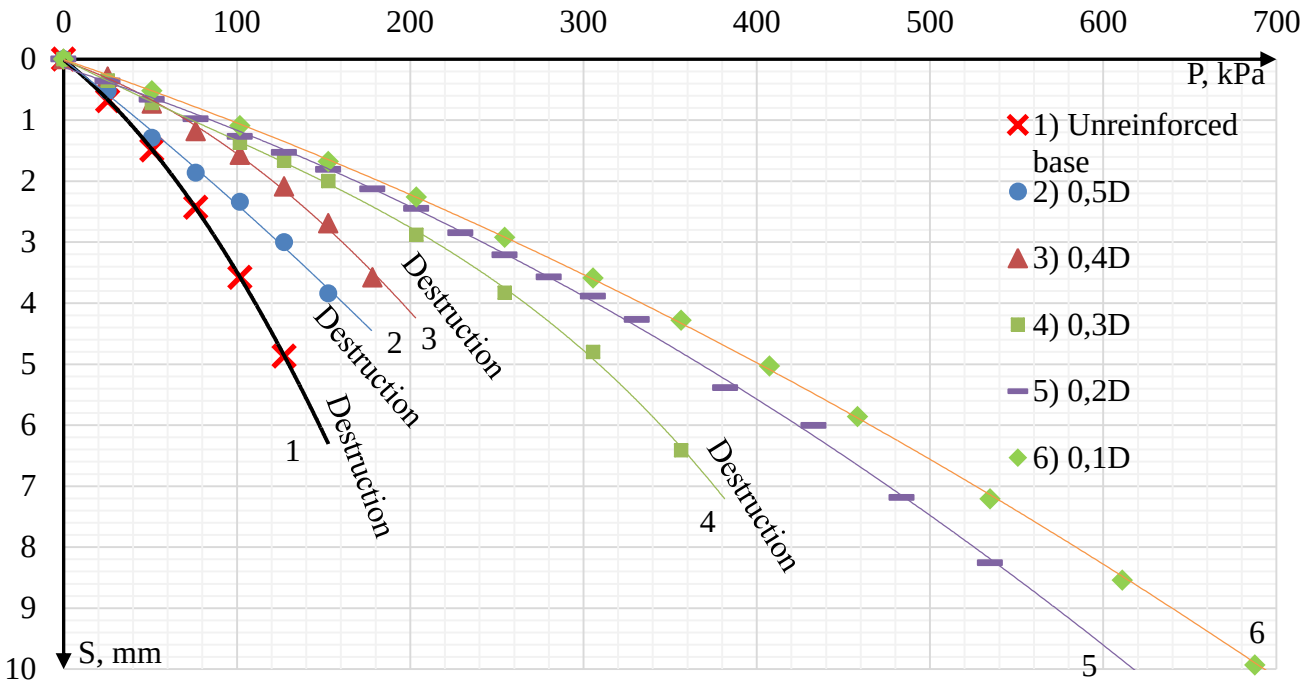

Figure 2 - Effect of distance to the reinforcing element on the development of die deformations at $\rho_1 = 1{,}54\ \frac{g}{cm^3}$ of 200x200 mm sheet

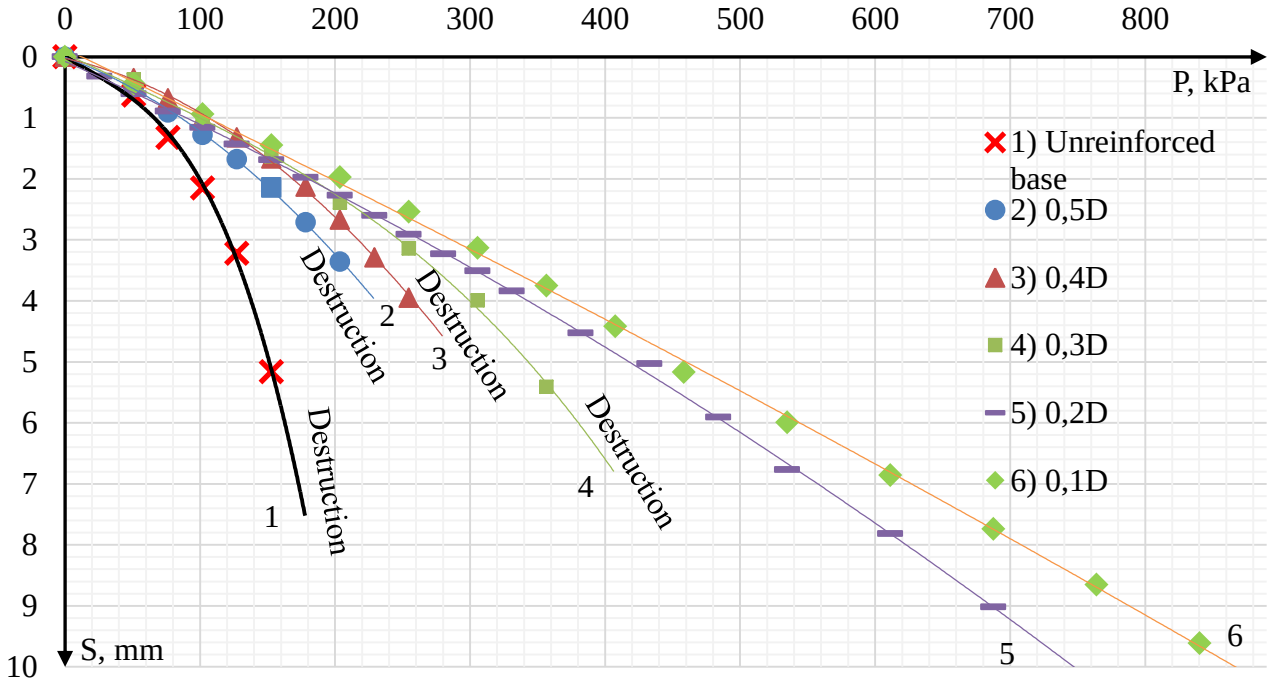

Figure 3 - Effect of distance to the reinforcing element on the development of die deformations at $\rho_2 = 1{,}68\ \frac{g}{cm^3}$ of 200x200 mm sheet

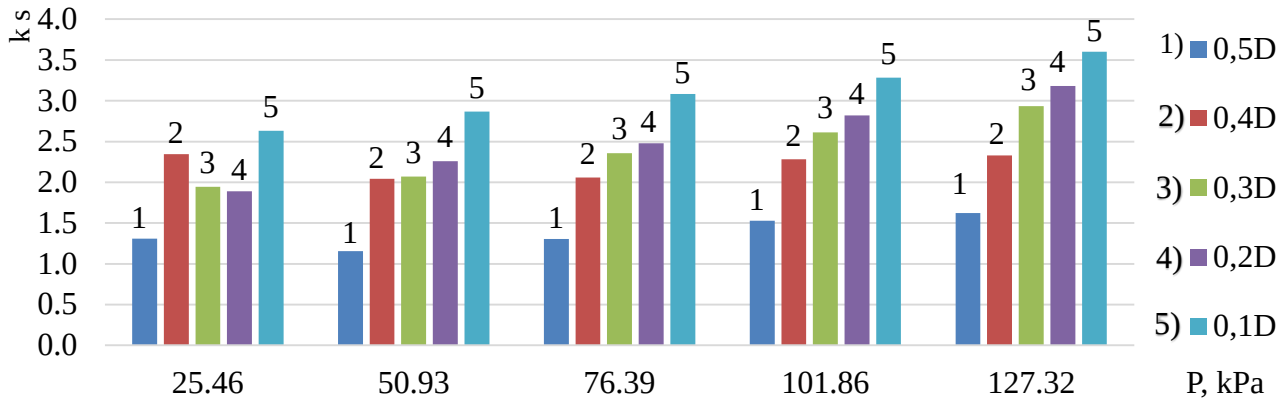

Figure 4 - Reinforcement efficiency (k_s) depending on the depth of the reinforcing element at $\rho_1 = 1.54 \frac{g}{cm^3}$ of 200x200 mm sheet

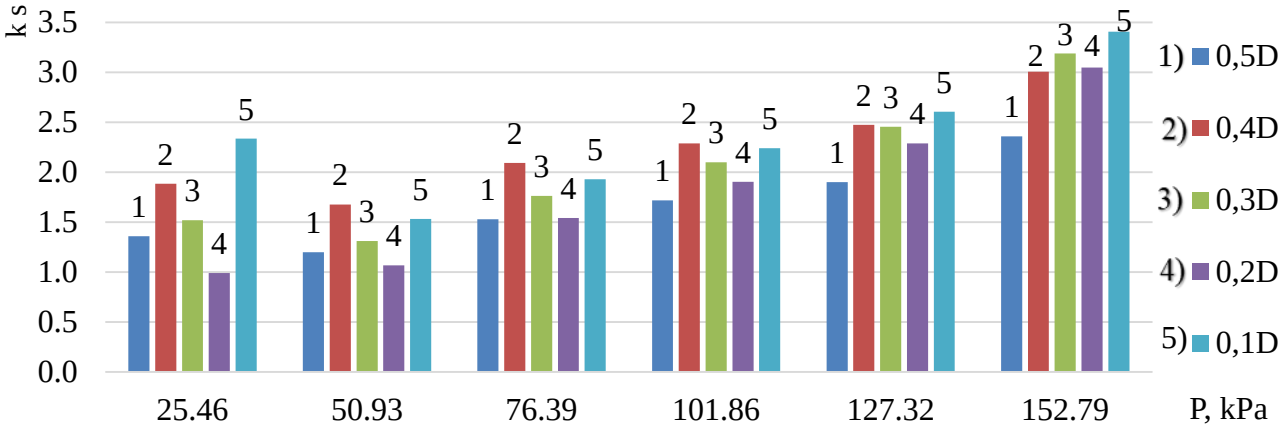

Figure 5 – Reinforcement efficiency (k_s) depending on the depth of the reinforcing element at $\rho_2 = 1.68 \frac{g}{cm^3}$ of 200x200 mm sheet

Table 2. Values of reinforcement efficiency coefficient $k_s=s_{unr}/s_r$ depending on soil density, distance to reinforcing element and reinforcement size at P=60 kPa

Armature dim.	k_s at soil density $\rho = 1{,}54$ g/cm^3					k_s at soil density $\rho = 1{,}68$ g/cm^3				
	Distance to reinforcement, h_s					Distance to reinforcement, h_s				
	0,1D	0,2D	0,3D	0,4D	0,5D	0,1D	0,2D	0,3D	0,4D	0,5D
100x150	1.50	1.41	1.30	1.12	-	1.52	1.46	1.27	1.18	0.96
150x150	2.67	2.87	2.05	1.80	1.49	2.45	1.92	1.66	1.56	1.50
200x200	4.83	4.11	3.66	3.71	2.11	3.58	2.66	3.15	3.96	2.86
250x250	5.15	4.28	3.49	2.79	2.05	3.21	3.00	2.55	2.74	2.33

Conclusion

The following conclusions are drawn from the results of the study:

1. Changing the density for unreinforced base from 1.54 g/cm^3 to 1.68 g/cm^3 resulted in an increase in the failure load by 1.3 times. For reinforced soil massifs the ultimate load at density increased by 1.06...1.80 times depending on the distance to the reinforcing

element.

2. The increase in bearing capacity and decrease in deformability of the foundation at transition from $\rho_1 = 1.54 \frac{g}{cm^3}$ to $\rho_2 = 1.68 \frac{g}{cm^3}$ caused by the increase in the contact area of soil and reinforcement and, consequently, by the increase in friction forces between the elements of reinforced soil.

3. The location of polyvinyl chloride is most effective in the zone of development of tangential stresses: at a depth of (0.1-0.2)D from the bottom of the die. The effectiveness of the reinforcement increases as the loads on the foundation model increase. The reduction of strain values in the whole range of reinforcement size variations for the reinforced foundation compared to the natural one with density $\rho_1 = 1.54 \frac{g}{cm^3}$ ($\rho_2 = 1.68 \frac{g}{cm^3}$) was: at the distance to the reinforcement 0,5D – 7.6…38.4 % (1.5…57.7 %); 0,4D – 10.9…57.4 % (3.9…66.7 %); 0,3D – 16.7…65.9 % (12.8…68.7 %); 0.2D – 14,8…70,2 % (23.2…67.22 %); 0.1D – 22.2…73.7 % (23.3…71.6 %).

4. The way of loss of strength and load-bearing capacity of the foundation was determined - soil mass over the reinforcement or exceeding the limit values of deformations. For the reinforcement burial depth (0.1...0.2)D the soil outburst was not fixed due to exceeding the value of the maximum allowable settlement. When the reinforcement element was buried (0.3...0.5)D, when the soil reached the critical load, a sharp protrusion of the soil from under the footing of the foundation was observed. The destructive load is greater the smaller the thickness of the layer between the reinforcement and the die.

References

1. Antonov V.M. Eksperimental'nye issledovaniya armirovannyh osnovanij [Experimental studies of reinforced foundations]. Tambov, GOU VPO TGTU, 2011. 79 p. (Rus)

2. Khryanina O.V. Sovmestnaya rabota gibkogo fundamenta s armirovannym osnovaniem [Joint operation of flexible foundation with reinforced basement]. Penza, PGUAS, 2016. 203 p. (Rus)

3. Ponomarev A.B., Tat'yannikov D.A. Analiz raboty peschanyh podushek, armirovannyh gorizontal'nymi geosinteticheskimi elementami [Analysis of the performance of sand cushions reinforced with horizontal geosynthetic elements]. Osnovaniya, fundamenty i mekhanika gruntov, 2019, № 6, pp. 2-7. (Rus)

4. Tat'yannikov D.A., Kleveko V.I. Analiz raboty armirovannogo peschanogo osnovaniya na osnove shtampovyh model'nyh ispytanij [Performance analysis of reinforced sand foundation based on die model tests]. Vestnik PNIPU. Ser.: Urbanistika, 2012, № 4(8), pp. 92-102. (Rus)

Воздействие армирования на прочность и деформативность песчаного основания

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Аннотация. В статье представлены результаты лабораторных испытаний жестких поверхностных моделей фундаментов на песчаном основании, армированном листами горизонтально расположенного непластифицированного поливинилхлорида. Был выполнен комплексный многофакторный анализ воздействия глубины заложения арматуры, ее размеров, плотности грунта засыпки на деформационно-прочностные характеристики основания.

Ключевые слова: армирование грунтов, армоэлемент, вертикальное перемещение, штамп.

УДК 69.05

The impact of digital technologies on reducing construction costs

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Abstract
The construction industry is undergoing a digital transformation that significantly reduces costs and enhances efficiency. This article explores the impact of advanced digital technologies such as Building Information Modeling (BIM), artificial intelligence (AI), cloud computing, and automation on cost reduction in construction projects. The integration of these innovations streamlines project management, minimizes material waste, and optimizes labor allocation. Digital tools improve real-time decision-making, enhance risk assessment, and reduce delays, ultimately leading to substantial financial savings. Moreover, the adoption of smart construction technologies enables predictive maintenance, improving the lifecycle cost of infrastructure. The article also examines challenges related to implementing digital solutions, such as high initial investments and the need for workforce upskilling. Despite these challenges, the long-term benefits outweigh the initial costs, making digitalization a crucial factor in modern construction economics.
Keywords: automation, BIM, cloud computing, construction costs, digitalization, efficiency, innovation.

Introduction

The construction industry has long been associated with high costs, extended project timelines, and inefficiencies. However, digital technologies such as Building Information Modeling (BIM), artificial intelligence (AI), cloud computing, and the Internet of Things (IoT) are transforming cost management, improving productivity, and minimizing resource waste [4].

This study examines how digital innovations contribute to cost reduction in construction. The focus is on key technologies, their benefits, and challenges associated with their implementation.

In recent years, the increasing complexity of construction projects has further emphasized the need for advanced digital solutions. Rising material costs, labor shortages, and stricter regulatory requirements have made traditional construction methods less sustainable. By leveraging digital technologies, companies can enhance project accuracy, optimize workflows, and reduce overall expenses, making construction processes more efficient and cost-effective.

Methods and Materials

This study is based on a review of industry literature and reports. The primary sources include academic books, peer-reviewed articles, and professional research on digital transformation in construction [1, 2, 3]. The analysis highlights the cost-saving potential of BIM, AI, cloud computing, and IoT, supported by case studies and statistical data.

To assess the impact of digital technologies on cost management, this research examines real-world case studies from construction projects that have implemented these innovations. Data on project budgets, timelines, and resource utilization before and after digital adoption are analyzed to measure cost savings and efficiency improvements.

Comparative analysis helps identify key factors influencing successful digital transformation.

Additionally, expert opinions from industry professionals, including project managers, engineers, and technology specialists, are incorporated to understand the challenges and best practices in implementing digital tools. Surveys and interviews provide insights into the adoption barriers, workforce adaptation, and financial considerations associated with integrating new technologies into construction workflows.

Results and Discussion

One of the most significant advancements in construction is BIM, which enables the creation of detailed digital representations of buildings before construction begins. By identifying potential design flaws early, BIM minimizes rework costs and reduces material waste. It also improves collaboration among architects, engineers, and contractors, leading to better decision-making and more efficient project management. Research indicates that BIM adoption can reduce costs by up to 20% by enhancing accuracy and preventing unforeseen expenses [3].

AI and automation are playing an increasingly important role in construction cost reduction. AI-powered algorithms analyze vast amounts of project data to predict potential risks, optimize material usage, and enhance scheduling accuracy. Machine learning applications help forecast project timelines and minimize costly delays. Meanwhile, automation, such as the use of robotics for repetitive tasks like bricklaying and concrete pouring, reduces labor costs while improving precision [2]. Autonomous machinery also enhances workplace safety, reducing accident-related financial losses.

The adoption of cloud computing has revolutionized project management by enabling real-time collaboration and data sharing. Traditional paper-based documentation has been replaced with digital records, cutting administrative costs and improving project transparency. Cloud-based platforms facilitate instant communication, allowing teams to make timely decisions and prevent unnecessary downtime. Additionally, cost estimation tools integrated into these platforms provide real-time budget tracking, helping construction managers avoid financial overruns and optimize expenditures [4].

The Internet of Things (IoT) is another game-changer for construction. Smart construction sites now utilize sensors and connected devices to monitor material usage, equipment performance, and environmental conditions. These systems ensure optimal resource utilization and predictive maintenance, preventing unexpected equipment failures and costly repairs. Moreover, smart technologies contribute to energy efficiency, reducing long-term operational costs and promoting sustainability in construction projects [1].

Despite the benefits, adopting digital technologies in construction presents several challenges. High initial investment costs, resistance to change, and the need for workforce upskilling are common barriers. Small and medium-sized construction firms, in particular, may struggle to implement advanced technologies due to budget constraints. Additionally, integrating digital solutions into existing workflows requires careful planning to ensure a smooth transition [3]. However, the long-term financial and operational benefits of digitalization make it a crucial step for companies aiming to remain competitive.

Conclusion

Digital technologies are revolutionizing cost management in construction, offering solutions to traditional inefficiencies. From BIM and AI to cloud computing and IoT, these innovations enhance project planning, reduce waste, and improve productivity. Despite implementation challenges, the long-term financial benefits outweigh the initial investment. Embracing digital transformation is essential for construction firms to remain competitive in an increasingly technology-driven industry.

As digital tools continue to evolve, their integration into construction processes will become even more critical. Companies that proactively adopt these technologies will gain a competitive edge by improving operational efficiency, reducing environmental impact, and delivering higher-quality projects. Future research should focus on overcoming adoption barriers and developing cost-effective solutions to make digitalization accessible to firms of all sizes.

References

1. Eastman C., Teicholz P., Sacks R., Liston K. (2011). BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers, and Contractors. John Wiley & Sons, 640 pages. New Jersey (Eng).
2. Brynjolfsson E., McAfee A. (2014). The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies. W.W. Norton & Company, 320 pages. New York (Eng).
3. Smith P. (2014). BIM & the 5D Project Cost Management: Challenges and Benefits. Procedia - Social and Behavioral Sciences, Vol. 119, pp. 475-484. Amsterdam (Eng).
4. World Economic Forum (2016). Shaping the Future of Construction: A Breakthrough in Mindset and Technology. 104 pages. Geneva (Eng).

Влияние цифровых технологий на снижение стоимости строительства

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Аннотация. Цифровые технологии трансформируют строительную отрасль, снижая затраты, повышая продуктивность и сокращая потери ресурсов. Ключевые инновации, такие как информационное моделирование зданий (BIM), искусственный интеллект (ИИ), облачные вычисления и Интернет вещей (IoT), оптимизируют планирование проектов, минимизируют ошибки и повышают эффективность. BIM уменьшает перерасход материалов, ИИ улучшает точность расписания, а IoT обеспечивает мониторинг в реальном времени. Несмотря на высокие затраты на внедрение и необходимость обучения персонала, долгосрочные финансовые выгоды делают цифровую трансформацию необходимой для конкурентоспособности строительных компаний.

Ключевые слова: автоматизация, BIM, облачные технологии, строительные затраты, цифровизация, ИИ, IoT.

УДК 728

Construction of low-rise residential buildings in a sharply continental climate

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Abstract
Options for constructing low-rise residential buildings in a sharply continental climate are considered, requiring a special approach to design and the selection of building materials that can withstand sharp temperature fluctuations. Additionally, economic aspects of design are analyzed to ensure a reduction in operating costs.
Keywords: low-rise residential buildings, frame construction, sharply continental climate.

Introduction

The construction of low-rise residential buildings in a sharply continental climate requires a comprehensive approach to design and technology selection due to significant temperature fluctuations. In regions such as Siberia and the Urals, winter temperatures can drop to -40°C, while summer temperatures can reach +30°C and above.

The relevance of this article is determined by the climatic features and the requirements for the energy efficiency of buildings. The right choice of materials and technologies can reduce operating costs and enhance the comfort of living in low-rise buildings.

The analysis of climatic conditions affecting the choice of building materials and technologies, the requirements for highly porous materials, and modern frame construction technologies that allow for the acceleration of the construction process of low-rise residential buildings, along with their advantages and disadvantages, will help to explore the features of design and construction in a sharply continental climate to enhance comfort and reduce operating costs.

Results and Discussion

In climatic conditions such as those in Yakutsk and Verkhoyansk, special approaches to construction are required: the selection of materials capable of withstanding low temperatures and fluctuations, as well as effective thermal insulation. The use of frame structures allows for the creation of lightweight, durable buildings with good thermal insulation, which minimizes heating costs. Designers must take climatic features into account to ensure comfortable living conditions and the longevity of the buildings.

When constructing buildings in a sharply continental climate, the choice of building materials requires special attention to their resistance, moisture, and thermal performance characteristics. Effective thermal insulation is crucial for reducing heat loss. Building design should consider the orientation of windows, limiting the glazing area on the northern side. The use of synthetic and composite materials, such as aluminum composite panels, provides warmth and moisture protection.

In the conditions of a sharply continental climate, the choice of construction technology for low-rise residential buildings is of great importance for resource efficiency and durability. The main construction technologies in these conditions include: frame construction, brick, SIP panels, laminated timber, aerated concrete, and concrete.

In sharply continental climates, frame construction is gaining popularity due to its reliability and energy efficiency. Frame construction is an effective way to create housing that meets modern requirements and economic factors. In 2024, the cost of constructing a frame house with an area of 100 m² starts from 2.56 million rubles, which is 30% lower than the cost of a house made of aerated concrete. The use of SIP panels, consisting of sandwich panels with thermal insulation, allows for a reduction in construction time to 1.5-2 months and provides excellent thermal insulation.

The advantages of frame construction include high strength, ease of assembly, and the possibility of project adaptation. In frame construction, materials such as wood, composite materials, and increasingly metal frames are used.

Energy-efficient building design in a sharply continental climate requires consideration of significant temperature fluctuations, which affect heating and cooling. The main task is to minimize heat loss through effective thermal insulation materials and structural solutions. In this regard, the details of assembly and architectural solutions, such as the orientation of the building, roof shape, and window placement, are important.

Economic aspects of design are also crucial, as initial investments in energy-saving technologies are justified by reduced operating costs.

Frame construction is characterized by cost-effectiveness and rapid erection (up to four months), providing a good level of insulation. Brick construction is known for its strength and durability but requires significant investment in thermal insulation due to high thermal conductivity. SIP panels are becoming popular due to their lightweight and quick installation, offering a high level of thermal insulation, but they are sensitive to moisture. Laminated timber combines aesthetics with good thermal insulation properties but requires regular maintenance. Aerated concrete and concrete provide durable structures but also need intensive thermal insulation, and aerated concrete is more expensive and slower to install than frame construction.

In recent years, there has been a growing interest in low-rise housing. Low-rise buildings create a more friendly and comfortable living environment for people. As global experience shows, low-rise construction often involves the creation of local communities with developed social and communal infrastructure, making this model particularly sought after. This direction is becoming attractive for young families due to the affordability of housing and the developed infrastructure. Low-rise construction contributes to the creation of quality urban architecture and the rational use of space.

In the modern conditions of a sharply continental climate, the implementation of innovative technologies in the construction of low-rise residential buildings has become a necessity for improving the quality and durability of structures. One such development is self-healing concrete, which can extend the lifespan of buildings and reduce repair costs. 3D printing ensures precision and speed in project implementation, while Building Information Modeling (BIM) helps plan and visualize structures, reducing errors and

improving resource management.

Eco-friendly construction solutions and the use of recycled materials help minimize the carbon footprint. Automation and robotics enhance work quality and reduce labor costs in challenging conditions. New finishing materials with high performance characteristics are becoming important for durability. The economic aspects of implementing such technologies ensure reduced operating costs, making projects more attractive to investors. Innovations are shaping comfortable and safe living spaces that can withstand the climatic conditions of a sharply continental climate.

Conclusion

Thus, when designing and constructing low-rise residential buildings in a sharply continental climate with harsh temperature fluctuations, special attention must be paid to thermal insulation and energy efficiency, allowing for the use of highly porous materials. Modern frame construction technologies reduce construction time and improve the quality of structures. Designing energy-efficient buildings requires the application of modern technologies, automation, and the integration of renewable energy sources, which helps reduce costs. Innovations in construction, including new materials and digital technologies, open new horizons in low-rise construction.

Therefore, the right approach and the use of modern technologies in construction allow for the creation of comfortable and energy-efficient low-rise housing in a sharply continental climate with harsh temperature fluctuations.

References

1. Aloyan R.M., Fedosov S.V., Oparina L.A. Energoeffektivnye zdaniya sostoyanie, problemy i puti resheniya [Energy-efficient buildings – state, problems, and solutions]. Ivanovo, PresSto. 2016. 240 p. (Rus).
2. Uselis Y.V. Social'no-ekonomicheskoe obosnovanie koncepcii razvitiya maloetazhnogo stroitel'stva [Socio-economic justification of the concept for the development of low-rise construction]. Moskovskij ekonomicheskij zhurnal. 2022, № 12, pp. 726-734. (Rus).
3. Sharply continental climate — Ruviki: Internet Encyclopedia [Electronic Resource]. Available from: https://ru.ruwiki.ru/wiki/резко_континентальный_климат. (Accessed 12.12.2024). (Rus).

Строительство малоэтажных жилых зданий в условиях резко-континентального климата

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Аннотация. Рассматриваются варианты строительства малоэтажных жилых зданий в условиях резко-континентального климата, требующие особенного подхода к проектированию и выбору строительных материалов, которые способны выдерживать резкие перепады температуры, а также анализируются экономические аспекты проектирования, обеспечивающие снижение затрат на эксплуатацию.

Ключевые слова: каркасное строительство, малоэтажные жилые здания, резко-континентальный климат.

УДК 69-692

The current state of modular construction

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Abstract
Modular construction is modern technology in which buildings are assembled from ready-made blocks produced in factory conditions. The article reveals the main advantages of the method: speed of construction, cost savings, high quality, environmental friendliness and design flexibility. Key applications are considered, including residential buildings, commercial real estate, social facilities and industrial structures. The prospects for the development of the industry, such as the integration of environmentally friendly materials and smart technologies, are also discussed. Modular construction is an effective solution to modern challenges in construction, offering a cost-effective, environmentally sustainable and fast-track approach to building construction.
Keywords: buildings, ecology, economy, innovation, modular construction, speed, technology.

Introduction

Modular construction in Russia is rapidly gaining popularity in recent years, because it becomes an effective alternative to traditional construction methods, such as brick, gas block, concrete panels, etc. This technology combines fast speed of erection building construction, environmentally friendly construction and economic benefits, aesthetic beauty, and following minimalist trends. This article focuses in modular construction, its advantages, applications and prospects.

Modular construction is a chance to get affordable and comfortable housing for almost every person, without getting into mortgages and loans. And at the same time, it will look beautiful, practical, ergonomic.

The sequence of construction of a modular house:

1.Installers assemble the lower floor with the floor.

2. Frames of walls and partitions are erected on the base, and a roof is made.

3. Sheathe the walls from the outside, lay thermal insulation.

4. They put windows and doors.

5.Install electrical wiring, perform interior decoration.

6. Install plumbing.

Advantages of modular construction

Low cost

Modular construction, comprising project development, preparation of documents, technical equipment and finishing, costs about 2 times cheaper than capital construction. For example, a modular spacious durable house for a family of 5 people can be built for about 3.5 million rubles [1].

High speed of construction

A typical modular building is erected, on average, in 5-7 days by one work team. Experienced craftsmen are able to assemble a small structure in 1 day. The fact is that the

main elements of the future building are manufactured at the factory, after which they are assembled on the construction site according to the type of a children's designer. With capital construction, it is impossible to build even a garage in such a short time. It only takes a week to install the foundation [1].

Long service life

Contrary to popular belief, a building with a modular frame can serve up to 50-80 years, or even longer, subject to regular maintenance and scheduled repairs. Their design has increased resistance to all negative environmental factors, including abnormal weather events. Metal parts are protected from corrosion. They are not afraid of fire, pests, fungus, and do not collapse over time.

Environmental friendliness

Modern modular houses and non-residential buildings are built from certified materials with high environmental friendliness and safety for people and the environment.

A pleasant microclimate in the interior

In modular buildings of various types, only their frame is metal. For insulation, steam and waterproofing, exterior and interior decoration, modern "breathable" materials are used, which ensure proper air circulation in the interior, optimal air exchange and heat exchange. This helps to maintain a comfortable temperature and fresh air inside the building, and in any season.

Saving energy resources

The walls of modular buildings have a sandwich structure, which helps to keep the interior cool in summer and warm in winter. This allows you to save quite a lot on heating and air conditioning, which is impossible to achieve in houses with brick walls.

Mobility

A modular house can easily "move" to another place. Its design is not only easy to assemble, but also easy to disassemble, and all modular elements are preserved in perfect condition and can be used for reassembly.

Modular construction itself, thanks to the principles of such construction, is used in completely different fields. These can be commercial buildings, temporary buildings, as well as houses-cabins for workers, private residential buildings, apartment buildings, residential complexes, etc. [2].

As an example, Russian group of companies "Monarch" plans to build a plant for the production of large modules for construction, which will be located in New Moscow. Each module will be a block with an area of up to 100 square meters, and each of the blocks will already have ready-made repairs and utilities.

Prospects of modular construction

Modular construction significantly speeds up the construction process due to the factory readiness of the elements. Modular buildings, as well as buildings built using a steel frame, are erected much faster, it is elementary to recall industrial 3D printing. They are more durable, environmentally friendly and earthquake-resistant. The construction of such structures is more economically profitable due to the reduction of “wet” processes, equipment and the number of workers on construction sites [1].

Conclusion

Modular construction is an innovative approach. Its advantages, such as speed, cost-effectiveness and environmental friendliness, make it attractive to both private customers and large corporations. In the face of modern challenges such as urbanization and environmental sustainability, modular construction is becoming a real salvation for building the future.

References

1. **Shelomentsev A.S., Polyakova I.Yu.** Modul'noe stroitel'stvo kak novyi tolchok razvitiya berezhlivogo stroitel'stva [Modular construction as a new impetus for lean construction development]. In: Aktual'nye voprosy stroitel'stva na Dal'nem Vostoke Rossii. Materialy nauchno-prakticheskoy konferentsii [Current issues of construction in the Russian Far East. Proceedings of the Scientific and Practical Conference]. Far Eastern State Transport University, Khabarovsk, 2023, p. 76. (Rus)
2. **Sergeeva D.S.** Stroitel'stvo modul'nykh zdanii kak reshenie bystrogo vozvedeniya individual'nykh chastnykh domov [Construction of modular buildings as a solution for rapid erection of individual private houses]. StudArctic Forum, 2021, vol. 1, no. 21, pp. 89–94. (Rus)

Современное состояние модульного строительства

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Аннотация. Модульное строительство – это современная технология строительства зданий собираются из готовых блоков, произведенных в фабричных условиях. В статье освещаются главные преимущества метода: скорость строительства, экономия средств, высокое качество, экологичность и гибкость конструкции. Рассматриваются ключевые области применения, включая жилые здания, коммерческую недвижимость, социальные объекты и промышленные сооружения. Также обсуждаются перспективы развития отрасли, такие как внедрение экологически чистых материалов и интеллектуальных технологий. Модульное строительство — это эффективное решение современных задач в строительстве, предлагающее экономичный, экологически устойчивый и ускоренный подход к строительству зданий.

Ключевые слова: экология, экономия, инновации, здания, модульное строительство, скорость, технологии.

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Influence of reconstruction of industrial buildings on city life

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Abstract
Industrial buildings built in the past are often architectural monuments that reflect the history of the city's development. However, industrial architectural monuments often require reconstruction for their further use**.** The purpose of the article is to examine domestic and foreign experience in the reconstruction of industrial zones and to evaluate the given experience from the point of view of urban studies.
Keywords: reconstruction, renovation, industrial architecture, public spaces.

Introduction

Industrial buildings built in the 18th and 19th centuries were initially located outside the urban area. With the gradual growth of cities, industrial areas were absorbed by residential and public buildings, but despite this, they continued to function until the collapse of the Soviet Union. The very location of factories near residential buildings has a negative impact on the ecological state of the environment and the life of the population.

Gradually, the buildings of once prosperous industrial enterprises fell into disrepair or were partially leased, which led to a chaotic distribution of public spaces. In the best case, the former factory buildings could house offices, pharmacies and various stores, in the worst case, the former workshop buildings were doomed to slow destruction and subsequent demolition. Abandoned industrial buildings negatively affect the urban component of the city. They disrupt the visual perception of the city and pose a danger to the population if such areas are not protected. The trend of industrial zone reconstruction emerged in the late 20th century, when the need for certain types of factories died out, or industrial enterprises, including old factory buildings, lost their profitability. Reconstruction of former industrial areas is possible for their use in various fields, such as housing complexes, cultural and exhibition centers, city parks, offices and shops [3].

Below we will consider successful examples of industrial area reconstruction in Russia and abroad.

Materials

Sevkabel Port, Saint Petersburg, Russian Federation. Sevkabel Port is a renovation project of the Siemens & Halske plant territory, located on Vasilievsky Island. The goal of the project was to create a multifunctional cluster and a picturesque place for leisure and recreation of guests and citizens of Saint Petersburg.

The first floor of the historic building, made of red brick, is occupied by workshops, office premises and offices, a large area is allocated for a restaurant. The cable packaging workshop was converted by architects into a hall for holding mass events. The administrative building accommodated educational facilities, gyms and shops. The first floor of the production workshop, which occupies the largest area and is located on the

seashore, is given over to a multifunctional zone, a club and a restaurant. The second floor is planned to house a museum, gallery, theatre and exhibition space [4].

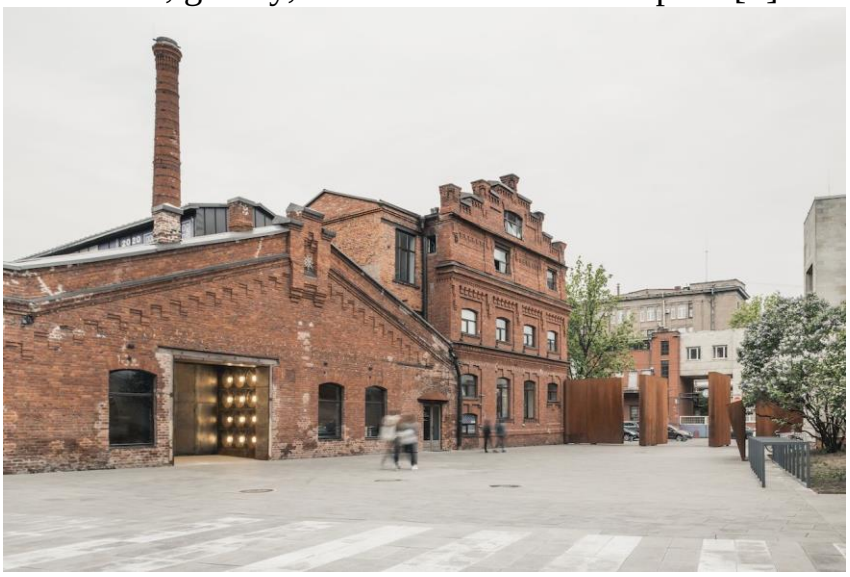

Figure 1 – the main facade of Sevkabel port [4]

Art Zone 758, Beijing, China. "Factory 798" (Art Zone 758) is a major contemporary art center, located in the building of a military electronics factory. The factory, with an area of approximately 640 thousand m2, was built in the 1950s with the participation of the USSR and the GDR. [1]

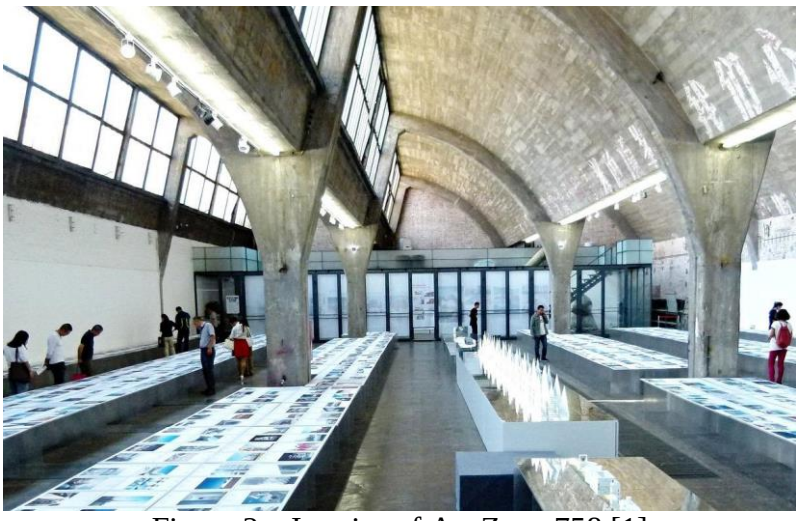

Figure 2 – Interior of Art Zone 758 [1]

Between 1995 and 2003, the factory gradually became a popular art space. Designers Hu Yong and Huang Rui left the interior walls, partitions and slogans from the Chinese Cultural Revolution on the facades of the buildings. Production equipment, machines and mechanisms act as exhibits, and large-scale exhibitions are held in a large room [2].

Results

The stated industrial complexes have been transformed into popular public spaces, which now serve as a point of attraction for citizens and tourists. The modern appearance of the new public spaces was achieved through careful restoration of industrial buildings

and structures and gentle internal redevelopment. Large spaces of former workshops and warehouses are successfully used and can be used as public centers, both in Russia and abroad. Many public and cultural centers organized based on former factories are loft-style premises, often used for exhibitions, for organizing work areas (coworkings) for placing public establishments such as restaurants and boutiques.

Conclusion

Such spaces give creative individuals the opportunity to express themselves and serve as a platform for the implementation of many socio-cultural projects. In addition, the reconstruction of industrial facilities for a new function can extend the service life of buildings, also, it allows to "bring a new life" to old buildings. Former industrial areas that once polluted the atmosphere with their emissions and reduced the quality of life of the population now serve the purpose of popularizing creativity, which can create art objects from sometimes nondescript standard buildings of industrial enterprises.

References

1.798 Art Zone. Tripadvisor. Available from: https://www.tripadvisor.ru/Attraction_Review-g294212-d1793347-Reviews-798_Art_Zone-Beijing.html (Accessed 15.12.2024). (Rus)

2. Avanesov A.D., Boloboshko D. S., Lanin E.B., Ogurcov G. K. Obzor otechestvennogo i zarubezhnogo opyta renovacii proizvodstvennyh zdanij [Review of domestic and foreign experience in renovation of production buildings]. Nauchnye issledovaniya, 2017, №1 (12). Available from: https://cyberleninka.ru/article/n/obzor-otechestvennogo-i-zarubezhnogo-opyta-renovatsii-proizvodstvennyh-zdaniy (Accessed 15.12.2024). (Rus)

3. Bushtec D. V., Zabruskova M. Yu. Renovaciya byvshih promyshlennyh territorij i ob"ektov sredinnoj zony v obshchestvennye prostranstva [Renovation of former industrial areas and objects of the medial zone into public spaces]. Izvestiya KazGASU. 2018. №2 (44). Available from: https://cyberleninka.ru/article/n/renovatsiya-byvshih-promyshlennyh-territoriy-i-obektov-sredinnoy-zony-v-obschestvennye-prostranstva (Accessed 15.12.2024). (Rus)

4. Proekt «Sevkabel' Port» v Sankt-Peterburge [Project "Sevkabel Port" in Saint-Petersburg. Project Russia]. Available from: https://prorus.ru/projects/proekt-razvitiya-pribrezhnoj-territorii-zavoda-siemens-halske-sevkabel-port/ (Accessed 15.12.2024). (Rus)

Влияние реконструкции промышленных зданий на жизнь города

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Аннотация. Промышленные здания, построенные в прошлом, зачастую представляют собой архитектурные памятники, что отражают историю развития города. Однако памятники промышленной архитектуры нередко нуждаются в реконструкции для их дальнейшего использования. Цель статьи заключается в рассмотрении отечественного и зарубежного опыта реконструкции промышленных зон и оценке приведенного опыта с точки зрения урбанистики.

Ключевые слова: реконструкция, реновация, промышленная архитектура, общественные пространства.

УДК 365.262.2

On the development of the rental housing market in the Russian Federation

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Abstract
At the current stage of housing sector reform in Russia, the main task of the state housing policy is to develop mechanisms to increase the availability of housing for various categories of the population. Currently, various programs and subprograms are being implemented aimed at a comprehensive solution to housing problems. This article describes the mechanisms for the development of the rental housing market in Russia.
Keywords: housing stock, rental housing, apartment buildings.

More than half of the housing stock in Russia was built during the Soviet era and has expired or is expiring its standard service life. It is obvious that it is necessary to increase the volume of housing construction, reduce its cost, increase effective demand, and much more. These are complex and large-scale tasks that require solutions.

Studying the experience of creating rental social housing in developed countries can help alleviate the acuteness of the housing problem. At present, the mechanism of housing rental, including subsidized by the state, municipalities or employers, is traditional in European countries and the USA.

In the 19th and early 20th centuries, it was apartment buildings that largely solved the housing issue in Russia. St. Petersburg was especially successful, which was built mainly as a city of apartment buildings. In pre-revolutionary Moscow and St. Petersburg, only 5% of city residents owned housing.

The housing problem in Russia is still acute today. According to surveys, 42% of Russians feel the need to buy housing. In Moscow, about 200 thousand families are on the waiting list to receive housing under social rent, in small towns people do not believe in the possibility of receiving housing on a mortgage or through social rent. It is obvious that the existing systems are not coping. Therefore, renting apartments from the state is increasingly called one of the promising areas of development of the housing market in Russia. Construction of housing for social rent will satisfy demand and relieve social tension.

So far, construction of apartment buildings in Russia is a rare occurrence. However, the state cannot currently afford to provide the population with property, so it is necessary to more actively implement alternative mechanisms for providing housing, one of which is the institution of rent. The government, in particular of St. Petersburg, considers this segment as one of the key mechanisms for reducing the queue for housing in the city. Rental prices for such apartments are below market prices, so this mechanism is popular. At the moment, there are about 175 thousand families in St. Petersburg who are on the waiting list to improve their housing conditions. Accordingly, the volume of construction of rental housing should be increased several times. However, the payback period for such

projects is up to 25 years, which is certainly a serious deterrent. Another difficulty that may arise is the psychological factor. Russians are still confused by the fact that by renting an apartment in an apartment building, even at a minimum price, they will not be able to get it into ownership. What makes the project attractive is the opportunity to improve their housing conditions at an affordable price in the very near future.

Currently, in Russia, on average, about 5% of the population rents housing. In large cities, the share of those living in rented housing increases to an average of 8.5%, and in Moscow it reaches 15...17%. For comparison, on average, in Germany, up to 45% of the country's residents rent housing, in the USA - 34%, and in New York this figure reaches 67%. However, the idea of rental houses in modern Russia has not yet become widespread due to the low profitability of this area. For Russian investors, the desired level of profitability should be 10-12%, and for Europe, 4% is a normal profitability.

Currently, in Russia, rental housing is represented mainly by renting out housing on the secondary market. Thus, the share of rented housing is about 30%, but officially less than 1/5 of this housing is rented out. The most common category of tenants in Russia are students, internal and external migrants, families with an income that does not allow them to purchase housing, highly mobile workers, single people, i.e. people renting apartments from private individuals - apartment owners. This is a type of commercial rent, but today this market is a segment of the shadow economy. The "gray" market is characterized by the absence of normal pricing mechanisms and low quality of rented housing. Economy class rental housing is mainly represented by apartments in residential buildings of the first mass series, which are significantly inferior in their consumer qualities to residential buildings of modern construction. Reconstruction measures are required to eliminate the physical and moral deterioration of mass-produced buildings. However, during reconstruction, a number of serious organizational, technical and economic problems arise, such as: the problem of resettling homeowners and providing them with adequate housing conditions; deterioration of existing buildings (reinforcement of structures, major repairs are required); limitations of the existing layout of apartments; territorial attachment of buildings, etc. In this regard, new construction is the most economically feasible solution.

The socio-economic processes taking place in the country also lead to changes in the real estate market and changes in consumer requirements for housing. These requirements include the availability of a comfortable living environment and the provision of various types of apartments to the consumer (free layout of apartments, combination of residential and professional functions in an apartment, etc.)

In order to develop a civilized rental housing market, first of all, it is necessary to establish the status of a tenement house at the legislative level, and also to develop a system of interaction between the state and investors. There should be certain requirements from the state, creating guarantees against abuse by unscrupulous participants and measures of state incentives, for example, preferential rates of land rent.

According to experts, the owners of apartment buildings should not be individuals, but real estate funds. The use of closed-end mutual investment funds will already allow, under today's conditions, to increase the level of profitability to 7...10%, and subject to state support and the removal of administrative barriers - even higher, which is a very attractive

indicator for conservative investors. There are also tax advantages to using closed-end mutual investment funds in the development of apartment buildings. In particular, investors can count on "tax holidays" and the absence of double taxation. Simultaneously with these measures, the creation of a regulatory framework for the construction and operation of rental housing, the creation of an information base and the dissemination of information to the population about rental housing as a way to solve housing problems of various categories of citizens will ensure competitive conditions with the "shadow" market.

Despite the fact that the Ministry of Regional Development of the Russian Federation has developed a Program for the Development of the Rental Housing Market in the Russian Federation and it is planned that by 2030 the rental housing market in the country should grow to 20% of the total housing stock, in general, under today's conditions, the construction of apartment buildings for investors remains not the most attractive segment. However, the development of rental housing in Russia could solve several problems at once: provide the population with square meters; legalize, streamline and develop a civilized market of high-quality rental housing; solve the problem of social housing, provide housing to people who have lost it as a result of natural and man-made disasters, young families and other categories of citizens, whose support is a priority of state policy. At the same time, such support can be targeted, targeted, carried out using market mechanisms - tax benefits and deductions, rental certificates, targeted loans and credits.

О развитии рынка арендного жилья в РФ

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Аннотация. На современном этапе реформирования жилищной сферы в России основная задача государственной жилищной политики – разработка механизмов повышения доступности жилья для различных категорий населения. В настоящее время осуществляются различные программы и подпрограммы, направленные на комплексное решение жилищных проблем. В данной статье описываются механизмы развития рынка арендного жилья в России.
Ключевые слова: жилищный фонд, арендное жилье, доходные дома.

УДК 692

The impact of green technologies on smart homes and smart buildings

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Abstract
The purpose of this study is to examine and analyze the key aspects of the impact of green technologies on smart homes. The relevance of the study lies in the fact that in recent years green technologies have had a noticeable impact on the evolution of smart homes and smart buildings. These technologies focus on increasing energy efficiency, reducing the carbon footprint and improving the quality of life.
Keywords: Green technologies, smart homes.

Introduction

With the growing population, as well as with increasing awareness of environmental issues, green technologies are becoming increasingly important in the design and operation of smart homes and smart buildings. These technologies are aimed at reducing the negative impact on the environment, increasing energy efficiency and improving the quality of life. This study will analyze key aspects of the impact of green technologies on smart homes and smart buildings, including their role in sustainable development, the integration of renewable energy sources and the application of innovative resource management systems. It will also consider how these technologies contribute to creating a more comfortable and safer environment for residents, as well as their impact on the economic efficiency of building operation.

Energy efficient technologies

One of the important systems incorporating green technologies are renewable energy sources. These sources include wind, solar and hydropower.

Wind energy

To generate wind energy, wind turbines can be installed on the territory of houses or on the houses themselves. Combined with modern technologies, it allows you to optimize the use of wind energy and use energy even in areas with low wind.[1]

Solar energy

Solar panels, as a source of solar energy, in smart homes make it possible to create their own electricity. Such energy can be stored using batteries and used at night. Such panels require minimal maintenance, which makes them a very profitable economic solution.[1]

Hydropower

To create hydropower, small hydroelectric power plants can be installed in smart homes that are located at a constant source of water. Houses can also use systems such as rainwater harvesting for future use in household needs or for watering the garden.[1]

All these systems can be combined with each other, which makes it possible to achieve a more reliable and stable power supply.

The use of energy-saving windows and doors can reduce energy consumption in the premises. Green facades and roofs are beneficial for the microclimate, as well as reducing noise and improving the air.

Environmentally friendly materials

Environmentally friendly materials also play an important role in the impact of green technologies on smart homes. The use of such materials reduces the negative impact on the environment. Recycled materials are used to reduce construction waste, and modern technologies make it possible to recycle waste and obtain useful products and recycled materials. The development of green technologies leads to the birth of new environmentally friendly materials, which in the future can replace many traditional materials in construction.[3]

Smart Energy management Systems

The use of smart modern control technologies in homes allows you to reduce energy consumption. The systems collect and analyze data and provide reports to homeowners. There is an optimization in the consumption of water, lighting and heating, which allows efficient use of building resources and cost reduction. One of these technologies is motion and light sensors. They allow you to turn on and off the lights automatically at certain times. Smart thermostats can adjust the temperature depending on weather conditions and so on.

With the help of mobile applications and voice commands, homeowners can manage and configure the building's energy saving systems themselves from anywhere.[1]

Green technologies as a decor

Green roofs and facades not only have environmental benefits and additional protection of the building, but they are also a unique design element. Green technologies make it possible to create biotechnical systems and botanical gardens inside houses. Green walls on which plants grow vertically can be installed on houses, improving air quality, providing additional protection for the building and hiding ugly walls.[2]

Other useful features of smart homes

A smart home is equipped with many other useful features for a more comfortable stay in it. Buildings equipped with special sensors can notify about serious problems in the building, which can be very dangerous, such as gas leaks, ventilation problems or water leaks. Alerts are sent to the owner's mobile phone with a special alert and signal. For people who have vision problems, tactile technologies are added to applications, so a person can use vibrations after pressing to navigate the controls. A very useful system for modern and more expensive smart homes is to monitor the physiological state of a person. With the help of such a system, which analyzes and reports on the condition of residents, you can take better care of your health, and with the introduction of green technologies, you can also improve it.

Conclusion

One of the main problems of green construction in Russia is the lack of information and qualified specialists. However, the impact of green technologies on smart homes and smart buildings is an important element of modern construction and resource management. These technologies contribute to increasing energy efficiency and improving the quality of

life of residents in smart homes. The integration of renewable energy sources, environmentally friendly materials and smart control systems not only makes buildings more sustainable but also creates aesthetic and comfortable conditions for their inhabitants. Thus, green technologies play a key role in shaping a sustainable future and protecting the environment.

References

1. Strunin, D.A. Zelyonye tekhnologii i ustoychivoye razvitie [Green technologies and sustainable development]. 2024, №. 32, pp. 23-25. Available from: https://moluch.ru/archive/531/117034/ (Rus)
2. Eko-bum v stroitel'stve: vliyanie zelenykh tekhnologiy na mirovuyu i rossiyskuyu praktiku. [Eco-boom in construction: the impact of green technologies on global and Russian practice] Available from: https://unigreen-energy.com/blog/zelenoe-stroitelstvo-vliyanie-zelenyh-tekhnologij-na-mirovuyu-i-rossijskuyu-praktiku/ (Accessed 02.12.2024). (Rus)
3. Makeeva Yu. V., Kuznetsova N.V. Primenenie "umnogo stekla" v arkhitekture // Sovremennoye stroitel'stvo i arkhitektura [The use of "smart glass" in architecture // Modern construction and architecture.] – 2023. – № 1(32). – Pp. 14-18. Available from: https://cyberleninka.ru/article/n/primenenie-umnogo-stekla-v-arhitekture/viewer (Rus)

Влияния зелёных технологий на умные дома и интеллектуальные здания

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Аннотация. Целью данного исследования является рассмотрение и анализ ключевых аспектов влияния зелёных технологий на умные дома. Актуальность исследования заключается в том, что в последние годы зелёные технологии оказывают заметное воздействие на эволюцию умных домов и интеллектуальных зданий. Эти технологии сосредоточены на увеличении энергоэффективности, уменьшении углеродного следа и повышении качества жизни.
Ключевые слова: зелёные технологии, умные дома.

УДК 004.89

Architectural features of the decision support system for route planning and assessment of cross-country freight transport

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Abstract
The article discusses the architectural features of the decision support system (DSS) for route planning and assessment of the cross-country ability of freight transport, and particularly the integration of its software modules, such as the module for collection, processing and analysis, as well as visualization into a single system.
Keywords: decision support system, logistic, route planning, system architecture, transport accessibilit.

Introduction

The modern world of logistics relies heavily on effective route planning and the ability to respond quickly to dynamic changes in traffic and environmental conditions. In this context, Decision Support Systems (DSS) have emerged as an indispensable tool for managing cargo transportation. These systems integrate advanced algorithms and data analytics to provide comprehensive solutions for route optimization, ensuring that both transport characteristics and real-time factors, such as weather conditions, road obstructions, and traffic density, are accounted for. The development of such systems not only streamlines logistical operations but also minimizes costs and environmental impact, making them a critical component of sustainable freight management.

A key requirement for DSS architecture in this domain is its productivity and scalability. High-performance architecture enables the processing of large datasets in real time, while scalability ensures that the system can adapt to growing demands and complex scenarios. This flexibility is particularly important when assessing the cross-country capabilities of freight transport, as the system must evaluate various terrain types, seasonal conditions, and vehicle limitations. By leveraging cutting-edge technologies such as artificial intelligence, machine learning, and geospatial data integration, DSS can provide actionable insights, ensuring efficient and reliable transportation solutions. This article explores the design and implementation of such a system, focusing on the architectural principles that enable dynamic route planning and robust cross-country capability assessment for freight transport [1].

Methods of research

The DSS has modular architecture. This allows it to be flexible, scalable and able to adapt to changing conditions. The system can be divided into several logical levels, each of which performs specific functions and interacts with others through well-defined programming interfaces. The first level is responsible for data collection and integration with external sources. The sources are geographic information systems (GIS) for obtaining cartographic information,

meteorological services for accounting for weather conditions, as well as databases on road restrictions. Data on the characteristics of vehicles is also collected, which makes it possible to consider the cross-country traffic on various routes.

At the processing and analysis level, the system uses machine learning algorithms to evaluate possible routes. The analysis includes consideration of static and dynamic factors (the condition of the road surface, the presence of difficult sections or current weather conditions). This data is used to generate a list of potential routes suitable for a particular vehicle, as well as forming a preliminary risk assessment. The data obtained is used to predict the difficulties along the route, at the same time, optimizing routes – minimizing travel time, fuel costs and the likelihood of accidents.

The DSS architecture also includes a visualization layer, where the interface allows users to analyze the proposed routes at the previous level and make adjustments if necessary. Data visualization is carried out on the basis of cartographic services, which allows you to visually assess the route.

The architecture of the system is shown in Figure 1. The architecture is described in the form of a UML diagram of components. This visualization approach will allow you to visually see the main components of the system and their interaction both between the user of the system and between the components [2].

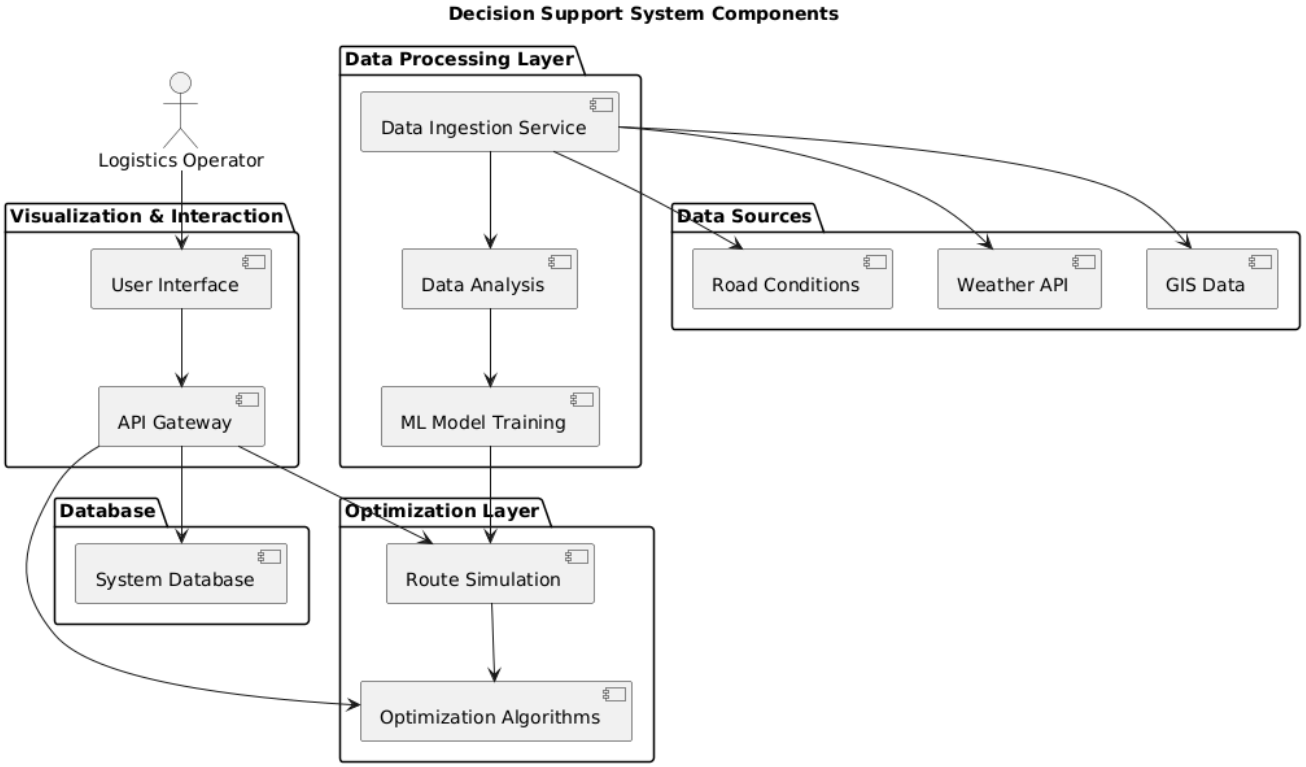

Figure1 - Architecture of the system

A key aspect of the presented architecture is its ability to integrate with external systems and services. This is achieved using standard communication protocols and open interfaces. For data exchange, the system uses REST API and WebSocket for interaction with geographic information systems, databases and meteorological services. Using such an architecture makes it easy to integrate new sources of information, as well as expand the functionality of the system

without having to make significant changes to its structure. Thanks to this architectural approach, the DSS adapts to the requirements and conditions of modern logistics, ensuring scalability in the face of changing external factors [3].

Conclusion

The described DSS architecture for route planning and evaluation of cross-country freight transport combines modular flexibility and efficient algorithms for data analysis and processing. It also takes into account key factors for choosing the optimal route, which increases logistics efficiency, reduces risks and costs. Prospects for the modernization of the system architecture include the integration of individual neural network technologies for deeper decision-making, as well as computer vision technologies for real-time data analysis.

References

1. Iskanderov Yu.M., Laskin M.B. Formirovanie i ispol'zovanie intellektual'noy sistemy podderzhki prinyatiya resheniy v logisticheskikh sistemakh [Formation and usage of an intelligent decision support system in logistics systems]. Sistemnyy analiz v proektirovanii i upravlenii, 2021, T. 25, № 3, S. 302–308. (Rus)
2. Qaiser F.H., Al-Ghamdi S.G., Bandh S.A., Khan A.H., Ahmad R. Decision support systems for sustainable logistics: a review and bibliometric analysis. Industrial Management & Data Systems, 2017, Vol. 117, No. 7, pp. 1376–1388.
3. Kopsha O.Yu., Tokarev D.G. Voprosy operativno-kalendarnogo planirovaniya transportnoy logistiki v intellektual'nykh sistemakh podderzhki prinyatiya resheniy [Issues of operational and calendar planning in transport logistics within intelligent decision support systems]. Informatsionnye tekhnologii v modelirovanii i upravlenii: podkhody, metody, resheniya, 2021, S. 115–122. (Rus)

Архитектурные особенности системы поддержки принятия решений для планирования маршрутов и оценки проходимости грузового транспорта

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Аннотация. В статье рассматриваются архитектурные особенности системы поддержки принятия решений (СППР) для планирования маршрутов и оценки проходимости грузового транспорта, а в частности интеграции ее программных модулей, таких как модуль сбора, обработки и анализа, а также визуализации в единую систему.
Ключевые слова: архитектура системы, логистика, планирование маршрутов, проходимость транспорта, система поддержки принятия решений.

УДК 692

Multifunctional complex

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Abstract
We always strive for comfort, convenience and want everything to be at hand, in the modern world all this is possible thanks to architects. The purpose of this article is to analyze the advantages and disadvantages of multifunctional complexes, as well as the impact of such objects on the urban environment and public space. The objectives of the research are to eliminate problems in the design of MFC and increase the number of residents in the project interest.
Keywords: infrastructure, multifunctional complex (MFC), recreation, energy efficiency.

Introduction

The evolution of architecture and urban development has led us to the need for increasing density of construction, to the formation and expansion of functional links between different building objects. The shortage of free space in cities has led us to organize multifunctional development, increasing the efficiency of use of urban areas.

What is a multifunctional complex?

A multifunctional complex is an architectural object, a new format of urban planning in which different functions are integrated, independent from each other, forming a whole. In other words, such complexes combine residential, commercial, sports, public, recreational spaces and other infrastructure elements, creating unique conditions for living, working and recreation, as well as providing accessibility of various services to people unlike traditional buildings. . The main method of research is to analyse the identification of strengths and weaknesses of MFC and to study existing publications on this topic.

Pros and cons

Multifunctional systems have several advantages. Let’s take a closer look at the economic, social and environmental aspects.

1. Comfort and convenience. As mentioned earlier, all the necessary objects for comfortable living are close to each other. Residents do not need to spend time on trips to different parts of the city to visit a shop, workplace or gym. With a variety of services and recreational facilities, people are able to spend their free time profitably without leaving the area.

2. Security. Modern complexes are equipped with lighting devices on the surrounding areas, video surveillance and security systems. Also, public and commercial spaces can have different working regimes and this significantly reduces the level of crime at night.

3. Improved system. Since multifunctional complexes are a fresh look at convenience and have appeared recently, it is natural for new projects to be equipped with modern utilities, car parks and other elements.

4. Energy efficiency and environment. MFC projects are developed with the principles of sustainable development in mind. Energy-efficient or green technologies such as solar

panels, rainwater harvesting and wastewater treatment systems, the use of environmentally friendly materials and other innovations that reduce negative environmental impacts are used.

5. Optimization. Unlike usual buildings that occupy a large area, complexes do not require separate structures for each task. The MFC uses every square meter efficiently, and combining different functions reduces maintenance costs. Here all types of rooms are serviced by one water, electricity and heating system.

6. Diversity of the urban environment. From the point of view of urban planning, the multifunctional complex attracts attention, creates dynamics, distinguishes originality and enlivens the surrounding space with different functions and architectural solutions, excluding uniformity and monotony.

7. Public spaces. The project includes special areas for recreation, socializing and meetings, alleys, parks, areas for general assembly of people and events. All this forms active social interaction and creates a sense of community.

Despite its many advantages, multifunctional complexes have some disadvantages. We will find ways to solve the difficulties related to the design of complexes.

1. Privacy. For some residents of the complex, the feeling of lack of privacy due to the proximity of different functions can be a problem. The solution may be the use of soundproofing materials, the creation of enclosed seating areas, and the separation of zones using landscaping.

2. Transport load. The concentration of large numbers of cars and people increases the load on transport infrastructure, leads to traffic jams and lack of parking spaces. To solve this problem, it is necessary to take into account the development of public transport at the project stage, create underground and above-ground car parks taking into account the number of residents and visitors to the complex, and also develop an efficient transport scheme to relieve the traffic of cars.

3. The risks of mass construction of MFC. Good planning of construction, careful analysis of market, demand and offers will allow eliminating the risks associated with overloading of objects in the city. Otherwise, neglecting the above rules will reduce the cost of square meters and make it more difficult to sell or rent premises.

4. Building density. It is important for the architect to provide sufficient greenery and parks within the complex, because often high density development results in less green space and open spaces, which negatively affects the comfort of the residents and the quality of the environment.

Other tools such as green roofs or vertical gardens can also be used. In this case, it is important to remember that these kinds of devices require constant maintenance and will incur additional costs. It is also worth considering the climate of the construction zone; in our case the plants should be frost resistant and perennial. Compliance with these requirements guarantees improvement of the microclimate and aesthetics of the complex.

5. Improper zoning. Clear division of zones will help avoid inconvenience and conflicts of interests of residents. For example, it is not recommended to have a living area with large crowds of people whose noisy companies can interfere with others.

6. Layout. An equally important aspect of building a complex is flexible layout. Let's

imagine that the demand for some premises has decreased, in this case they will have to be re-equipped for other needs, and this may entail high costs.

7. Insulation. In order not to lead to social isolation, creation of a closed society within the area and limited interaction with the surrounding city public events and cultural programs are organized.

8. High cost. The main disadvantage of a multifunctional complex is its high cost. This is due to the introduction of modern technologies, increased level of comfort, a multitude of services, aesthetics and other tools for absolute convenience and pleasure living in this place.

Conclusion

The study established that Multifunctional Complexes have both significant advantages and tangible disadvantages, which require special attention.

MFC becomes the new standard of modern architecture and represents the future of urban development, if their advantages are maximized and their disadvantages minimized. The establishment of MFC implies an integrated approach that takes into account economic, environmental and social requirements. Successful projects must find a balance between functionality, aesthetics and comfort, ensuring high quality of life for their residents.

All this makes the complexes an attractive choice for those who are looking for a comfortable and modern place to live.

References

1. Barsukova N. I., Zhukova I. V. Multifunctional complexes as one of the trends in the organization of a modern comfortable environment, 2021, no. 11 Available from: https://cyberleninka.ru/article/n/mnogofunktsionalnye-kompleksy-kak-odna-iz-tendentsiy-organizatsii-sovremennoy-komfortnoy-sredy/viewer (Accessed 29.11.2024). (Rus)

Многофункциональный комплекс

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Аннотация. Мы всегда стремимся к комфорту, удобству и хотим, чтобы все необходимое находилось под рукой, в современном мире все это стало возможным благодаря архитекторам. Целью данной статьи является анализ преимуществ и недостатков многофункциональных комплексов, а также влияние таких объектов на городскую среду и общественное пространство. Задачи исследования – устранение проблем в проектировании МФК и увеличение числа жителей в заинтересованности проекта.

Ключевые слова: инфраструктура, многофункциональный комплекс (МФК), рекреация, энергоэффективность.

УДК 62-783

Architectural and landscape complex with a sports and entertainment center in the town of Tambov

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Abstract
The relevance of the architectural-landscape complex with a sports and entertainment center is that the city needs a central sports core with a well-designed plan for the placement of objects of the architectural-landscape sports complex. The purpose of this project is to solve the problems associated with the development of the territory along the banks of the rivers Tsna and Studenets in the town of Tambov, the creation of an architectural and landscape complex, as well as the development of a sports and entertainment center.
Keywords: coastal territory, landscape, leisure, sports center, pool, spa.

Introduction

There are several areas in the complex: training, demonstration, quiet and active recreation, economic and administrative. The training zone includes a sports and entertainment center. It can be used for professional sports. There is a one-stop room for 1,200 viewers. The complex also includes a spa center with a basin of 25 metres. In addition, the sports center system has a gym and a training room for various difficulties. The center has a power zone, namely a restaurant with a large main room on the 2nd floor.

Project description

A special feature of the project is the Sports and Entertainment Centre, which has a special place in the compound.

The facade is made in light paste colours. The walls of the main building are plastered, and the walls of the restaurant are painted with decorative tiles. The main entrance comes from a perforated facade on the second floor, where the pattern resembles the wave. The colour solution in blue and blue tones and the facade wave pattern support the overall theme of the sports and entertainment center with water sports zones. Also in the design of facades is used stained glass glazing, which gives lightness to the image of the center.

The main facade of the sports and entertainment center is shown in Fig. 1.

Figure 1 - The main facade of the sports and entertainment center

The Sports and Entertainment Centre consists of several objects connected to the footpaths and corridors on the second floor. Individual blocks of the sports center have their entrances and organized spaces in front of the entrances. The entry of the gym and gym block is north-oriented and designed for athletes who come to training or compete. There are two entrances to the restaurant. One of them is for the restaurant visitors and is the main one. It's northwest-oriented and has an access area. The second entrance is north-west oriented and designed for unloading. There is a separate entrance to the medical unit from the north-west. The entrance to the spa center is southwest. There is an open pool entrance area in front of the spa center. There is also an additional entrance to the sports center on the inside of the yard. The area chosen for design has extensive greening, most of which are preserved and form an extensive recreational zone, which also serves as a protection against noise and dust. The visualization of the object is shown in Fig. 2.

Figure 2 - Visualization of an object

Conclusion

The design of such facilities is a key factor in solving the current problem:

1. Creation of a sport core of a city-wide significance;
2. Organization of the territory with division into different functional zones, not only sports and entertainment, but also allocation of medical and rehabilitation zone;
3. Defining the urban planning concept of interrelation of urban development with the recreational territory;
4. Development of volume-planning and constructive solution of the building of the sports and entertainment center.

References
1. 13. SP HKH.1325.800.2016. Sportivnye sooruzheniya. Pravila proektirovaniya [Sports facilities. Design rules]. Moscow, Minstroj Rossii, 2016. 42 p. (Rus)
2. Konstituciya Rossijskoj Federacii (prinyata vsenarodnym golosovaniem 12.12.1993) (s uchetom popravok, vnesennyh Zakonami RF o popravkah k Konstitucii RF ot 30 dekabrya 2008 g. № 6-FKZ, ot 30 dekabrya 2008 g. № 7-FKZ, ot 5 fevralya 2014 g. № 2-FKZ, ot 21 iyulya 2014 g. № 11-FKZ) [The Constitution of the Russian Federation]// Sobranie zakonodatel'stva RF. 2014. № 31. St. 4398. (Rus)

Архитектурно-ландшафтный комплекс со спортивно-развлекательным центром в городе Тамбове

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Аннотация. Актуальность архитектурно-ландшафтного комплекса со спортивно-развлекательным центром заключается том, что городу необходимо центральное спортивное ядро с проработанным планом размещения объектов архитектурно-ландшафтного спортивного комплекса. Целью данного проекта является решение задач, связанных с застройкой территории по берегу рек Цны и Студенец в городе Тамбове, создание архитектурно-ландшафтного комплекса, а также разработка спортивно- развлекательного центра.
Ключевые слова: спортивный центр, ландшафт, досуг, бассейн, спа-зона, прибрежная территория.

УДК 62-783

Study of the cultural heritage object "Red Barracks" located in Tambov

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Abstract
The article is devoted to the study of cultural heritage object "Red Barracks", located at Studenetskaya St., Tambov, as well as the study of buildings and structures of "Red Barracks" in other cities of Russia. The reasons for the preservation of monuments and objects of cultural heritage are considered. This problem is relevant for every city.
Keywords: cultural heritage object, monument, "Red Barracks", Tambov.

Introduction

"Red Barracks", former barracks of voivode Bobarykin, are located at 9Zh Studenetskaya St., Tambov. The object of cultural heritage was created in 1902. This object belongs to the monuments of regional significance [4].

The cultural heritage object is a part of the historical development of Tambov and clearly demonstrates the life, culture and history of the town in 1902 [2].

"Red Barracks" buildings

Barracks of Boborykin, later "Red Barracks", now is a hotel-type apartment house. This is a three-story brick building with a complex pitched roof.

The front facade is emphasized by the central four-storey risalite [1].

According to the planning structure, the building has a cellular planning system. The structural scheme of the building is made with a longitudinal and transverse arrangement of internal and external walls; the structural system is a wall system.

The building has central heating systems in satisfactory condition, water supply and drainage, electricity and lighting systems are connected to the city networks.

From the outside of the building the basement part of the foundations is plastered with cement-sand mortar. The foundation itself is a strip foundation made of brick. In general, visual inspection of the basement showed that damage and cracks are observed. In the basement part there is observed moistening of the masonry, plaster layer and mold growth along the perimeter of the lower part of the facades. In general, the technical condition of the structures of the basement part of the building is quite satisfactory. The original appearance of the basement part has been preserved.

External walls are made of 2.5 bricks and internal walls are made of clay ordinary bricks, plastered with lime plaster or wallpapered. There is widespread damage to the masonry on the facade surfaces of the walls. The technical condition is satisfactory. The original appearance has been preserved [3].

The roofing is made of iron with a cold attic. The technical condition of the roof is satisfactory. The original condition is preserved.

Figure 1 - The building of "Red Barracks" of the early 20th century

The buildings of the "Red Barracks" in other cities have been considered. Having analyzed the military buildings of 1900, we can conclude that the "Red Barracks" are made according to the standard solution, volumetric and spatial, as well as architectural and artistic solution. An example of such buildings is the ensemble of "Red Barracks" in the cities of Tomsk, Irkutsk, and Nizhny Novgorod.

Figure 2 - "Red Barracks" in the city of Irkutsk

Figure 3 - "Red Barracks" in the city of Tomsk

Figure 4 - "Red Barracks" in the city of Nizhny Novgorod

Conclusion

Thus, nowadays it is extremely important to preserve and maintain the good condition of these objects as they demonstrate the history of the city, its architecture at the time of their construction. They give an opportunity for architects to learn from the already built buildings, and also, when adapting the monument to modern use, these objects enable the appearance of entourage of both office and residential spaces. It is the monuments of architecture and objects of cultural heritage that can become the most unforgettable place for tourists and residents of the city.

References

1. Yu. K. Shchukin, A. A. Gorelov, G. A. Molchanova. Tambov staryj, Tambov novyj: Fotoal'bom / [Tambov old, Tambov new: A photo album.]. Tambov: Yulis, 2002. – 207 p. (Rus)
2. Gorelov, A. A. Tambov: Spravochnik- putevoditel' [Tambov: Guide-guide]. Tambov, Proletarskij svetoch, 2003, pp. 35-45. (Rus)
3. Klimkova, M. A. Tambovskaya guberniya na dorevolyucionnyh otkrytkah. [Tambov Province on pre-revolutionary postcards]. T. 2017. 379 p. (Rus)
4. Akostra. Tambov - leto 2018. Starye zdaniya. Chast' 1-ya. [Tambov - summer 2018. Old buildings. Part 1]. Available from: https://akostra.livejournal.com/1400643.html (Accessed 27.11.2024). (Rus)

Исследование объекта культурного наследния «Красные казармы», расположенного в Тамбове

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Аннотация. Статья посвящена исследованию объекта культурного наследия «Красные казармы», расположенного по адресу г. Тамбов, ул. Студенецкая, 9Ж, а также изучению зданий и сооружений «Красных казарм» в других городах России. Рассмотрены причины сохранения памятников и объектов культурного наследия. Эта проблема очень актуальна для каждого города.

Ключевые слова: «Красные казармы», Тамбов, объект культурного наследия, памятник.

УДК 62-783

Children's technology park “Quantorium” in the town of Rasskazovo

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Abstract
Within the framework of the strategic concept “Modern Model of Additional School Education” approved in Russia, the idea of developing a network of technoparks comes to life. The purpose of these spaces is to provide opportunities for teenagers from 10 to 18 years old to master innovative technical skills. This initiative is being implemented thanks to funding from the federal budget and alternative extra-budgetary sources, which is directly related to the instruction of the President of the Russian Federation of May 27, 2015. It is proposed to create the first such technopark in the town of Rasskazovo, Tambov region, with full improvement of the territory to maximize the effectiveness of training programs and infrastructure. In the selected town there are no buildings with similar functionality, so the project solves the problem of increasing the level of development of children and teenagers, and since the Tambov region is famous for its black soil and agro-industrial achievements, the project takes into account the direction with this bias.

Key words: children's technopark, innovative technologies, development of agro-industry, new model of additional education system for children.

Introduction

“Quantorium”, an extracurricular educational space on the Russian innovation background, is a cutting-edge place equipped with cutting-edge technologies. Its mission: to lay the foundation for a new era of engineering talent in Russia through the study and implementation of breakthrough technologies, the development of promising projects, and the discovery of the scientific and technical potential of young people.

The main concept of “Quantorium” is to immerse children in the world of advanced knowledge, where theory and practice merge. Classes are held in quantums, so-called laboratories, as well as a quantum is a direction where children are engaged in their own type of activity. For example, in the IT-quantum there is the study of programming and data protection on the Internet, in the biokvantum they study microbiology and biotechnology. Any child can get into “Quantorium”, regardless of the degree of his/her giftedness. Any child, regardless of his or her talent level, can get into “Quantorium”.

Results and discussion

In the framework of the study typological analysis of existing similar institutions, analysis of optimal layouts and facade solutions for such facilities were carried out. On the basis of these analyses the architectural and planning solution of the building was developed. The main facade of the “Quantorium” is shown in Fig. 1.

Figure1 - Main facade of the Quantorium children's technopark

In the course of the work, it was revealed that there is only one operating “Quantorium” in the Tambov region, located in the center of Tambov. Basically, children's technoparks integrate into the existing development: offices, administrative buildings and others.

A distinctive feature from other children's technoparks is the presence of freestanding greenhouses, while linking them to the building and creating a single composition.

The children's technopark is divided into blocks: general block, quantums, youth center, office block and greenhouses (Fig. 2.).

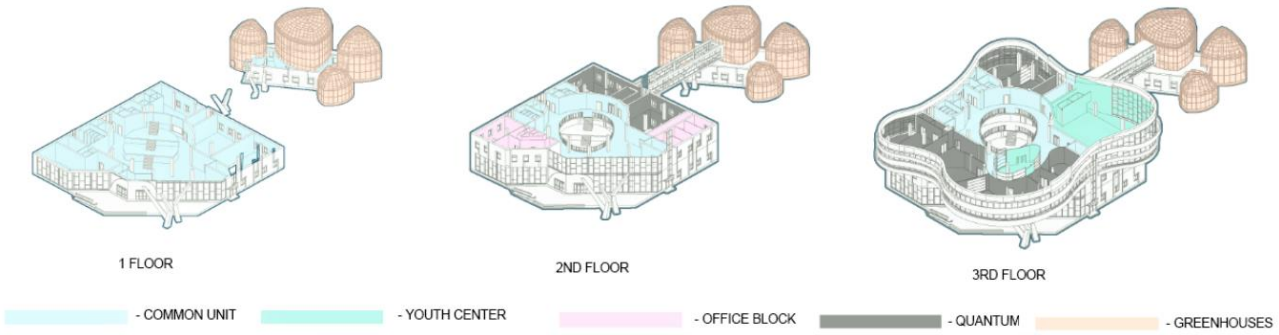

Figure 2 - Functional zoning of the children's technopark

The final in the design is the master plan with its landscaping. Playgrounds and training area repeat the shape of the main floor of the “Quantorium”. The connection between the functional zones is sidewalks, between the breakdown of these paths there is an ornamental and fruit garden. The general plan also includes a learning zone where children and teenagers plant flowers and seasonal vegetables.

Conclusion

The design of such facilities represents a key factor for solving the current problem:

1. Enriching general education in order to form modern competencies and professional skills;
2. Expansion of infrastructural potential in the town of Rasskazovo;
3. Activation of scientific and technological potential of the youth of Russia;
4. Introduction of a unique Russian approach to children's supplementary education

centered on engineering sciences;

5. Training of new personnel in the agrarian and industrial sphere;

6. Development of the system of identification and subsequent support of talented children in the field of engineering activities.

The analysis emphasized the importance of this direction as a measure contributing to changes in the educational sphere and scientific and technological development of Russia.

References

1. I.A. Suhorukova, T.I. Shashkova, E.V. Solovec. Arhitekturnoe proektirovanie obshcheobrazovatel'noj shkoly: metodicheskie ukazaniya. [Architectural design of general education school: methodical instructions], - Voronezh, 2021.- 36 p. (Rus)

2. Metodicheskie rekomendacii po sozdaniyu i funkcionirovaniyu detskih tekhnoparkov «Kvantorium» na baze obshcheobrazovatel'nyh organizacij [Methodological recommendations on the creation and functioning of children's technology parks “Quantorium” on the basis of general education organizations], 2020. (Rus)

Детский технопарк «Кванториум» в городе Рассказово

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Аннотация. В рамках утвержденной в России стратегической концепции «Современная модель дополнительного школьного образования» формируется идея развития сети технопарков. Цель этих пространств – обеспечение возможностей для подростков от 10 до 18 лет осваивать инновационные технические навыки. Реализация данной инициативы осуществляется благодаря финансированию из федерального бюджета и альтернативных внебюджетных источников, что напрямую связано с поручением Президента Российской Федерации от 27 мая 2015 года. Предлагается создание первого такого технопарка в городе Рассказово Тамбовской области с полным благоустройством территории для максимальной эффективности обучающих программ и инфраструктуры. В выбранном городе нет зданий с похожим функционалом, поэтому проект решает задачу по повышению уровня развития детей и подростков, а так как Тамбовская область славится своим черноземом и агропромышленными достижениями, в проекте учтено направление с этим уклоном.

Ключевые слова: детский технопарк, инновационные технологии, развитие агропромышленности, новая модель системы дополнительного образования детей.

УДК 71

Reorganization functional zoning of the territory according to accessibility conditions on the example of a microdistrict in Tambov

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Abstract
In this article an urban planning study of a microdistrict in the town of Tambov is carried out, using the method of accounting for the intensity of use of functional zones by residents based on modern studies of accessibility, mobility and connectivity according to the criterion of time spent between key objects of the district.
Keywords: area, functional zoning, porosity, permeability, microdistrict, territory, urbanity.

Currently, modern concepts of the device of a comfortable city and accumulated experience show that the urban "compact city" is a promising vector of development, it is associated with minimizing the time spent on moving between key objects of the city, district, quarter. Without the connectivity of a quarter, a microdistrict, a district, it is impossible to achieve effective interaction between the city and residents, minimizing the time spent on the road becomes crucial given the increasing pace of life.

The urban environment must be rebuilt in accordance with modern needs, this is reflected in the writings of R. Lewis. In his opinion, the street layout should be easy to navigate, with the correct grid and small blocks, be clear and understandable for residents. Also, the streets of the city in such a system should be continuous and closely interconnected in order to provide all residents of the area with more than one path to their destination [1]. To do this, the quality of the functional zoning of the urban environment is assessed, the concepts of connectivity, porosity and permeability are applied. The connectivity of the territory can be considered as a characteristic of "porosity", where "porosity of the urban structure" is a characteristic that determines the number and size of passages, free spaces in the grid of the urban structure. Only open "pores" are taken into account, closed spaces are not... they do not affect permeability" [1].

Permeability is a part of a system with several variables, between which there is a certain relationship that forms the joint work of these variables. In the writings of M. Mahaffy, this is called "organized complexity". We are talking about the theory that a city becomes more efficient when its parts are well interconnected, while the scenario of using the city center is of a mixed nature and is actively used by a large percentage of residents and tourists of the city. [2].

Within the framework of this study, the territory was selected, which is located in Tambov, within the boundaries of streets: from the north – B-r Enthusiasts Street, from the south – a roundabout, from the east – Sovetskaya Street, from the west – K. Marx Street.

The presented area has a multi-time development, residential and industrial, with the practical absence of public and recreational areas. This situation has developed due to the

fact that intensive construction has been carried out here since the 50s and 60s of the last centuries. In the 20th century, industrial enterprises were located on the territory under consideration: the ZHBT plant, the asphalt plant, the HIMPOLIMER Research Institute, VNIIRTMASH, TAMBOVPOLIMMASH, as well as the railway tracks of enterprises. Garages adjoined the territory of the factories and construction of low-rise individual residential buildings began (from K. Marx Street), multi-storey construction of standard panel houses was carried out in the 70s along B-r Enthusiasts Street. Since 2000, industrial enterprises have lost their functionality, and subsequently the adjacent territories of former industrial enterprises were transferred to residential complexes built within the boundaries of factory territories, without ensuring integration with newly formed residential neighborhoods. As a result, between the central streets Sovetskaya – B-r Enthusiasts – K. Marx formed a microdistrict of sufficient depth with chaotic, isolated residential, public and industrial zones. Using this method, the problem of connectivity of these zones and redefinition of functional zoning was solved. With an interval of 600 m, in this work it is assumed that the pedestrian speed is 600 m/min.

The functional zoning of the urban structure of a residential area specifically in this study is based on taking into account the intensity of use of each functional area by residents of the area, depending on accessibility conditions. The essence of using the method is to zone the territory and redefine it based on the criterion of time spent moving around the territory. The starting points for the movement of human flows are public transport stops that connect the area with the entire territory of the city as a whole. Points of attraction are considered points of attraction of flows — residential buildings, schools, kindergartens, shopping malls, the center of a residential area, etc. for the distribution and redefinition of urban flows and functional areas in accordance with historical buildings.

A grid of streets is applied to the plan of the area under study. In each cell, the corresponding number is indicated – the time of movement from the stop. It turns out a temporary grid, from which it follows for what period of time a resident of a given area can penetrate deep into the territory. The selected territory has the following functional zones: residential buildings of various storeys, placement of business, public and commercially significant facilities, placement of communal warehouses, recreation, special public buildings, industrial zone of hazard class 5, special purpose. According to our urban planning study, it is possible to go deeper into the area in 10 minutes, which is the optimal allowable time. At the same time, most residential and public buildings are surrounded by a solid fence or dead ends, which makes it difficult to move around the territory.

Summing up the results of the urban planning study, as a result of which conclusions were drawn about the studied territory and problem areas of the selected area and its functional zones were determined, namely, a zone of communal warehouses was formed in the center, which borders on dilapidated two-storey housing, exits from the center are blocked by buildings and fences that reduce the connectivity of the territory and railway tracks are practically not used. This is due to the low connectivity of the territory, porosity, lack of communication and mobility of the street network, which demonstrates an outdated model of interaction, but it follows that the functional zoning of the territory should be

revised.

In order to ensure the comfort of the urban environment, it is necessary to establish connections between key facilities for residents, with a minimum of dead ends and obstacles. To organize a transport and pedestrian network with the maximum possible number of direct crossings to key sites and main streets of the neighborhood, which will help create a comfortable relationship between the neighborhood and the district as a whole [4].

It is necessary to reorganize the functional areas in this area to meet modern needs in the form of garages and a production area in the center of the block, which should be moved outside the block and create an additional recreation area in the form of a garden or park with a public part, since at the same time, residents of the neighborhood currently need it. The reorganization should be carried out gradually, in several stages, starting with garages, relocation of people from dilapidated housing, and so on. At the same time, landscaping should be carried out in accordance with the vector of development of the territory, in our case it is the breakdown of the garden or the organization of park space.

References

1. Artibise Y. Urban Fabric: The Form of Cities. Available from: https://medium.com/@yuriartibise / urban-fabricthe-form-of-cities-72048a34cb8c (Accessed 30.09.2024).
2. Mekhaffi M. Novaya programma razvitiya gorodov, versiya OON. [New Urban Agenda, UN version]. Moslenta. Available from: https://moslenta.ru/urbanistika/mat-poryadka.htm. (Accessed 15.11.2024). (Rus)
3. Krasheninnikov I. A. Perspektivy analiza «poristosti» gorodskoj tkani [Perspectives on analyzing the "porosity" of urban fabric] // Architecture and Modern Information Technologies, 2017, № 3 (40), p. 215–226. — Available from: http://marhi.ru / AMIT / 2017 / 3 kvart17 / 16_krasheninninkov / index.php (Accessed 15.10.2024). (Rus)
4. Baluhina N. V., Gibadulina A. R. Analiz gorodskogo bloka v proektah kompleksnoj zhiloj zastrojki [Analysis of the urban block in integrated residential development projects]. Akademicheskij vestnik UralNIIproekt RAASN, 2022, № 3 (54), pp 30-40. (Rus)

Реорганизация функционального зонирования территории в соответствии с условиями доступности на примере микрорайона в г.Тамбове

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Аннотация. В данной статье проводится градостроительное исследование микрорайона в городе Тамбове, по методу учета интенсивности использования функциональных зон жителями на основе современных исследований доступности, мобильности и связности по критерию временных затрат между ключевыми объектами района.

Ключевые слова: микрорайон, пористость, проницаемость, район, территория, урбанизация, функциональное зонирование.

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Renovation of the former oxygen station of the Komsomolets plant

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Abstract
In modern conditions of urban development, one of the key tasks is the efficient use of abandoned and unused industrial facilities. This not only promotes economic growth, but also improves the quality of life of citizens by creating new public spaces. The main purpose of this work is to develop a renovation project for the oxygen station, which provides for its transformation into a modern recreational and leisure center. In the course of the work, a historical and cultural analysis of the territory was carried out, a study of the architectural features of the building was carried out, architectural and planning solutions were developed, and an assessment of the economic efficiency of the facility was carried out. As a result of this work, it is planned to create a project that will become not only an example of successful renovation of an industrial facility, but also an important element of urban infrastructure. The project demonstrates how abandoned buildings can receive a second life, turning into significant objects for society and the city.
Keywords: industrial facilities, modern use, renovation, restoration.

The oxygen station of the Komsomolets plant was built in 1943. Before the war, the plant used imported oxygen. During the war, the supply stopped, and its own oxygen station was designed on the bank of the Tsna River [4]. In the nineties, "oxygen" still continued to work, but with the change in economic conditions and the transition to new technological tracks, it lost its significance and was abandoned. Despite the lack of any function, many residents of the city of Tambov can not imagine the embankment without "oxygen". Most people associate the building with street graffiti, which is filled with one of the facades of the oxygen station. Reconstruction and adaptation of such industrial facilities for new functions is an important task of architecture and urban planning.

The main goal of this work is to develop a project for the renovation of the oxygen station, which provides for its transformation into a modern recreational and leisure center. This involves a comprehensive study of the architectural, functional and social aspects of the transformation, as well as an analysis of successful examples of similar projects in other cities [3].

The relevance of this work is determined by the need to find new solutions for the adaptation of abandoned industrial facilities in the context of urban growth and an increase in their population. The implementation of such projects contributes to the preservation of architectural heritage, improving the environmental situation and creating new opportunities for leisure and recreation of citizens [2].

Stages of work:

1. Analysis of the historical and cultural context of the Komsomolets plant and its impact on the urban landscape.

2. Object research

Stage includes a study of the building's condition, architectural analysis, and

evaluation of the possibility of restoration. It was important to preserve the original elements, such as brickwork, massive metal structures and elements of engineering infrastructure that form the unique character of the object.

3. Justification of the choice of recreational and leisure activities as a new function of the object.

The project creates a new cultural point of attraction that will be of interest to both young people and the older generation. It also draws attention to the city's industrial history and shows how abandoned buildings can be transformed into modern and useful objects.

4. Development of architectural and planning solutions that ensure comfortable and safe use of the object [1].

- Development of the renovation concept:
- Determining the functional purpose of the building (for example, a cultural center, office space).
- Preservation of historical identity while adapting to modern needs.
- Visualization of the project (sketches, layouts).
-Preliminary approval of the concept with stakeholders (authorities, investors, local community).

5. Assessment of the economic efficiency of the project and its impact on the social environment of the city.

The project supports the development of the local economy by providing jobs during the restoration and further use of the facility.

Evaluation of renovation efficiency:

- Matching the actual use of the concept.
- User satisfaction.
- Maintenance of the building's technical condition.

As part of this work, an analysis of the territory of the former oxygen station of the Komsomolets plant was carried out and a proposal was submitted for the renovation of the building for a recreational and leisure center. As a result of the work, it is planned to create a project that will become not only an example of successful renovation of an industrial facility, but also an important element of urban infrastructure contributing to the development of culture and improving the quality of life in the city.

As a result of the analysis of the existing condition of the building and its design features, optimal planning solutions were developed that ensure comfortable use of premises for various recreational and leisure functions. The project provides areas for active recreation, cultural events, cafes, as well as spaces for holding master classes and meetings.

The developed spatial planning solutions fully meet modern safety and comfort requirements, as well as take into account the historical value of the building. The project uses modern construction and finishing materials that ensure high performance and aesthetic appeal of the building.

The project takes into account all necessary measures to ensure accessibility of the center for people with limited mobility, which includes the installation of ramps, elevators

and special sanitary facilities.

In conclusion, it should be noted that the renovation of the former oxygen station of the Komsomolets plant as a recreation and leisure center is a successful example of adaptive use of industrial facilities. The project demonstrates how abandoned buildings can get a second life, turning into significant objects for society and the city. The implementation of this project will be an important contribution to the development of the urban environment and culture, as well as serve as an example for subsequent renovation initiatives.

References:

1. Tishkov V. A., Ageeva E. Yu. Metodologicheskie osnovy arkhitekturno-stroitelnoy renovatsii: priyomy i sredstva [Methodological foundations of architectural and civil engineering renovation: techniques and means] // Privolzhskiy nauchny zhurnal [Privolzhsky Scientific Journal]. Nizhegorod. gos. arkhitektur.-stroit. un-t. Nizhny Novgorod, 2022, № 1. pp. 156–162. (Rus)
2. Bushtets D. V., Zabruskova M. Yu. Renovatsiya byvshikh promyshlennykh territoriy I obektov seredinnoy zony v obschestvennye prostranstva [Renovation of former industrial areas and facilities in the middle zone into public spaces] // Izvestiya Kazan. gos. arkhitektur.-stroit. un-ta [Proceedings of the Kazan State University of Architecture and Civil Engineering], 2018, № 2, pp. 47–54. (Rus)
3. Krogius V. R. Dostoprimechatelnoe mesto – instrument sokhraneniya [Point of Interest – Conservation Tool] // Vestnik «Zodchiy. 21 vek» [Herald “Architect. 21st century"]. Saint-Petersburg, 2009, № 2/31 (fevral). p. 91. (Rus)
4. Klimkova M. Kislorodnaya stanciya zavoda «Komsomolec» [Oxygen station of the Komsomolets plant]. Available from: https://marina-klimkova.livejournal.com/1138611.html. (Accessed 30.03.2021). (Rus)

Реновация бывшей кислородной станции завода «Комсомолец»

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Аннотация. В современных условиях развития городской среды одной из ключевых задач является эффективное использование заброшенных и неиспользуемых промышленных объектов. Это не только способствует экономическому росту, но и улучшает качество жизни горожан, создавая новые общественные пространства. Основная цель данной работы заключается в разработке проекта реновации кислородной станции, который предусматривает превращение её в современный рекреационно-досуговый центр. В процессе работы проведен историко-культурный анализ территории, выполнено исследование архитектурных особенностей здания; разработаны архитектурно-планировочные решения, выполнена оценка экономической эффективности объекта. В результате выполнения данной работы предполагается создать проект, который станет не только примером успешной реновации промышленного объекта, но и важным элементом городской инфраструктуры. Проект демонстрирует, как заброшенные здания могут получить вторую жизнь, превратившись в значимые для общества и города объекты.

Ключевые слова: промышленные объекты, реновация, реставрация, современное использование.

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Renovation of children’s country health camps

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Abstract
The article deals with the problem of preservation and use of the territories of destroyed children's camps, their renovation and adaptation. The work was carried out in the framework of obtaining information and familiarization with the presented topic for further development of the thesis master's work on a related topic. The results of this research allow us to obtain reliable data that can be used for the successful implementation of future projects. Additionally, this work aims to enhance students' professional skills and abilities in research activities.
Keywords: children's health camps, renovation, reconstruction, restoration.

Introduction

In the 1980s, Russia had approximately 40,000 children's health camps. After the dissolution of the Soviet Union and the subsequent economic crisis, many of these camps faced difficult times. The enterprises that had previously supported the camps financially either went bankrupt or could no longer afford to continue funding them. As a result, the remaining camps struggled to maintain their facilities and infrastructure. By 2015, the number of camps had decreased to approximately 3,000. Some were sold to private developers, while others were abandoned.

Today, children's health camps continue to be one of the most popular options for organizing summer holidays. It is clear that there is a need to revive and restore these valuable facilities for the benefit and development of children. The issue of organizing children's leisure has been and remains relevant today. It is manifested in the annual decrease in the number of camps in the Russian Federation and the decrease in the quality of services provided by them. This is confirmed by media reports, reports from Rospotrebnadzor, and statements from politicians.

Every year, there is a decrease in the number of camps, which leads to a situation where the children's health system is unable to fulfill its functions. This issue has been brought to the attention of the federal government. During a meeting of the Presidium of the Council of Legislators, the Minister of Construction mentioned the readiness of his department to implement a federal program for the restoration and construction of summer recreation facilities for children, using standard projects and prefabricated structures as part of the federal targeted program [3].

Renovation plays an important role in transforming abandoned facilities into modern, up-to-date spaces that meet current standards and requirements. This approach helps preserve the original purpose of these buildings and can be seen as a more sustainable alternative to demolition and rebuilding.

Firstly, renovations save time and resources compared to starting from scratch. They also allow us to adapt existing structures to meet modern needs. Regarding the

organization of children's leisure activities, the modern approach offers various types of camps with different pastimes. Currently, camps can be categorized into two main types depending on the duration of stay:

1. Day camps
2. Round-the-clock camps (country-type)

This type of camp typically runs for 21 days and during that time, children do not leave the camp. There are between 10 and 20 groups with 15 to 20 people each, each group having counselors and a teacher. The camp has a daily schedule, and each day can focus on a specific activity or be more varied [1].

The research has shown that there is an increasing demand for children's health camps throughout the year. This has led us to consider creating institutions that can accommodate children year-round. There are two ways to categorize children's camps. The first is based on the camp's location and activities. There are four main types of camps:

- Camps located in natural areas that focus on active recreation.
- Camps in urban areas that offer indoor classes.
- Sports or arts and craft camps.
- Mixed camps that offer a variety of activities.

Inpatient camps are specially designed to protect the health of children, mainly located outside of cities;

- These are created based on general education institutions such as schools, children's centers, youth clubs, and sports stadiums;
- They can be organized on an existing base, such as in the premises of other institutions and organizations that were originally created for different purposes, like campsites, hospitals, hotels, or military bases;
- There are also field and tent camps, expedition camps, and mobile camps that can be moved around on wheels.

This classification allows for updating the regulatory framework for children's recreation and health improvement in general.

Another approach to classifying children's healthcare facilities based on their primary activities:

- Sport and recreation;
- Travel and tourism services;
- Work and leisure;
- Preventive measures (health resorts).
- Summer (winter) schools for children's creativity;
- Leadership development camps for students;
- Military-sports or civil-patriotic activities;
- Family holidays.

A modern children's health camp can be seen as a type of educational institution for children that combines various forms of additional education that have emerged in the field of summer recreational activities for children. These include wellness centers for children, camp sites for children, summer camps for children, ecological playgrounds, holiday homes, sanatorium-style children's camps, eco villages, summer health schools,

tourism schools, leadership schools, and more. Market research shows that there is an increasing demand for centers with diverse offerings, including thematic shifts based on children's interests. This creates a new approach to designing modern children's camps and presents new challenges for architects.

The idea of renovating children's health camps has received support not only from government officials but also from the business community. The clear relevance and year-round demand for these facilities, coupled with the lack of funding from municipalities for reconstruction, has created favorable opportunities for entrepreneurs.

There are many objects on the territory of the old camps that can be used to study history: sculptures of pioneer heroes, buglers, airplanes, and others. The interiors of clubs and canteens were often decorated with artistic paintings and examples of mosaic art. For modern children, such objects can be very interesting, as they are overgrown with legends and folklore. There are already examples of successfully transforming abandoned pioneer camps into modern wellness centers. Demand for such facilities is continuously growing, opening up opportunities to revitalize and update this essential part of children's infrastructure.

For your information: 450 children's health camps in our country require major repairs. Since 2019, 52 children's organizations have been closed across Russia, some of which have been converted into institutions of a different orientation. At the same time, more than 400 camps are not operating, as their infrastructure does not meet modern requirements. Over the past five years, no more than 10-12 new children's camps have opened in Russia, which is very small. This means that it is advisable to restore abandoned pioneer camps.

References

1. Gavrilov D.I. Proektirovanie i stroitel'stvo pionerskikh lagerej [Design and construction of pioneer camps]. Moscow, 1953, 47 p. (Rus)

2. Azhgikhin S.G., Truboba V.V., Denisenko A.A. Struktura detskikh ozdorovitel'nykh lagerej [The structure of children's summer camps] Moscow, 2009. (Rus)

3. Torshin V.N., Povolyaeva M.N., Koval' S.A. Teoriya i praktika organizacii podgotovki kadrov uchrezhdenij otdyha i ozdorovleniya detej [Theory and practice of the organization of training institutions of recreation and health of children]. Moscow, Novoe obrazovanie, 2011, 120 p. (Rus)

Реновация детских загородных оздоровительных лагерей

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Аннотация. В статье рассматривается проблема сохранения и использования территорий разрушенных детских лагерей, их реновации и приспособления. Работа осуществлялась в рамках получения информации и ознакомления с представленной темой для дальнейшей разработки диссертационной магистерской работы по смежной теме. Работа позволяет получить достоверные данные для благоприятной разработки будущего проекта. Также, работа нацелена на получение профессиональных умений и навыков в научно-исследовательской деятельности.

Ключевые слова: реновация, реконструкция и реставрация, детские оздоровительные лагеря, классификация детских учреждений отдыха.

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Reconstruction of the first floors of residential buildings of mass construction in the 1950s-80s

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Abstract
The necessity of reconstruction of the first floors of residential buildings of typical mass construction in the 50-80s of the XX century is substantiated. The possible use of premises located on the ground floors to accommodate cultural, leisure and social enterprises, as well as apartments for low-mobility groups of the population with access directly to the courtyard area is considered.
Keywords: modernization of residential buildings, spatial planning solutions; vertical zoning; intra-block network of enterprises.

Currently, the existing housing stock accounts for a significant part of the total volume of buildings and structures in the Russian Federation. The most active formation of the housing stock took place from the late 50s to the mid-80s of the 20th century. The basis of typical medium-rise buildings at that time were five-storey mass-produced houses in brick, large-block and large-panel design. During the period under review, more than 290 million square meters of total area were commissioned, which currently accounts for about 10% of the country's housing stock. This made it possible to significantly reduce the severity of the housing shortage in the post-war decades.

Currently, taking into account the increased demands of the urban population for the level of comfort, social and consumer services, and the state of landscaping of the adjacent territory, it has been established that the buildings of the period under review and the development as a whole do not meet the requirements currently imposed on residential buildings of modern mass development. In addition, according to residents and engineering staff of management companies, standard buildings of the first mass series do not meet the requirements of energy efficiency, engineering equipment and their operation is associated with certain problems. Over the long-term period of operation of apartment buildings, the following disadvantages have been identified: low level of thermal protection of external fences, insufficient sound insulation of enclosing structures, spatial planning solutions involving walk-through living rooms, combined sanitary units, insufficient area of auxiliary premises (bathrooms, kitchens, hallways, storage areas) according to modern requirements.

Residential premises located on the first and last floors of residential buildings of the "Khrushchev" period are considered to be the least in demand in the secondary housing market.

Apartments on the top floors have a high level of heat loss in winter, and are also prone to overheating in summer. This is primarily due to imperfect coating designs (combined ventilated and non-ventilated) and to the wear of the insulation in the roof, which has practically ceased to perform its function due to constant freezing and thawing as a result of roof leaks.

Apartments located on the first floors of residential buildings of the period under review do not have summer rooms in the form of balconies and loggias, they have an insufficient level of insolation due to shading by green spaces formed over the past decades. In buildings without a basement, the floors of the first floors are arranged on the ground with the placement of utilities in underground channels. The level of thermal protection of the floors on the ground does not meet modern requirements, which leads to excessive hypothermia of the apartments on the first floors. Engineering systems, namely sewerage, work with great interruptions associated with constant blockages.

All the listed disadvantages of ground-floor apartments lead to their gradual withdrawal from the housing stock. Local purchase of apartments in buildings of the first mass series, the facades of which are oriented to main city streets, and changing their purpose to non-residential leads to a deterioration in the architectural appearance of the entire building due to the chaotic design of entrance groups, changes in the size, shape and cutting of window openings other than the main building. Within the same building, there are sometimes several different enterprises that differ significantly in the design of the facade.

Despite the unpopularity of the apartments located on the ground floors, they are convenient for categories of people belonging to low-mobility groups, since they provide easy and almost unhindered access to the courtyard area.

Along with the change in housing requirements over the past decades, the social appearance of the population has also changed. There has been a significant aging of the population living in the blocks of mass development of the period under review, the consumer orientation of the population has changed, requiring a consolidation of the network of social and consumer services enterprises (shops "within walking distance", pharmacies, hairdressers, medical centers, etc.). There is also a need for creative activity of people of different ages.

The complex reconstruction of the first floors of the Khrushchev buildings can contribute to the creation of a developed system of social and consumer services for residents, the so-called "walking distance" enterprise system. In recent years, enterprises providing daily consumer services (for example, shops, hairdressers, pharmacies) have become the most in demand among residents, as well as cultural and leisure facilities (children's development centers, day care kindergartens, coworking, clubs for the elderly) [2].

The creation of a developed system of institutions will minimize the time spent by the working population to receive a specific service and reduce the ways of movement of people with limited mobility.

The integration of institutions of social and cultural services of the population into existing residential buildings does not require a separate land plot. At the same time, it is necessary to place groups of rooms with different functions (residential and public) according to the principle of vertical zoning. The residents of the house have access to the apartments through the entrances to the entrances from the courtyard area. The entrance to the institutions should be autonomous, carried out from the street, from the main or end facades, and ensure accessibility requirements for low-mobility groups of the population.

The solution to the problem of providing comfortable housing for people with limited mobility is possible by installing apartments for the disabled on the ground floors with the organization of separate exits from them directly to the courtyard territory. The layout of apartments in this case must comply with the requirements of SP 59.13330.2020 "Accessibility of buildings and structures for low-mobility groups of the population", take into account the peculiarities of movement of disabled people of different groups, provide for increased areas of auxiliary premises, and provide a separate exit with an inclined ramp.

One of the new trends in the renovation of typical residential buildings in Western Europe is the organization of winter gardens and front gardens at the ground floor level. This contributes to the creation of a special favorable microclimate, reduces the separation of man from nature, and mitigates the negative effects of urban environmental factors on humans [3].

When developing and implementing projects for the comprehensive reconstruction of the first floors of residential buildings, the rights and interests of citizens living in multi-apartment buildings should not be violated. After making a decision on the conversion of residential premises into non-residential, it is necessary to obtain approval of the project for the placement of the enterprise with the owners of residential premises.

Thus, the complex reconstruction of the first floors of residential buildings of mass construction using domestic and foreign experience can contribute to the formation of a comfortable urban environment that preserves the traditions of old buildings and ensures compliance with the requirements of modern standards. At the same time, it is necessary to take into account the design features of the buildings being rebuilt, the climatic, engineering and geological conditions of the region, as well as the current legislative framework.

References

1. Shubin I. L., Umnyakova N. P., Matveeva I. V., Andrianov K. A. Kachestvo obolochki zdaniya - osnova ekologicheski bezopasnoj sredy zhiznedeyatel'nosti [The quality of the building shell is the basis of an environmentally safe living environment]. Zhilishchnoe stroitel'stvo, 2019, No. 6, pp. 10-15. – DOI 10.31659/0044-4472-2019-6-10-15. (Rus)
2. Strashnova Yu.G. Social'no-ekologicheskaya znachimost' metodov rekonstrukcii pyatietazhnoj zhiloj zastrojki bez snosa [Socio-ecological significance of methods of reconstruction of five-storey residential buildings without demolition]. Biosfernaya sovmestimost': chelovek, region, tekhnologii, 2022, No. 1(37), pp. 26-35. – DOI 10.21869/2311-1518-2022-37-1-26-35. (Rus)
3. Panihin D. A., Matveeva I.V. Opyt rekonstrukcii zhiloj zastrojki v stranah Zapadnoj Evropy [Experience in the reconstruction of residential buildings in Western Europe] // Resursoenergoeffektivnye tekhnologii v stroitel'nom komplekse regiona, 2018, No. 9, pp. 50-54.

Переустройство первых этажей жилых зданий массовой застройки 1950-80-х гг.

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Аннотация. Обоснована необходимость переустройства первых этажей жилых зданий типовой массовой застройки 50-80-х годов XX века. Рассмотрено возможное использование помещений, расположенных на первых этажах, для размещения предприятий культурно-досуговой и социально-бытовой направленности, а также квартир для маломобильных групп населения с выходом непосредственно на дворовую территорию.
Ключевые слова: модернизация жилых зданий, объемно-планировочные решения; вертикальное зонирование; внутриквартальная сеть предприятий.

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Bewertung der Möglichkeit, das «Spartak»-Stadion in Tambow so umzubauen, dass es den Anforderungen des «Russischen Fussballverbandes» entspricht

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Zusammenfassung
Dieser Artikel befasst sich mit der Möglichkeit, das «Spartak»-Stadion in Tambow so umzubauen, dass es den Anforderungen des «Russischen Fußballverbands» entspricht. Das Spartak-Stadion im Herzen der Stadt ist für die Bürger nicht nur eine Sportstätte für Wettkämpfe, sondern auch ein Ort, an dem jeder seine Emotionen teilen und seine Lieblingsfußballmannschaft anfeuern und unterstützen kann. Das Stadtzentrum ist für die Bürger nicht nur eine Sportstätte für Wettkämpfe, sondern auch ein Ort, an dem alle gemeinsam ihre Lieblingsfußballmannschaft anfeuern und unterstützen können, nämlich ihre Mitbürger. Doch selbst bei einem möglichen Aufstieg in die erste russische Fußballliga werden die Tambower Fußballer nicht auf ihrem Heimplatz spielen können. Leider entspricht das „Spartak"-Stadion nicht den Anforderungen des Russischen Fußballverbands, was die Möglichkeit ausschließt, Heimspiele auszutragen. Die Durchführung einer Studie zum gewählten Thema kann meiner Heimatstadt helfen, ein Heimstadion auf höchstem Niveau zu bekommen, in dem es möglich sein wird, die besten Fußballmannschaften Russlands unter komfortablen Bedingungen, die den Anforderungen des «Russischen Fußballverbands» entsprechen, zu sehen, Kinder und Jugendliche an den Profisport heranzuführen.
Schlüsselwörter: Anforderungen, Arbeitsprojekt., Wiederaufbau, Russischer Fußballverband, Stadion

In diesem Artikel geht es um die Bewertung der Möglichkeit, das Stadion „Spartak" in der Stadt Tambow so umzubauen, dass es den Anforderungen des Russischen Fußballverbandes entspricht. Wenn man über den Wiederaufbau eines Gebäudes oder einer Struktur nachdenkt, ist es notwendig, seine Geschichte zu untersuchen. Das erste Projekt des „Spartak"-Stadions wurde im Jahr 1945 von dem sowjetischen Architekten Wladimir Georgiewitsch Samorodow entwickelt, und im Jahr 1946 begann auf Initiative des Vorsitzenden der Sportgesellschaft „Spartak" N. A. Zarutskij ein wahrhaft großer Bau, an dem nicht nur professionelle Bauarbeiter und Handwerker beteiligt waren, sondern auch Studenten des Staatlichen Pädagogischen Instituts Tambow, Schüler von Hochschulen und Militärschulen. Der Ort für den Bau der Sportanlage wurde im Herzen der Stadt an der Kreuzung zweier Hauptstraßen - Sovetskaya und Karl Marx - in der Aue des Studenets-Flusses gewählt, an dessen Ufer im Jahr 1637 die Mauern der Tambower Burg errichtet wurden. Das Hauptbaumaterial für den Bau des Stadions war Holz, und der wichtigste architektonische Stil – der Klassizismus. Während des Baus des Stadions wurden die Süd- und Nordtribüne rechts und links des Haupteingangs, von der Seite der Karl-Marx-Straße, errichtet. Der Bau dauerte etwa 4 Jahre und bereits im Jahr 1950 fanden die ersten Sportwettkämpfe für Skater statt.

Im Jahr 1973 wurde das Stadion zum ersten Mal umgebaut, und Plastiksitze anstatt der Holzsitze wurden erst im Jahr 2004 eingeführt.

Im Jahr 2017 stieg die Tambower Fußballmannschaft in die Fußball-Nationalliga auf,

und der neue Status der Mannschaft erforderte einen Umbau des Stadions für die weitere Austragung der Heimspiele der Mannschaft. Tambow sah sich dann zum ersten Mal mit den Anforderungen des Russischen Fußballverbands konfrontiert. Die grundlegenden Anforderungen an Stadien für die Austragung von Spielen dieses Niveaus sind in der RFU-Norm (RFU) „Fußballstadien“(1) festgelegt. Um die Anforderungen des RFU zu erfüllen, wurde ein Plan für den Wiederaufbau des Spartak-Stadions in vier Phasen entwickelt: Austausch der Beleuchtungsanlage, die eine Mindestausleuchtung des Fußballfeldes von 1200 Lux im Arbeitsmodus gewährleisten kann; Installation von Entwässerung, Heizung, automatischer Bewässerung, hochwertigem Rasenbelag des Fußballfeldes; Renovierung der Infrastruktur, der öffentlichen Bereiche, Installation von Sicherheitssystemen und Zugangskontrollen; Erhöhung der Anzahl der Zuschauerplätze auf 7000 Plätze. Gegenwärtig sind nur die ersten beiden von insgesamt vier Phasen des Wiederaufbaus abgeschlossen.

Bewerten wir die Durchführbarkeit der beiden anderen Anforderungen:

1. Sicherheits- und Zugangskontrollsysteme

Die Installation von Sicherheits- und Zugangskontrollsystemen in einem Fußballstadion ist ein wichtiger Aspekt, um die Sicherheit von Zuschauern, Spielern und Personal zu garantieren, Unfälle zu vermeiden und die Steuerung der Personenströme bei öffentlichen Veranstaltungen zu erleichtern. Betrachten wir die obligatorischen Bedingungen für die Erfüllung dieses Punktes: Installation einer Videoüberwachung in den Schlüsselbereichen des Stadions, einschließlich der Eingänge, Ausgänge, Tribünen usw.; Installation eines Ausweissystems und elektronischer Drehkreuze; Installation von Beschallungsanlagen, Notfallsystemen, Hinweistafeln; Verhaltensüberwachung und -analyse: Einsatz künstlicher Intelligenz zur Analyse der Zuschauerströme im Stadion; regelmäßige Patrouillen und Zusammenarbeit mit den Strafverfolgungsbehörden, Ausarbeitung von Evakuierungsplänen.

Dieser Punkt des RFU-Reglements ist leicht zu verwirklichen, es bedarf lediglich der Finanzierung, einschließlich öffentlicher Zuschüsse, privater Investitionen und Sponsoren.

2. Erhöhung der Anzahl der Sitzplätze für Zuschauer

Derzeit bietet das Stadion 4990 Zuschauern Platz, was nicht den RFU-Vorschriften entspricht, die eine Mindestanzahl von 7000 Plätzen vorsehen. Die Situation wird durch die Lage des Stadions noch komplizierter. Es befindet sich im Stadtzentrum und verfügt aufgrund seiner Nähe zu den Hauptverkehrsstraßen der Stadt und der dichten Bebauung nur über eine begrenzte Installationskapazität. Es gibt mehrere Möglichkeiten, die Anzahl der Tribünen zu erhöhen:

A. Analyse der derzeitigen Konfiguration der Tribünen und der Möglichkeit, durch Optimierung der Sitzplatzanordnung zusätzliche Sitzplätze zu schaffen. Beseitigung einiger Gänge und Einrichtung einer kompakteren Sitzordnung;

B. Bau eines zusätzlichen Stockwerks über den bestehenden Tribünen unter Verwendung von Metallkonstruktionen;

C. Verwendung von vorgefertigten Konstruktionen zur Schaffung provisorischer Tribünen.

Zusammenfassend lässt sich sagen, dass der Wiederaufbau des Spartak-Stadions eine

reale Möglichkeit ist, wobei jedoch alle oben genannten Aspekte, einschließlich der rechtlichen, finanziellen und sozialen, berücksichtigt werden müssen. Es ist auch zu bedenken, dass die Hälfte der RFU-Anforderungen bereits erfüllt ist. Mit dem richtigen Ansatz und den richtigen Mitteln kann das Stadion nicht nur die Anforderungen des RFS erfüllen, sondern auch zum wichtigsten Zentrum des Sportlebens in Tambow werden.

Das «Spartak»-Stadion und der Fußball tragen zur Entwicklung des Gemeinschaftssinns, der sozialen Integration und der lokalen Wirtschaft bei.

Literaturverzeichnis

1. Istoria Stadiona // URL: https://fcspartak68.ru/modules/content/page.php?id=373 (Accessed: 04.12.2024). (in Rus.)
2. Standart RFS «Standart RFS (STO) «Futbol'nyye stadiony»» ot 16.01.2019 № 205/2 // Obshcherossiyskaya obshchestvennaya organizatsiya «Rossiyskiy futbol'nyy soyuz». - 2019 g. - № 2. - St. 3-12. (in Rus.)
3. Nadezhnost' stroitel'nykh konstruktsiy i osnovaniy. Osnovnyye polozheniya. GOST 27751-2014. – Vved. 01 iyulya 2015 g. – M.: Standartinform, 2019. – 14 s. (in Rus.)

Оценка возможности реконструкции стадиона «Спартак» в г. Тамбов под требования «Российского футбольного союза»

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Аннотация. В данной статье рассматривается возможность реконструкции стадиона «Спартак» в г. Тамбов под требования Российского футбольного союза. Стадион «Спартак», расположившийся в самом центре города, является для горожан не просто спортивным сооружением для проведения соревнований, а местом где все собравшиеся могут разделить общие эмоции, болея и поддерживая любимую футбольную команду, своих сограждан. Однако, даже при потенциальном выходе в Российскую Премьер-Лигу, тамбовские футболисты не смогут играть на родном поле. К сожалению, стадион «Спартак» не соответствует требованиям «Российского футбольного союза», что исключает возможность проведения домашних матчей, поэтому проведение исследования на выбранную тему может помочь моему родному городу обрести домашний стадион высшего уровня, где будет возможность наблюдать за лучшими футбольными командами России вживую в комфортных условиях, соответствующими требованиям «Российского футбольного союза», приобщать детей и молодежь к профессиональному.

Ключевые слова: проект производства работ, реконструкция, Российский футбольный союз, стадион, требования.

УДК 621.643

Reconstruction of oil terminal

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Abstract
The reconstruction of oil storage facilities is a critical aspect of modern energy infrastructure management, aimed at enhancing operational efficiency, safety, and environmental sustainability. This paper explores the methodologies and technologies employed in the reconstruction of oil depots, focusing on the integration of innovative design principles and advanced materials.
Keywords: oil storage facilities, reconstruction, technologies, petroleum products, turnover.

Introduction

Tank farms play a key role in ensuring a stable and secure supply of energy resources, but many face challenges associated with aging infrastructure, poor operational reliability and potential environmental risks. In the context of growing requirements for safety and environmental protection, as well as increasing volumes of refining and storage of oil and petroleum products, it becomes necessary to reconstruct oil depots. Reconstruction not only helps to improve the technical condition of facilities, but also allows for the introduction of modern technologies that increase operational efficiency and minimize the negative impact on the environment.

Oil depots built in Soviet times are technically and technologically outdated, and therefore require major reconstruction [1]. As reported in [2], domestic demand for gasoline and diesel fuel in the Russian Federation declined in the 1990s, while the structure of such enterprises remained the same and the number of workers remained almost at the same level, which led to a deterioration in the financial and economic performance of oil depots, and, as a consequence, their condition.

The purpose of this article is to study the possible problems of oil depots in need of reconstruction. And the result of this work will be the presentation of a project for the reconstruction of an oil depot.

Methods and materials

The research focuses of reconstruction of an oil depot using the example of the Kosyrev oil storage located in the Lipetsk region. Taking into account the condition of the tank farm and the need to increase the turnover of petroleum products due to the increasing demand for petroleum products, it was decided to develop a project to reconstruct the tank farm of the Kosyrev oil depot.

This oil depot was put into operation in 1955, and therefore most of the technological equipment no longer meets modern requirements. Having studied the technical documentation and compared it with modern requirements for equipping oil tank farms, it was decided to carry out reconstruction in order to update the process equipment and expand the tank farm.

The current annual turnover of the oil depot is 286,855 tons/year, it is planned to increase to 515,000 tons/year, so not only the tank farm, railway and road overpasses are subject to reconstruction, in order to be able to accept and release more product.

Results

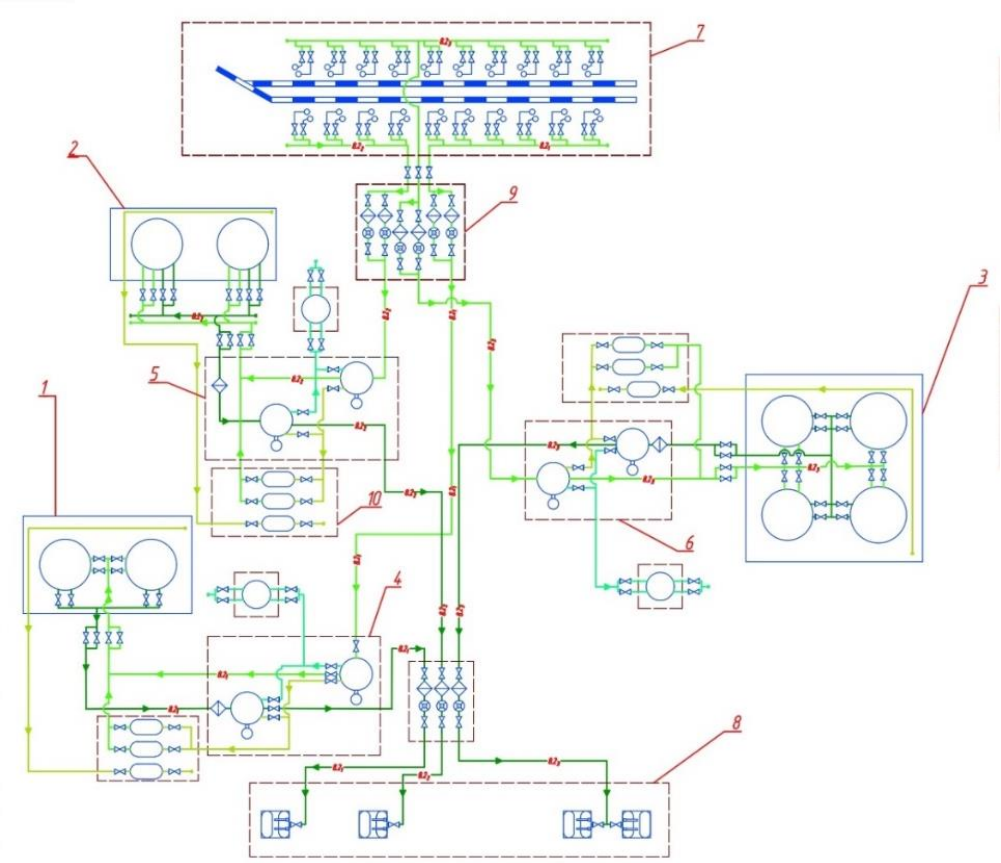

Figure 1 – Block diagram of the oil deport under study before reconstruction

Having analyzed the old tanks, it was decided that it would be more economically profitable to repair them, and to introduce new groups with tanks into the tank farm to avoid turnover.

Then, based on the required turnover, using calculations, the optimal number of tanks of the required volume was selected, and a new tank farm was assembled in accordance with regulatory documents regulating safe distances between tanks.

New railway and road overpasses for dispensing petroleum products into tank trucks were also separately calculated. This is the principle on which road overpasses are calculated:

The number of loading devices for each type of petroleum product, pcs, is determined by the formula:

$$n_{i.\text{НУ}} = \frac{G_{i\ daily.road}}{\rho_{i\ min} \cdot q \cdot K_{\text{и}} \cdot \tau}$$

$G_{i\ daily.road}$ is the average daily sales of the *i-th* petroleum product by road transport, kg;

$\rho_{i\ min}$ is the minimum density of the *i-th* oil product, kg/m3;

q is capacity of the loading device, m^3/h (for oil products with a viscosity of up to 60 mm/s2, take the capacity of the loading device 40 - 100 m^3/h, if more than 60 mm/s^2, then take more than 100 m3/h).

A capacity of 60 m^3/h was taken and the device ASN-12VG module Du100, shown in Fig. 2 was selected.

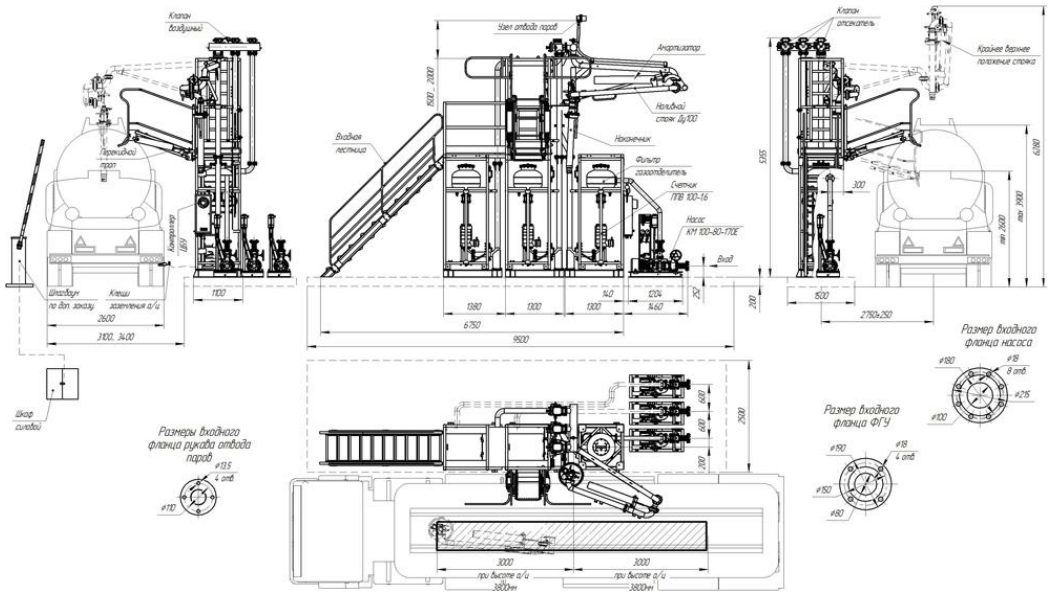

Figure 2 - ASN-12VG module Du100

K_i is the loading device utilization rate, we take K_i =0,7.

τ is number of operating hours of filling devices per day (8 hours, 12 hours, 24 hours), we take τ = 8 hours.

The average daily sales of the i-th petroleum product, kg, by road transport is determined by:

$$G_{i\,daily.road} = \frac{G_{i.year.road} \cdot K_{pp}}{365},$$

where $G_{i.year.road}$ is the average annual sales of the i-th petroleum product by road transport, kg;

K_{pp} is the coefficient of uneven consumption of the i-th petroleum product, we take K_{pp} = 1.4.

The number of tank trucks, pcs., per day was determined by:

$$n_{i.tt} = \frac{G_{i\,daily.road}}{V_{tt} \cdot \rho_{i\,min}},$$

where $G_{i\,daily.year}$ is the average daily sales of petroleum products, kg;

V_{tt} is the tanker capacity, m^3;

$\rho_{i\,min}$ is the minimum density of the i-th oil product, kg/m^3;

All tank trucks transporting petroleum products are of the same brand: Tank semi-trailer PPTs40-63.010, shown in Fig. 3 tank truck has a capacity of 40 m^3.

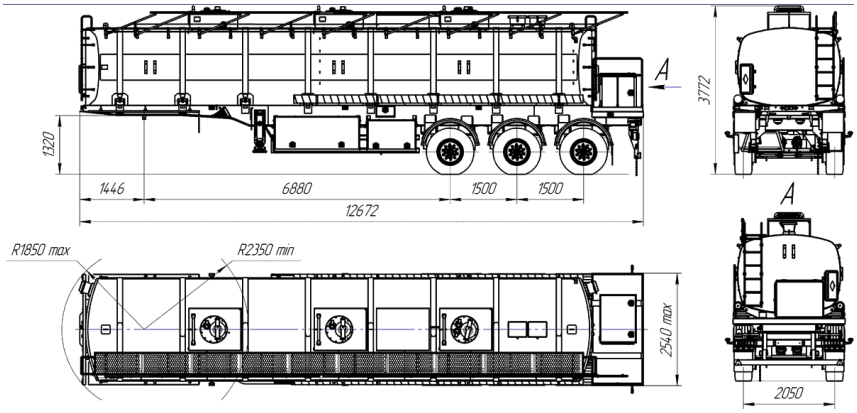

Figure – 3 Tank semi-trailer PPTs40-63.010

The number of loading risers is calculated based on the annual cargo turnover for each oil product.

Determine the average daily sales of the i-th petroleum product by road using the formula:

$$G_{AE92.daily.road} = \frac{(515000 \cdot 1.4 \cdot 0.21) \cdot 1000}{365} = 414821.9 \text{ kg},$$

$$G_{AE95.daily.road} = \frac{(515000 \cdot 1.4 \cdot 0{,}2) \cdot 1000}{365} = 395068.9 \text{ kg},$$

$$G_{DF.daily.road} = \frac{(515000 \cdot 1.4 \cdot 0.59) \cdot 1000}{365} = 1165452.1 \text{kg},$$

Determine the number of filling devices using the formula:

$$n_{AE92.fd} = \frac{414821{,}9}{767.6 \cdot 60 \cdot 0.7 \cdot 8} = 1.6\ pcs\,; n_{AE92.fd} = 2\ pcs.$$

$$n_{AE95.fd} = \frac{395068.9}{773.2 \cdot 60 \cdot 0.7 \cdot 8} = 1.5\ pcs\,; n_{AE95.fd} = 2\ pcs.$$

$$n_{DF.fd} = \frac{1165452.1}{868.7 \cdot 60 \cdot 0.7 \cdot 8} = 3.99\ pcs\,; n_{DF.fd} = 4\ pcs.$$

Determine the number of tank trucks per day using the formula:

$$n_{AE92.tt} = \frac{414821.9}{767.6 \cdot 40} = 13.5\ pcs\,; n_{AE92.tt} = 14\ pcs, \quad n_{AE95.tt} = \frac{395068.9}{773.2 \cdot 40} = 12.8\ pcs\,; \quad n_{AE95.tt} = 13\ pcs,$$

$$n_{DF.tt} = \frac{1165452{,}1}{868.7 \cdot 40} = 33.5\ pcs\,; n_{DF.tt} = 34\ pcs.$$

We calculated all the necessary communications such as: pipelines, pumps, emergency leakage tanks and metering units with pressure gauges. And based on the calculations, a new technological scheme was created, with new tanks and communications.

Conclusion

The implementation of measures to reconstruct the oil transshipment depot guarantees compliance with the necessary fire and industrial safety requirements, and also eliminates defects acquired during the operation of tank equipment and tanks associated with the negative impact of the environment and groundwater, as well as uneven settlement of the tank, technological wear and other factors. The result of reconstruction shown in Fig. 4.

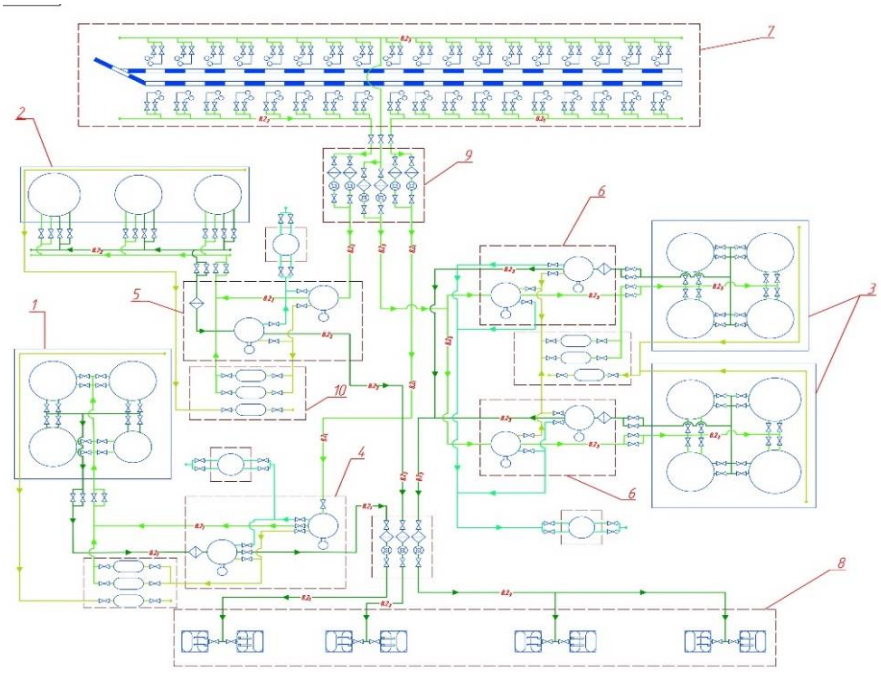

Figure – 4 Block diagram of the oil deport under study after reconstruction

References

1. Fel'dman A. L., Podolyanets L.A., Fel'dman L.A. Problema gorodskikh neftebaz na primere funktsionirovaniya Krasnoyarskoy (Zlobinskoy) neftebazy [The problem of urban oil depots using the example of the functioning of the Krasnoyarsk oil depot Zlobino]. Vestnik yevraziyskoy nauki. 2016. №4 (35), Available from: http://naukovedenie.ru/index.php?p=vol8-4 (accessed 12.12.24) (Rus)

2. Shmakov K. Restrukturizatsiya predpriyatiy nefteproduktoobespecheniya [Restructuring of an oil supply enterprise]. ECO 2019, 2, pp. 146-155 (Rus)

Реконструкция нефтяного терминала

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Аннотация. Реконструкция нефтехранилищ является важнейшим аспектом управления современной энергетической инфраструктурой, направленным на повышение эксплуатационной эффективности, безопасности и экологической устойчивости. В данной статье рассматриваются методологии и технологии, используемые при реконструкции нефтехранилищ, с упором на интеграцию инновационных принципов проектирования и современных материалов.

Ключевые слова: нефтебаза, реконструкция, проектирование, нефтепродукты, продуктооборот.

УДК 2.01

Embankment as the main pedestrian area of the city of Tambov

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Abstract
The study of the problems of the organization of coastal territories, domestic and foreign experience of zoning allows us to identify the main methods of their arrangement. The article reveals the main methods of forming the urban landscape of the coastal territory on the example of the city of Tambov.
Keywords: coastal zones; problems of organization and arrangement; zoning techniques; urban landscape.

Introduction

The coastal zones of cities represent unique territories that are of great importance to residents and ecosystems. However, when organizing and shaping urban landscapes in coastal areas, architects and urban planners face a number of problems that require attention and solutions.

The problems of forming the pedestrian zone of the embankment

One of the main problems is the insufficient planning and management of coastal zone development. Often, construction and infrastructure projects in coastal areas are carried out without due consideration of environmental and landscape features, which leads to disruption of natural balances and deterioration of environmental quality [1].

Another problem is the lack of public involvement in the decision-making process for the organization of coastal zones. Urban residents often do not have the opportunity to express their opinion on the development of coastal areas, which can lead to conflicts and rejection of landscaping projects by the population [1].

Another important aspect is the preservation of the natural wealth and biodiversity of coastal zones. Irrational use of coastal areas can lead to the disappearance of unique ecosystems, which will negatively affect the environment and wildlife.

To solve these problems, it is necessary to develop comprehensive strategies for the organization and formation of urban landscapes in coastal zones. It is important to take into account the needs of residents, conserve natural resources and create sustainable and environmentally friendly urban landscapes [2].

Examples of excellent realization of the potential of the coastal territory

One of the striking examples of successful embankment design in Russia is the embankment of the Moskva River (Fig. 1). Large-scale embankment improvement projects have been implemented in the capital, such as the City Beach on Gorkovskaya Embankment, Zaryadye Park and others. These projects not only improved theappearance of the coastline, but also created comfortable conditions for recreation and active pastime of citizens [3].

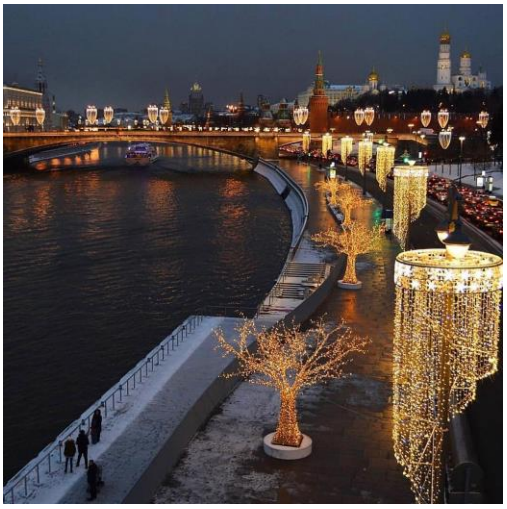

Figure 1 - Photograph of the embankment of the Moscow River, Moscow [https://m.fotostrana.ru/public/post/233977/1589187695/]

Another example of successful embankment design in Russia is St. Petersburg (Fig. 2). In projects for the improvement of embankments in St. Petersburg, special attention is paid to the preservation of the historical appearance of the city, which makes them especially valuable for residents and tourists [3].

Figure 2 - Photograph of the Neva River embankment, St. Petersburg [https://dzen.ru/a/YIMlnxGWPlViaMTS]

Foreign experience in the design of embankments offers valuable lessons for cities seeking to improve their infrastructure and make the urban environment more attractive and functional.

Conclusion

In general, the formation of coastal territories in Tambov is a complex and multifaceted process that requires an integrated approach and consideration of various aspects. Modern technologies and techniques make it possible to create unique and attractive coastal areas that become real gems of the urban environment.

Asknowledgements

The main lessons that can be learned from foreign experience in designing embankments include:

1. Integration with the urban environment: successful embankments should be organically integrated into urban development and infrastructure, create a harmonious space for living and recreation.

2. Multifunctional: Embankments should offer a variety of opportunities for recreation, sports, cultural events and commercial activities in order to attract different audiences and stimulate the development of urban life.

3. Sustainability and environmental friendliness: when designing embankments, it is necessary to take into account aspects of sustainable development and conservation of the natural environment in order to create environmentally friendly and comfortable spaces for residents and visitors.

4. Public participation: It is important to involve local residents, the business community and other stakeholders in the embankment design process in order to ensure broad support and successful implementation of the project [1].

One of the key aspects of the organization is the rational use of coastal zones, taking into account their natural features and potential. This includes conducting an analysis of the existing state of coastal territories, defining the goals and objectives of urban landscape formation, as well as developing a strategy for the development of coastal zones, taking into account the needs of the urban community.

References

1. Shimko V. T., Kudryashov N. K. Architectural design planning. Generating a project idea: a tutorial for students studying in the areas of "Architectural Environment Design" and "Architecture". Moscow, Architecture-With , 2016. 248 p.

2. Vishnevskaya E. V., Barsukova N. I. Methodology of design engineering as a basis for the complex organization of open spaces in the urban environment. Orenburg, Bulletin of Orenburg State University, 2015. 121-127.

3. Zolotova M. S. Creation of an architectural and landscape environment and improvement of the water protection coastal strip. Available from: https://moluch.ru/archive/91/19166/. (Accessed 21 May 2015)

Улица Набережная как главная пешеходная магистраль города Тамбова

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Аннотация. Изучение проблем организации прибрежных территорий, отечественного и зарубежного опыта зонирования позволяет выявить основные приемы их обустройства. В статье раскрыты основные приемы формирования городского ландшафта прибрежной территории на примере города Тамбова.

Ключевые слова: прибрежные зоны; проблемы организации и обустройства; приемы зонирования; городской ландшафт.

УДК 69.059.25

Choosing ways to replace floors in historical buildings of provincial cities

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Abstract
In the process of restoration, reconstruction and major repairs of historical buildings in provincial cities, one of the main types of construction and repair work is work on strengthening or replacing elements of inter-floor, basement and attic floors. The choice of ways to strengthen and replace floors is a complex multifactorial process that affects the cost and quality of construction and repair work. This article discusses the basic principles of choosing ways to replace floors, which can be most effective in the restoration and reconstruction of historical buildings, including buildings in Tambov.
Keywords: historical buildings; floors of historical buildings; replacement and repair of floors; restoration and reconstruction of buildings.

In the historical buildings of provincial cities, there are a large number of buildings with a service life of 100 years or more. As a rule, most of these buildings are objects of cultural heritage. A typical example of this is the buildings of the historical development of Tambov [1]. An analysis of the condition of buildings related to the historical development of Tambov indicates the need for various types of construction and repair work on them. Some types of such work were discussed in the articles of the staff of the Department of "GSandAD" TSTU [2-6]. To establish the technical condition of the historical buildings of Tambov in order to preserve them, the staff and undergraduates of the department constantly monitor the buildings. As a result of monitoring, it was found that in most buildings, the floors of buildings have the greatest wear and damage. There is especially significant damage in the inter-floor and attic floors made of wooden structures. The results of the study show the following. The floors are arranged with wooden beams and with the filling of a wooden ramp between them, the ramp is filled with construction debris. The ceilings are plastered with shingles, and the floors are made of tongue-and-groove boards. Attic floors are insulated, as a rule, with inefficient insulating backfills made of slag or construction debris. Most of the floors have an unsatisfactory technical condition. The floor beams are damaged by rot in their places of support, on the exterior walls. The bearing capacity of the beams is insufficient. Overlaps in most cases require a complete replacement of all elements. At the same time, the new floors must meet the requirements of strength and rigidity, as well as increase the stability of the load-bearing skeleton of the building as a whole. They must meet the requirements for heat and sound insulation, as well as fire safety requirements for operational reliability.

The experience of replacing wooden floors with floors that meet the listed requirements shows that choosing a new solution is a multifactorial process. The main factors influencing the choice of a new solution include: the new functional purpose of the

building; the structural solution of the load-bearing island of the task; the bearing capacity and technical condition of the walls and foundations; the technical features of the installation of new floors; the complexity of the proposed overlap options; the need to increase the rigidity and stability of the building due to the installation of new floors; tightness during repair and construction work. These requirements can be met by installing monolithic reinforced concrete girderless floors, as well as by installing monolithic reinforced concrete slabs on load-bearing metal beams.

The construction of monolithic girderless floors has a number of significant advantages. Since the plates rest on the walls along the contour, they create hard drives, which, together with the walls, increase the rigidity of the supporting skeleton of the building and, consequently, its stability. The advantages also include the possibility of its use in buildings of complex shape and plan configuration. It does not require the use of heavy lifting equipment. The device ensures the easy accessibility and transportability of materials necessary for the construction of floors. This solution ensures fire resistance, sound insulation of floor-to-floor ceilings, and thermal protection of attic floors at no significant cost to achieve regulatory targets. The method makes it possible to provide the bearing capacity of floors with a small plate thickness from 0.12 m to 0.16 m.

A limitation of the method is the impossibility of using it with relatively large spans. With large spans, a large thickness of slabs is required or the introduction of additional supports and beams, which leads to a change in the building's load-bearing islands.

The installation of monolithic slabs on metal beams is used in buildings with spans of 7-9 m or more. In this case, a partial reconstruction and reinforcement of the wall elements on which the new floor beams are supported is also required. The main difficulty in choosing a new design solution in this case is to ensure reliable support of the beams on the exterior walls with small cross-sectional walls. To increase the bearing capacity of the piers, they need to be reinforced. In this case, in order to reduce the load on the walls from the ceiling beams, it is also necessary to reduce the size of the spans by installing new supports inside the building. Due to these difficulties and based on the actual spatial planning and structural solutions of buildings, both methods are often used simultaneously for different cross-sections of structural solutions.

In general, the existing experience of replacing floors indicates the need to take into account when choosing the method, the features of the structural solutions of the walls and the strength of the masonry in the places where the elements of the floors rest on the walls. A significant problem may also be related to the planning decisions of the building, namely, the size of the overlapping spans, the pitch of the window openings, the size of the piers, as well as the overall shape of the slab. For these reasons, combinations of the first and second methods are most often necessary.

References

1. Seregin S.I., Kryukova A.A., Ledenev V.I. Otsenka vozmozhnosti sokhraneniya zhilykh zdaniy g. Tambova, imeyushchikh status nedvizhimykh ob"yektov kul'turnogo naslediya [Assessment of the

possibility of preserving residential buildings in Tambov that have the status of immovable cultural heritage sites]. V sbornike: Aktual'nyye problemy gorodskogo stroitel'stva. Sbornik trudov Vserossiyskoy nauchno-tekhnicheskoy konferentsii, Penza PGUAS, 2020. S. 79-84.
2. Berezenko A. S., Zhogoleva O. A., Ledenev V. I. Osobennosti i problemy ustrojstva vertikal'noj gidroizolyacii fundamentov v istoricheskih zdaniyah provincial'nyh gorodov [Features and problems of vertical waterproofing of foundations in historical buildings of provincial cities] Aktual'nye problemy gorodskogo stroitel'stva : Sbornik trudov Vserossijskoj nauchno-tekhnicheskoj konferencii, Penza, 29–30 yanvarya 2019 goda / Pod redakciej A.V. Grechishkina. Penza: Penzenskij gosudarstvennyj universitet arhitektury i stroitel'stva, 2019. S. 50-54.
3. Antonov A.I., Kartashova G.V., Berezenko A.S. Osobennosti ekspluatacii kirpichnyh sten istoricheskih zdanij v usloviyah sovremennoj gorodskoj zastrojki [Features of the operation of brick walls of historical buildings in modern urban conditions] Fundamental'nye i prikladnye nauchnye issledovaniya: aktual'nye voprosy, dostizheniya i innovacii [Elektronnyj resurs]: Vserossijskaya zaochnaya nauchno-prakticheskaya konferenciya. - Tambov: Izd-vo FGBOU VO «TGTU». 2017. Vyp.1.
4. Kryukov, A. V. Measures to Ensure Operational Reliability during Capital Repairs of Low-Rise Historical Buildings in Tambov / A. V. Kryukov, G. V. Zelenin // The World of Science Without Borders, 11 fevralya 2022 goda, 2022. P. 424-426.
5. Kryukov A. V., Zelenin G. V. Obespechenie dolgovechnosti i ekspluatacionnoj nadezhnosti kirpichnyh istoricheskih zdanij Tambova [Ensuring durability and operational reliability of brick historical buildings in Tambov] Sovremennye problemy materialovedeniya : Sbornik nauchnyh trudov III Vserossijskoj (nacional'noj) nauchno-prakticheskoj konferencii, posvyashchennoj pamyati d.t.n., professora, akademika Rossijskoj akademii arhitektury i stroitel'nyh nauk E.M. Chernyshova, Lipeck, 18 fevralya 2022 goda. – Lipeck: Lipeckij gosudarstvennyj tekhnicheskij universitet, 2022. S. 58-63.
6. Matveeva, I. V., Kartashova G. V., Berezenko A. S. Konstruktivnye resheniya ustrojstva metallicheskih poyasov v kirpichnyh stenah istoricheskih zdanij i ih uchet v processe restavracii [Constructive solutions for the installation of metal belts in the brick walls of historical buildings and their consideration during the restoration process] Ustojchivoe razvitie regiona: arhitektura, stroitel'stvo, transport: Materialy 5-j Mezhdunarodnoj nauchno-prakticheskoj konferencii Instituta arhitektury, stroitel'stva i transporta, Tambov, 24–25 maya 2018 goda. – Tambov: Izdatel'stvo Pershina R.V., 2018. S. 329-333.

Выбор способов замены перекрытий в исторических зданиях провинциальных городов

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Аннотация. В процессе реставрации, реконструкции и капитальных ремонтов исторических зданий провинциальных городов одним из основных видов строительно-ремонтных работ являются работы по усилению или замене элементов междуэтажных, надподвальных и чердачных перекрытий. Выбор способов усиления и замены перекрытий является сложным многофакторным процессом, влияющим на стоимость и качество строительно-ремонтных работ. В данной статье рассмотрены основные принципы выбора способов замены перекрытий, которые могут быть наиболее эффективными при реставрации и реконструкции исторических зданий, в том числе из зданий г. Тамбова.
Ключевые слова: исторические здания; перекрытия исторических зданий; замена и ремонт перекрытий; реставрация и реконструкция зданий.

УДК 341

Some relevant aspects of intellectual right protection in Japan

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Abstract
The purpose of this article is to study some important aspects related to the system of regulatory legal acts on intellectual property law in Japan, as well as some relevant in our opinion, points that have become topical in 2025. After analyzing the Japanese legal system, we will be able to draw a parallel with domestic legislation and identify similarities and differences, strengths and weaknesses between legal structures of these countries. In our work, we rely on the method of analyzing regulatory legal acts and comparing them.
Keywords: copyright; designs; licensing; patent; utility model.

Introduction

If we compare Russian and Japanese patent law, we can observe that, unlike domestic legislation, in Japan patent law is an independent, separate branch of law and is not regulated by the civil code as in our country (Although we used to have a separate code).

Materials and methods

We believe that the method of analyzing regulatory legal acts and comparing them is best suited for our research.

In Japan, the system of regulatory legal acts on intellectual property law consists of:

1) the main, basic law - Law No. 48 "On Copyright" dated 05.06.1970;

2) and three local but extensive laws dealing with individual intellectual property objects:

- Law No. 121 "On Patents" dated 04.13.1959;
- Law No. 123 "On Utility Mode" dated 04.13.1959;
- Law No. 125 "On Samples" dated 04.13.1959.

If we consider the similarities and differences, strengths and weaknesses between the legal structures that regulate the intellectual property law of Japan and Russia, then we can say the following:

- There are more similarities than differences in the field of invention protection. This is due to the fact that both States have adopted and adopted norms from the Paris Convention for the Protection of Industrial Property of March 20, 1883. Therefore, there are no significant differences in this area.;

- Considering the institution of free use, Russian legislation has even more advantages in this matter than the Japanese legal system. Article 1487 of the Civil Code of the Russian Federation establishes the exhaustion of the exclusive right to a trademark. In other words, our legislation has resolved the issue related to the principle of exhaustion of rights, but there is no such principle in Japanese, at least it is not expressed in a specific

norm. In our case, this rule solves the problem of parallel imports. However, the direct absence of such a rule in Japanese legislation is due to the absence of its urgent need, since Japan excludes the possibility of parallel imports in respect of goods patented in Japan.;

- it is worth mentioning the issues related to the right of premature use. Nevertheless, Japanese legislation has succeeded more than Russian legislation. If we consider the problems in the domestic legislation, in our opinion, they are caused by incomplete disclosure of this institution. The Civil Code has only one article regulating this issue, art. 1361 of the Civil Code of the Russian Federation. This is clearly not enough. Nevertheless, the absence of a specialized code in the field of intellectual property law inevitably leads to a more limited set of norms than it could be. Although we cannot but note that the fourth part of the Civil Code contains excellent tools for regulating this area.

If we consider this institution in the Russian Federation, then in practice, when the court meets with cases related to the right of premature use, there are the following problems:

1) the issue of establishing the fact of preparation for the use of an identical solution. That is, having only the intentions of a person is not enough, specific actions are important. Of course, the existence of such actions must be proved, but this is difficult to do, and therefore courts often do not recognize preparations for use at all. In general, this is a rather controversial issue that needs to be resolved.;

2) the issue of the volume of use of the identical solution. As a rule, we are talking about a specific number of manufactured products using a patented object, or pre-made preparations for their production. However, in addition to these facts, it should also be taken into account the number of products, for which additional preparations have already been made. The court may also proceed from a territorial feature, that is, territory as a criterion for the amount of pre-use (inventions, utility models and industrial designs).

In Japan, the situation is completely different. The operation of this institution is quite extensively regulated by the Japanese Patent Law of 1959. In this case, the main object is the invention. There are already strong differences with our legislation in this regard. Although, as we said earlier, the norms that regulate the protection of inventions, for the most part, were taken from the Paris Convention for the Protection of Industrial Property of March 20, 1883, therefore, the regulations of this institute are based on these norms.

Unlike Russian law, Japanese law has nevertheless formalized the principle of pre-use rights (official registration of transfer of rights), which should certainly be done in our country. The Japanese legislature has established the consolidation of pre-use rights and established the right to a non-exclusive license. If registration has not been carried out, due to certain circumstances, the right to pre-use will remain.

79 of the Law "On Patents" dated 04.13.1959 establishes that: "no right and (or) encumbrance may be binding on third parties until it is registered, except in cases expressly provided for by the Patent Law of Japan". The right of prior use is such a case.

The issue of establishing the fact of preparation for the use of an identical solution there is resolved in art. 80 of the Law "On Patents" dated 04.13.1959, which states that: "in a situation where a person has organized a case involving the use of a patented

invention or has made the necessary preparations for this before a patent for such an invention is declared invalid, and at the same time did not know that such a patent was in the process of being recognized, invalid, has the right to a non-exclusive license or to an exclusive license, to the extent that such an invention was used or intended to be used in cases where:

1. Two or more patents have been granted for the same invention, and such patents have been declared invalid.;

2. The patent of the original patent holder is declared invalid and a similar invention is transferred to another person".

In case of occurrence of one of these conditions, and their official registration, allows the person to retain the right to the invention.

Results and discussions

We agree with the approach of Japanese legal scholars and propose to develop a specialized regulatory legal act on intellectual property, or even several, taking an example from them.

Conclusion

Thus, this is necessary because it is impossible to cover all the diversity of relations arising in connection with intellectual property objects within the framework of one part of the Civil Code, which is why we believe that combining patent law with the Civil Code was a mistake.

References

1. Koh N.V. Svobodnoe ispol'zovanie po patentnomu zakonodatel'stvu Rossii i Yaponii. Sravnitel'nyj ocherk. [Free use under the patent laws of Russia and Japan. A comparative essay]. Pravo, 2010, No. 3, pp. 46 - 51. (Rus)

2. Patentnaya sistema Yaponii [Patent System of Japan]. Available from: https://www.wipo.int/patent-judicial-guide/en/full-guide/japan (Accessed 15.03.2025). (Rus)

Некоторые важные аспекты защиты интеллектуальных прав в Японии

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Аннотация. Целью данного исследования является изучение некоторых важных аспектов, связанных с системой нормативно-правовых актов, посвящённых праву интеллектуальной собственности в Японии, а также некоторых интересных, на наш взгляд моментов, которые стали актуальны в 2025 году. После проведённого анализа правовой системы Японии, мы сможем провести параллель с отечественным законодательством и выявить сходства и различия, сильные и слабые стороны между правовыми структурами.

Ключевые слова: авторское право; лицензирование; образцы; патент; полезная модель.

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Linguistique juridique: caracteristiques et defis de la nouvelle science

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Résumé
Sont examinés l'objet et le sujet de la linguistique juridique en tant que discipline scientifique, les relations entre la linguistique juridique et d'autres sciences, les défis de la linguistique juridique. Sont abordés de problèmes de la linguistique juridique parmi lesquels sont cités: l'étude des documents des sources juridiques, l'étude de la composition des termes juridiques du point de vue de leur origine et des différences entre le langage juridique et les autres strates de la langue littéraire, la rédaction de différents types de documents juridiques et la traduction juridique, l'expertise linguistique et le jargon juridique.
Mots-clefs: linguistique juridique, discours juridique, communication juridique, langage juridique

Introduction

Cet article s'inscrrit dans le cercle des études pragmatiques considérant le discours, la communication et le langage juridique tenant compte des buts et du contenu, de l'histoire et de l'état actuel de la science. Un examen détaillé du matériel théorique accumulé par les linguistes russes et français qui étudient la linguistique juridique permet de caractériser la nouvelle science et de présenter ces défis. Le but de l'article consiste à montrer le rôle et les particularités des domaines et des sections de la linguistique juridique qui gardent les traits de la jurisprudence et de la linguistique.

L'objet et le sujet de la linguistique juridique en tant que discipline scientifique

Chaque année augmente l'intérêt pour la nouvelle discipline philologique - linguistique juridique qui est apparue à la jonction de la jurisprudence et de la linguistique. Il s'agit de la scence relativement nouvelle dans l'espace linguistique qui recourt aux instruments et termes juridiques et en fait l'objet de l'examen linguistique. A l'issue de ce dernier sont données des recommandations pour le fonctionnement du système juridique basé à l'institut des droits, compte tenue de la réglementation de la communication sociale par les lois juridiques. Sont aussi formulées les préscriptions pour l'écriture des textes législatifs et pour l'explication de la recherche théorique et pratique dans le domaine de la traduction juridique, pour le choix de l'appareil terminologique et pour la réalisation de l'expertise linguistique de la documentation et des textes dans le domaine de droit. Cela ne fait aucun doute que le traits essentiels de la linguistique juridique sont à l'interaction du langage et du droit. Le sujet de la linguistique juridique en tant que discipline scientifique est lié à ces relations variées avec des phénomènes nommés. C'est à dire que le champs des études de la linguistique juridique est assez vaste et englobe toutes les renseignements sur la relation entre la langue juridique en tant qu'instrument essentiel de la science examinée et l'activité legislative de la société. Cette activité comprend l'interprétation de la loi, la nature des conflits, l'utilis ation de la langue dans des actes illicites (insultes, appels à la violence, plagiat, etc.). Dedifférents espects de la réglementation des relations socio-linguistiques internes dans l'état fédéral, l'étude du langage courant et de la conscience juridique font objet de la linguistique juridique.

Les rapports entre la linguistique juridique et d'autres sciences

A l'heure actuelle la linguistique juridique forme plusieurs sections qui sont révéles compte tenue de sa rencontre avec diverses sciences et disciplines scientifiques liées à la fois à la linguistique et à la jurisprudence.

En caractérisant la linguistique juridique comme "un des domaines relativement nouveaux", nous n'oublions pas que les questions du rapport entre la langue et le droit sont abordées depuis longtemps ainsi que celles entre les avocats et les linguistes. Prenons comme exemple la position des juristes de l'Antiquité. Un des grands postulats de l'époque était: le droit peut et doit être défini. Cette définition est prise comme la base des tâches résolues par la linguistique juridique à l'étape moderne. Tout cela a pour but de rendre le texte juridique plus précis, plus compréhensible.

La linguistique juridique étudie donc la langue comme un élément du domaine de droit qui aide à la formation des lois et à la rédaction des textes juridique qui comprennent les techniques d'écriture et d'interprétation des actes juridiques normatifs compte tenue du niveau de la culture juridique.

La linguistique juridique est intégrée dans une série de disciplines liées avec la linguistique, par exemple, la linguoconflictologie, la linguopersonnologie, la psycholinguistique, l'herméneutique, la rhétoriques du droit, la sociolinguistique, etc. Ainsi, la linguoconflictologie dans le cadre de la linguistique juridique est engagée dans l'étude des causes des conflits qui surgissent dans le domaine du droit. L'herméneutique juridique et la linguistique structurent le fonctionnement du langage juridique en termes des caractéristiques de la perception et de la compréhension des textes exécutés dans le langage juridique. L'interprétation est au centre de l'examen de la loi. L'expertise linguistique est un cas particulier d'expertise générale qui étudie les bases théoriques de l'examen linguistique judiciaire, elle est engagé dans le développement d'un soutien méthodologique pour la réalisation des examens linguistiques judiciaires d'œuvres vocales controversies.

A la périphérie de la linguistique juridique sont la rhétorique juridique et l'orthologie de l'activité linguistique. La rhétorique juridique étude le langage des avocats et des juges lié au comportement vocal. L'objet de l'orthologie juridique est l'exactitude linguistique des textes de la lois et d'autres documents juridiques.

Les rapports entre la philologie et le droit ont une vieille origine. Dans les plus anciens monuments juridiques des civilisations orientales, il existe des preuves de la reconnaissance de l'importance de l'oral et du lexique.

Les défis de la linguistique juridique

Parmi les taches actuelles de la linguistique juridique on voit les suivantes:

- la nécessité de l'uniformité du système des concepts de la linguistique juridique;
- l'étude des méthodes communes de la linguistique juridique et des disciplines juridiques;
- le développement et l'amélioration des nouvelles catégories et terminologies juridiques ainsi que celles existantes auparavant;
- l'examen des concepts utilisés dans la linguistique juridique, le développement et l'étude des méthodes de connaissance du langage juridique.

Ces derniers temps, les défis liés à la confrontation deviennent de plus en plus importantes, par exemple, la protection du statut de la langue russe en Russie et à l'étranger proche. L'expulsion de la langue russe du domaine de l'enseignement, du domaine officiel et des affaires existe dans certains sujets de la Fédération de la Russie ce qui nécessite certainement l'intervention de l'état et la reformulation de la législation.

Aux défis de la linguistique juridique en tant que pratique on peut ajouter les activités qui comprennent la création basée sur le langage naturel et le langage juridique spécifique en tant qu'instrument essentiel de l'activité législative et de l'interprétation de la loi, le règlement juridique des conflits et des relations nationales dans un état fédéral et les relations interétatiques, ainsi que la terminologie, la traduction et la lexicographie de l'activité juridique, le soutien des experts de l'activité judiciaire, la formation linguistique des spécialistes du droit, l'éducation linguistique et juridique de la population.

Les caractéristiques du langage juridique

La principale caractéristique du langage de la jurisprudence est le haut degré d'abstraction des termes juridiques. Ce langage est utilisé pour exprimer des concepts abstraits et des liens entre eux. Bien que l'éducation des juristes soit uniforme, les différences entre les institutions juridiques restent très importantes, ce qui signifie que nous ne pouvons pas parler d'uniformité du langage juridique. L'absence d'uniformité de la langue et d'autres facteurs font apparaître un certain nombre de difficultés auxquelles se heurtent les responsables de l'application des lois, les fonctionnaires et les organes législatifs de l'état. En Russie, les études linguistiques dans le domaine du droit mettent l'accent sur le problème de la création des normes linguistiques les plus élevées dans le domaine de la langue de la législation afin de créer un texte de loi compréhensible. A cet égard, il est nécessaire de distinguer les techniques juridiques et législatives. Cette question est traitée par les savants russes Baranov V. M., Aleksandrov A. S., Golev N. D. dans le cadre des études des relations entre la rhétorique et le droit [2]. Les thèmes les plus importants de la linguistique juridique française concernent les questions de la communication juridique et la formation du discours juridique [3] ainsi que les problèmes de la traductologie juridique [1]. La spécificité du langage juridique se manifeste à première vue par le lexique et la phraséologie typiquement juridiques. Ce langage varie fortement selon les communicants impliqués, le but de la communication juridique et le domaine du droit. La terminologie juridique pose un grand nombre de problèmes complexes concrétisés dans le langage juridique. L'une des branches du droit privé, régissant les rapports entre les personnes physiques ou morales, est *le droit civil*, une des disciplines juridiques qui présente un fort contenu culturel: *droit de la famille, des biens et des obligations*, etc. La procédure civile est l'ensemble des règles relatives à l'organisation d'une action en justice devant une juridiction civile. Dans le langage du droit civil et de la procédure civile, les expressions abstraites sont abondantes (par exemple, la complexité et la pluralité du concept DROIT interprété comme *droit processuel, droit civil, droit commercial, droit naturel, droit notarial, droits acquis, droit d'asile,* etc), elles sont relatives aux notions d'obligation, d'héritage, de propriété, de contrat, de préjudice, de condition, de coutume, de bonne foi, d'erreur, de possession, de juste titre, de consentement ou de cause (*action juridique, preuve juridique, régime*

juridique décision judiciaire, etc).

Les problèmes de l'étude de la langue juridique

Il y a encore beaucoup de problèmes abordés par la linguistique juridique. Mais, malgré les nombreuses tentatives de parvenir à l'unanimité sur la façon dont la loi devrait être écrite, qu'elle était facilement accessible à la compréhension, cette question reste ouverte. Le problème de la clarté du langage législatif est un problème fondamental qui doit être résolu progressivement. Cette question est importante car ce n'est qu'avec une clarté absolue du langage de la loi qu'un sujet de droit peut être légalement responsable en vertu d'un acte juridique normatif.

Il convient de noter que la science mondiale a développé deux points de vue sur ce problème. L'un d'entre eux considère la langue des actes juridiques comme une langue juridique particulière ayant un minimum de similitude avec la langue littéraire, tandis que l'autre considère la langue du droit comme une sorte de type (style) de langue littéraire. L'importance de la langue pour la jurisprudence tient au fait qu'elle n'est pas tant un moyen technique d'exprimer la volonté du législateur qu'une forme d'existence même d'un droit destiné à dialoguer avec le peuple dans la langue de ce peuple.

A l'heure actuelle, plusieurs domaines principaux peuvent être notés dans l'étude de la langue juridique:

1. l'histoire du langage juridique qui comprend l'étude des documents des sources juridiques (lois, transactions juridiques, testaments, décisions de justice, etc.), l'étude de la composition des termes juridiques du point de vue de leur origine (emprunts);

2. les différences entre le langage juridique et les autres strates de la langue littéraire dont les études examinent les caractéristiques du langage juridique à différents niveaux du système linguistique, par exemple, au niveau du vocabulaire, est notée l'utilisation spécifique des archaïsmes, des termes étrangers et l'emploi des métaphores dans le discours juridique (*le fardeau de la prevue, le poids de la loi, la justice est aveugle*). Au niveau syntaxique, on voit des phrases caractéristiques considérablement compliquées (*Le juge doit soulever d'office la nullité basée sur l'irrégularité de fond lorsqu'elle touche à une règle d'ordre public*);

3. les problèmes particuliers liés à la définition de la spécificité du discours juridique et les problèmes particuliers, tels que la manifestation du genre culturel de la communication, les caractéristiques pragmatiques (ainsi le verbe *motiver* permet une réelle concision: *La sentence doit être motivée*);

4. le langage juridique simple et la complexité le langage juridique (celle des documents juridiques et des lettres juridiques) ce qui pose le problème de la compréhension par les "non-avocats". Diverses mesures sont proposées pour simplifier le langage juridique: remplacement des termes juridiques proprement dits par des termes plus compréhensibles pour le grand public; suppression de l'utilisation des termes juridiques latins et remplacement de ceux-ci par des termes formés à partir de mots ordinaires; éviction des termes juridiques latins et des termes de base;

5. la traduction juridique. Premièrement, il faut tenir compte de la présence des minorités nationales qui ne possèdent pas ou qui maîtrisent mal la langue nationale. Deuxièmement, il y a l'absence d'équivalents dans la traduction des textes juridiques.

Troisièmement, il faut parler de la complexité de la traduction en fonction des différences entre les systèmes juridiques;

6. l'expertise linguistique dont le champ d'application comprend le plagiat, la paternité, la tromperie et la fraude, la protection des marques, la traduction juridique, l'expertise phonétique et graphologique, l'analyse du discours;

7. le jargon juridique avec une grande variété d'unités nominatives;

8. la lexicographie juridique. De nos jours, il existe de nombreux dictionnaires juridiques différents dans de différentes langues. De plus la lexicographie juridique est largement représenté sur les supports électroniques et sur Internet.

Conclusion

Le temps le plus récent du développement de la linguistique juridique se caractérise par sa transformation progressive dans une société indépendante en discipline scientifique. Ce développement témoigne que la linguistique juridique russe et française se renouvelle activement dans de nombreux domaines – non seulement sur le plan scientifique et pratique, ce qui se manifeste dans l'activité sociale des différentes branches: économique, informative, pédagogique, etc. Il y a un grand intérêt pour le renforcement du rôle de la linguistique juridique dans l'enseignement supérieur, en raison d'une forte demande dans les cadres capables de combiner les connaissances et les compétences linguistiques et juridiques.

Références

1. Dullion V. Droit comparé pour traducteurs // Revue internationale de Sémiotique juridique. 2015. № 28 (1), pp 91–106.
2. Shagieva G. R. The origins of legal linguistics // StudNet. 2022. № 5. [En ligne]. URL: file:///C:/Users/natbo/Downloads/istoki-yuridicheskoy-lingvistiki%20(1).pdf (consulté le 2 décembre 2024).
3. Maingueneau D. Le discours juridique comme discours constituant // *Actes Sémiotiques*, 2023. №128. [En ligne]. URL: https://doi.org/10.25965/as.7832(consulté le 2 décembre 2024).

Юридическая лингвистика: характеристики и задачи новой науки

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Аннотация. Рассматриваются сущность и предмет юридической лингвистики как научной дисциплины, взаимосвязь юридической лингвистики с другими науками, актуальные вызовы юридической лингвистики. Показаны проблемные аспекты изучения юридической лингвистики, к числу которых относятся: исследование документов источников, изучение состава юридических терминов с точки зрения их происхождения и различий между юридическим языком и другими слоями литературного языка, составление различных типов юридических документов, юридический перевод, лингвистическая экспертиза и юридический жаргон.

Ключевые слова: юридическая лингвистика, юридический дискурс, правовая коммуникация, юридический язык

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Theoretical and legal analysis of the concept of legal ideology

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Abstract
The article examines the theoretical and legal analysis of the concept of legal ideology as a key element of legal consciousness. Its role in the law-making process and the formation of public perception of law is examined. Various approaches to the definition of legal ideology are analyzed, its complex nature and relationship with social and normative processes are emphasized. The work examines the historical aspects of legal ideology, its evolution from an instrument of state propaganda to a complex mechanism influencing legal culture and law and order. It also analyzes controversial issues about its functional purpose, including normative, regulatory and educational roles. It is noted that in the context of digitalization and the formation of a multipolar world, legal ideology is becoming an important tool for regulating legal relations and stabilizing the legal system. The conclusion emphasizes the need for further research in this area to identify new mechanisms of its impact and determine development prospects.
Keywords: digitalization, legal consciousness, legal culture, legal ideology, legal order.

Introduction

Legal ideology plays a key role in the formation and development of legal consciousness, influencing the law-making process and public perception of law. In recent years, interest in the categories of "ideology" and "legal ideology" has increased significantly. Despite the widespread use of this term in legal science, its content remains a subject of debate. Various approaches to defining legal ideology emphasize its complex nature. In the context of digitalization and the formation of a multipolar world, it is becoming an important tool that determines not only the perception and interpretation of legal norms, but also the development strategy of the state. As noted by A.I. Klimenko and A.M. Mikhailov, legal ideology performs the function of legitimizing the rule of law, adapting to changing social conditions [2;3]. In modern society, its importance is increasing against the backdrop of rapid technological development, changes in the structure of public communications and the formation of new legal values. These processes require an in-depth analysis of the mechanisms of influence of legal ideology and the search for new methodological approaches to its study.

Diversity of approaches to understanding legal ideology

Historically, the concept of "ideology" goes back to the works of Destutt de Tracy, who defined it as "the science of ideas" [1]. Over time, the interpretation of this term has undergone significant changes, which has led to the emergence of many approaches to its understanding. Modern research demonstrates the absence of a single generally accepted definition of legal ideology, which complicates its theoretical understanding. As O.E. Leist emphasized, legal consciousness, and with it legal ideology, are multi-component phenomena that require interdisciplinary analysis.

A.I. Klimenko considers legal ideology through the prism of the idea of law itself, arguing that their nature is identical. In addition, he emphasizes that legal ideology can be

considered as one of the functions of the idea of law [2].

Attention to the concept of "legal ideology" in modern legal science is due to its complex and multifaceted nature. According to A.M. Mikhailov, legal ideology is not just a set of ideas, but a holistic mechanism that influences the legal consciousness of society, forming normative attitudes and models of legal behavior [3]. Unlike legal doctrine, which represents scientifically substantiated concepts and theoretical developments, legal ideology is focused on transmitting value attitudes aimed at legitimizing the legal system. It creates stable ideas about justice, freedom, equality and the rule of law, which directly affects the public perception of law and its implementation.

It follows from the above that legal ideology is not just a set of legal ideas, but a holistic system that forms normative attitudes and social guidelines. It has evolved from a tool of state propaganda to a complex phenomenon that influences legal consciousness and the rule of law. The traditional division of legal consciousness into legal ideology and legal psychology does not always reflect its complex nature, since ideas are formed under the influence of not only rational but also social factors. Legal ideology can express the interests of various groups, ranging from narrowly focused party concepts to universal doctrines aimed at justifying the rule of law and regulating social relations.

The question of the functional purpose of legal ideology remains debatable. In some concepts, it is considered as a form of distorted knowledge, designed to justify the existing social and legal system. However, this approach is limited, since it does not take into account the multidimensionality of ideological influence. A more productive point of view seems to be that legal ideology is a mechanism that structures legal consciousness and ensures the normative consistency of the legal order. In this regard, M.K. Mamardashvili compared ideology to "social glue" that connects individuals into a single legal system [4]. From this position, legal ideology acts not simply as a set of legal ideas, but as a specific instrument for the institutionalization of the legal order.

Some of the main functions of legal ideology include the legitimization of positive law, the streamlining of legal consciousness and the formation of a legal culture. As A.M. Mikhailov notes, legal ideology does not simply reflect existing legal norms, but actively participates in their creation, adaptation and transmission to public consciousness [3]. It acts as an important tool for the formation of legal reality, ensuring the consistency of legal norms, the elimination of contradictions in law enforcement practice and the creation of a single legal space necessary for the sustainable development of the legal system. Along with the regulatory function, legal ideology plays an important educational role, contributing to the formation of the legal identity of citizens. It integrates law into cultural and political processes, creating a stable legal environment. In this context, the study of the mechanisms of its influence remains a relevant area of legal science, especially in the context of the transformation of legal systems and the digitalization of society.

Conclusion

To sum up the study, we can conclude that legal ideology is an integral element of legal consciousness. It determines the vectors of development of the law-making process and ensures the adaptation of the legal system to new social challenges. Unlike legal doctrine, legal ideology affects not only scientific and normative aspects, but also socio-

psychological mechanisms, influencing the legal culture and behavior of citizens. In the context of the accelerating transformation of the world order, its importance increases, requiring a deeper analysis of its functions and mechanisms of influence. At the same time, there are many approaches to understanding legal ideology, and each of them focuses on its individual aspects, but only their combined analysis allows us to form a holistic understanding of this phenomenon within the framework of the general theory of law. On the one hand, this complicates scientific communication, but on the other hand, with the proper research approach, it makes it possible to take into account various characteristics of legal ideology, forming its multi-level understanding. At the same time, the absolutization of any of its features leads either to a narrowly utilitarian interpretation, devoid of theoretical significance, or to the mythologization of the concept. It seems optimal to consider legal ideology as a mechanism that organizes the ideological sphere of a modern politically structured society, which makes it in demand in modern conditions due to its ability to ensure normative consistency and maintain the stability of the legal order.

References

1. Trasi D. D. Osnovy ideologii. Ideologija v sobstvennom smysle slova [Fundamentals of ideology. Ideology in the proper sense of the word]. Moscow, Akademicheskij Proekt; Al'ma Mater, 2013, 334 p. (Rus)
2. Klimenko A. I. Pravovaja ideologija sovremennogo politicheski organizovannogo obshhestva: monografija [Legal ideology of a modern politically organized society: monograph]. Moscow, Norma, 2023, 384 p. (Rus)
3. Mihajlov A. M. Ponjatie pravovoj ideologii i ego mesto v sostave teoretiko-pravovogo znanija [The concept of legal ideology and its place in the theoretical and legal knowledge]. Vestnik Rossijskogo universiteta druzhby narodov, Serija: Juridicheskie nauki, 2017, T. 21, № 3, pp. 355-379. (Rus)
4. Mamardashvili M. K. Ocherk sovremennoj evropejskoj filosofii [An essay on modern European philosophy]. Moscow, 2010, 63 p. (Rus)

Теоретико-правовой анализ понятия правовая идеология

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Аннотация. В статье рассматривается теоретико-правовой анализ понятия правовой идеологии как ключевого элемента правосознания. Исследуется её роль в правотворческом процессе и формировании общественного восприятия права. Анализируются различные подходы к определению правовой идеологии, подчёркивается её многосложная природа и взаимосвязь с социальными и нормативными процессами. В работе рассматриваются исторические аспекты правовой идеологии, её эволюция от инструмента государственной пропаганды до сложного механизма, влияющего на правовую культуру и правопорядок. Также анализируются дискуссионные вопросы о её функциональном назначении, включая нормативную, регулятивную и воспитательную роли. Отмечается, что в условиях цифровизации и формирования многополярного мира правовая идеология становится важным инструментом регулирования правовых отношений и стабилизации правовой системы. В заключении подчёркивается необходимость дальнейших исследований в данной области для выявления новых механизмов её воздействия и определения перспектив развития.

Ключевые слова: правовая идеология, правовая культура, правопорядок, правосознание, цифровизация.

УДК 62-783

Multifunctional student co-living of superior comfort on the campus of TSTU

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Abstract
This paper considers multifunctional student co-living on the campus of TSTU. Co-living is a type of cohabitation for people with common intentions. Unlike a hostel, a distinctive feature of this type of housing is joint activities, such as eating or communication in common living areas. It is also the presence of a well-equipped co-working space. Today the design of student co-living is very important, because thanks to the presidential program of campus expansion, it is necessary to improve the quality of student accommodation to make it more modern and diverse. The article clarifies the concept of campus. A campus traditionally refers to the land and buildings of a college or university. The campus also includes academic, laboratory, residential, sports, administrative, and housekeeping buildings. However, public spaces also play an important role in the campus structure.
Key words: co-living, student dormitory, campus, territory of coliving.

Introduction

Today, a higher education institution is a unity of science, socio-cultural life, and professional environment, forming the composition of many public spheres, institutions and institutions. In this regard, the approach to the organization of the architectural and spatial environment is becoming more responsible and multitasking.

Universities have always been the center of attraction for people pursuing the goals of education, work and scientific activity. As a result, there is a need to provide people with temporary housing.

However, student dormitories are often separated from the university environment by their isolation and the almost complete transfer of social activities to the university. A change in the approach to the design of dormitories will make it possible to give student life outside the university the popularization of interpersonal live communication, teamwork in appropriate conditions, convenience of using functions necessary for the performance of household chores, etc.

The layout of the territory of the co-living

Thanks to the presidential program of expansion of university colleges, it is necessary to improve the quality of student accommodation and make it more modern and diverse.

The existing buildings of dormitories require transformation to meet modern trends and requirements, but it is not always possible to do this and fully demonstrate the appearance of modern housing for students. In the article a space-planning solution for a multifunctional student accommodation of increased comfort on the TSTU campus with landscaping of its territory is developed. In modern design practice, the design of multifunctional complexes has become one of the sustainable trends [1]. The layout of the territory of the co-living has been carried out with the installation of green areas, above-

ground parking lots. The designed building meets all modern architectural, structural and technological requirements.

It is assumed that the new college will be located in the northern part of the city of Tambov, on the campus of TSTU along Michurinskaya Street. At the moment old garages are located on the territory. The architectural solutions used in the co-living project are explained by the functional process, optimal use of the allocated territory, urban planning factors, surrounding buildings are aimed at improving the functional properties of the dwelling, the moral durability of planning solutions, and the aesthetic appearance of buildings. The main facade and the perspective image of the "Multifunctional student accommodation of superior comfort on the campus of TSTU" are shown in Figs 1 and 2.

Figure1 - The main facade of the "Multifunctional student accommodation of superior comfort on the campus of TSTU"

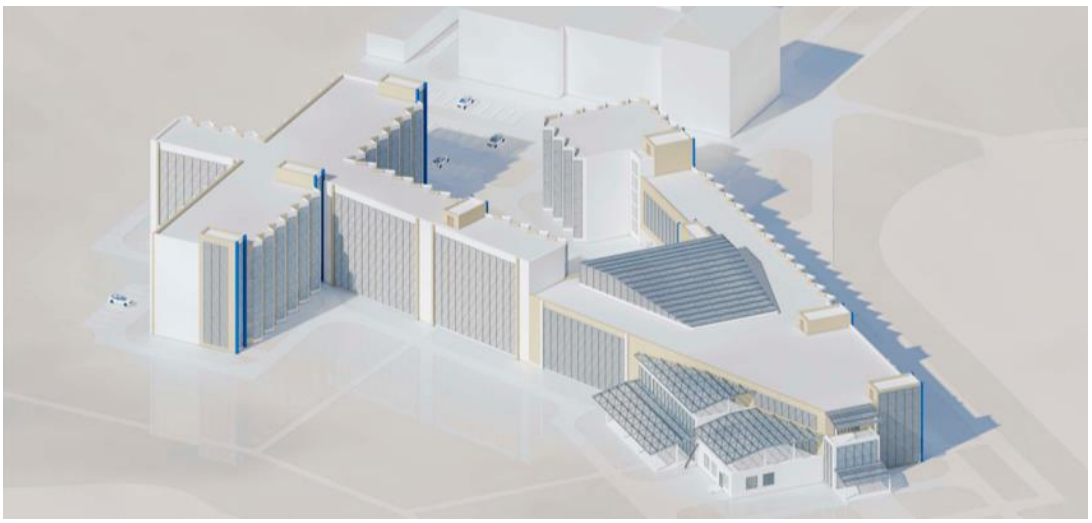

Figure 2 - Perspective image of the "Multifunctional student accommodation of increased comfort on the campus of TSTU"

The final design step is the master plan with its landscaping. The development of a master plan for multifunctional student clearing is carried out taking into account the current situation. It already provides for the main ground buildings and structures along with adjacent land plots.

Conclusion

In the course of the work, several important tasks have been solved:

- creation of an architectural environment that fully ensures the comfort and convenience of students' lives;
- the approach of residents to the natural environment and the entry of the natural environment into buildings;
- providing residents with the necessary services.

The projected roofing meets all the aesthetic, constructive, technological, urban planning, economic, engineering, environmental requirements and fits seamlessly into the existing building.

References

1. Barsukova N. I., Zhukova I. V. Mnogofunkcional'nye kompleksy kak odna iz tendencij organizacii sovremennoj komfortnoj sredy [Multifunctional complexes as one of the trends in the organization of a modern comfortable environment] // Manuskript. 2021. №11., 2021, no. 11 Available from: https://cyberleninka.ru/article/n/mnogofunktsionalnye-kompleksy-kak-odna-iz-tendentsiy-organizatsii-sovremennoy-komfortnoy-sredy/viewer (Accessed 29.11.2024). (Rus)

Многофункциональный студенческий коливинг повышенной комфортности на территории кампуса ТГТУ

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Аннотация. В статье рассматривается многофункциональный студенческий коливинг на территории кампуса ТГТУ. Коливинг - тип совместного проживания для людей с общими намерениями, а в отличие от общежития отличительной чертой такого типа жилья являются совместные мероприятия, например, такие как приём пищи или коммуникация в общих жилых зонах. Также это наличие обустроенного коворкинга (совместного рабочего пространства). На сегодняшний день проектирование студенческих коливингов очень актуально, т.к. благодаря президентской программе расширений студенческих кампусов, необходимо улучшать качество проживания студентов делать его более современным и разнообразным. Кампус – это студенческий городок, который включает в себя территорию и здания университета. В состав кампуса входят также учебные, лабораторные, жилые, спортивные, административные, хозяйственные корпуса. Однако общественные пространства так же играют немаловажную роль в структуре кампуса.

Ключевые слова: кампус, коливинг, студенческое общежитие, территория коливинга.

УДК 65.011.56

Development of CRM system for a law firm

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Abstract
The article considers the results of analyzing the needs of law firms in the use of customers relationship management (CRM) systems. The pros and cons of using CRM systems are highlighted. The basic structure of CRM-systems is considered. The stages of CRM system development are described.
Keywords: customer relationship management (CRM), CRM-systems development, , CRM systems in law.

Analysis of the needs of law firms in the CRM system

As a result of a thorough analysis of the activities of various law firms, several information processes have been identified that are quite complex to implement and require a lot of time. One of the most significant and complex processes is the customer relationship management process, which plays a key role in the company's success. The difficulties encountered in performing this process are due to the fact that usually one employee of the company simultaneously provides services to several clients, which leads to the need to record and process the data of each of them. As a result, there is often confusion, errors in data, incorrect problem setting, and many other problems. As law firms strive to simplify the process of providing services, as well as improve both the speed and quality of work with clients, they need to minimize the number of errors that occur while working with client data. The simplest, most affordable and effective solution to the problem is to use a special program to automate this process – a CRM system that greatly simplifies customer interaction and avoids many mistakes.

The pros and cons of CRM systems

CRM (Customer Relationship Management) is a system that allows you to manage customer relationships. Maintaining a database with customer information is the main purpose of this type of system, in simple terms.

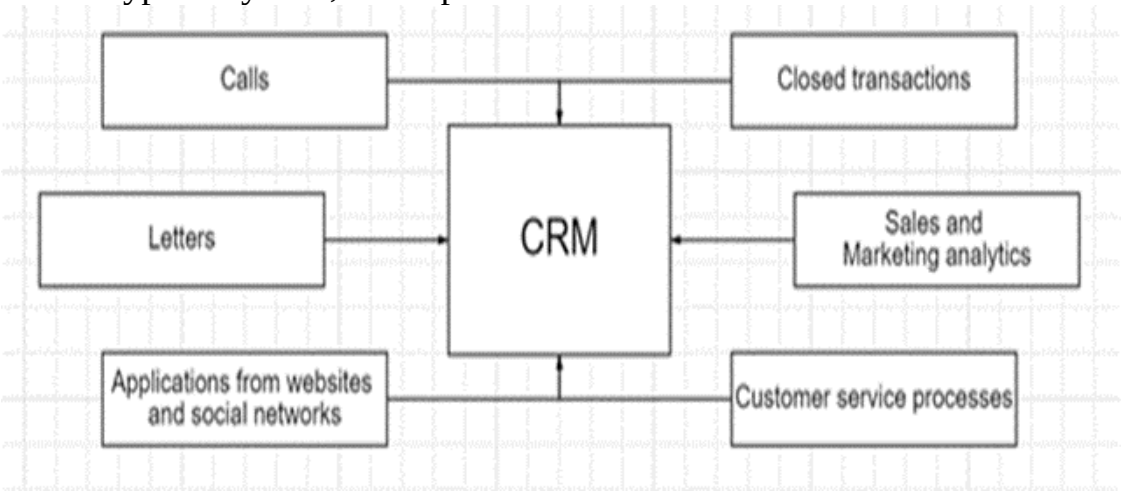

Figure 1 – CRM system features

The next section will outline some of the most significant advantages that the use of CRM systems provides:

✓ extend the time spent reaching out to clients and resolving their problems;
✓ increase in the number of new customers;
✓ increasing the efficiency of customer service;
✓ providing real-time event updates to current and prospective clients;
✓ boosting client satisfaction;
✓ employees' availability of current client information.

The following are the primary drawbacks of utilizing a CRM system:

✓ expenses for specialists in information support of the CRM system;
✓ employee education regarding the new information system;
✓ payment for the software's technical support.

The comparison shows that the CRM system, also known as the customer relationship management system, has numerous beneficial features that can greatly enhance the performance of the business. However, substantial financial investments are needed for the system's establishment and ongoing maintenance in order for it to operate fully and provide all potential benefits.

The basic structure of the CRM system

A CRM system, like any other system, has several main components in its composition. The main components of a CRM system include:

✓ customer database: includes details about each client, including contacts, past interactions with the business, purchases, advertising choices, and other data that helps better understand the client's needs;

✓ customer service and sales process management: The CRM system offers the chance to efficiently handle the complete sales process, which involves establishing and preserving leads as well as establishing and sustaining relationships with both current and potential clients.

✓ marketing tools: CRM systems come with a suite of marketing tools that let you use newsletters, plan and coordinate campaigns, and assess the efficacy of marketing initiatives;

✓ analytics tools: The CRM system includes integrated data analysis, reporting, and information visualization capabilities that enable businesses to make evidence-based decisions;

✓ user interface: The CRM system's user-friendly and intuitive interface is crucial to its effective operation because staff members need to be able to traverse it with ease in order to get the information they need and finish duties on time;

✓ service support: The CRM system has a wide range of functionality for monitoring work with customer requests, providing fast and high-quality customer support.

Numerous parts and modules make up the fundamental framework of a CRM system, which aids businesses in efficiently managing their client connections. By comprehending these components, a company may boost overall efficiency and revenue in addition to providing better customer service.

Stages of CRM system development

The process of creating a customer relationship management system, or CRM system, involves a number of crucial steps, each of which contains particulars and crucial elements that must be considered for the project to be completed successfully.

Analysis of the company's business procedures and client needs. Studying business processes and determining non-automated operations that can be improved with a CRM system are part of this step. It is also necessary to determine the requirements for the system parameters, taking into account important features and business goals. Proper execution of this stage will allow developers to create the most effective CRM system for the customer company.

Functional planning and selection of the platform. This step is intended to thoroughly identify the functional set that will be included in the CRM system and to choose the development platform that best suits the company's requirements. Determining which modules and other features will be most helpful for a specific client organization is just as crucial as identifying the system's primary functions. This will result in a successful solution that optimizes company procedures and increases user happiness. In order to select a platform that offers a dependable and scalable architecture for future business expansion, technological opportunities and limitations should also be taken into account at this point.

Database and user interface design. The stage includes designing a database for storing client information. The user interface is also being developed, which must meet the criteria for the quality of the user interface, for example: intuitiveness and ease of use. Taking into account the needs of users, an interface is being created that will allow them to work effectively with the data in the system.

Development and integration of modules, testing. At this point, a thorough database architecture is completed, which will be utilized to house all required client data, such as contact information, preferences, and past interactions. This stage also involves the development of the user interface, which must satisfy a number of quality standards, including crucial elements like intuitive clarity, usability, and simplicity of navigation. An interface that is as easy and efficient as feasible is being developed with end users' needs in mind. This will enable them to work with data in the system quickly and easily, increasing user happiness and overall productivity.

Implementation of the system and staff training. The process of incorporating the new CRM system into the business's current operations is part of this crucial phase. Simultaneously, the company's staff members receive extensive training designed to acquaint them with the key components of operating within the new system. The training consists of both theoretical and practical exercises, allowing staff members to become proficient in the system's operation, learn how to carry out different tasks, and address new issues as they arise.

Technical support and maintenance of the system. At this point, ongoing technical support is typically set up to give users the tools they need to handle new issues as they arise. To quickly address any problems or tasks that may come up while users are

interacting with the system, technical support is necessary. It covers troubleshooting, helping users navigate features, and answering support queries. Regular system updates are also a crucial component of maintenance since they enable you to maintain the system current, offer new features and enhancements, and guarantee data security.

The development of a CRM system is a complex process in which the correct execution of each stage is important, since an error at any stage can lead to a delay in the completion of the project and additional costs for correcting errors.

Conclusion

As a result of the analysis and the work done, the following conclusions can be drawn:

– law firms must use CRM systems in order to streamline the service delivery process and improve the caliber of work with clients;

– the CRM system, like any other software, has benefits and drawbacks. For instance, the CRM system's benefits include extending useful working hours, bringing in new clients, and increasing service delivery efficiency; the drawbacks include the expenses of hiring support specialists, educating staff to use the system, and paying for technical support;

– the CRM system has a basic structure, which includes customer database, sales management, marketing tools, service support;

– each step of system development must be properly completed to create a CRM system. These steps include platform selection and functional planning; database and user interface design; module development; integration and testing; system implementation and staff training; technical support; and system maintenance.

Therefore, it is evident that a legal firm can benefit much from the usage of a CRM system, however, the choice to use such a system should be carefully considered and balanced.

References

1. Dolgnostnaya instrukcia urista i uristkonsulta [Job description of a lawyer and legal adviser]. Available from: https://you-right.ru/stati/yuridicheskiy-menedzhment/dolzhnostnaya-instrukciya-urista-i-uriskonsulta (Accessed 15.12.2024). (Rus)

2. Krickaya M. Preimyshestva CRM-sistemi: vse plusi i minysi [Advantages of a CRM system: all the pros and cons]. Available from: https://kontur.ru/articles/6097 (Accessed 15.12.2024). (Rus)

3. Avtomatizaciya s nyla. Razrabotka CRM-sistemi: osnovnie etapi, funkcii i preimyshestva [CRM system development: main stages, functions and advantages]. Available from: https://a0.group/blog/razrabotka-crm-sistemy/ (Accessed 15.12.2024). (Rus)

Разработка CRM-системы для юридической компании

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Аннотация. В статье рассмотрены результаты анализа потребности юридических компаний в использовании систем управления взаимоотношениями с клиентами. Выделены плюсы и минусы использования CRM-систем. Рассмотрена базовая структура CRM-систем. Описаны этапы разработки CRM-систем.

Ключевые слова: CRM, разработка CRM-систем, управление взаимоотношениями с клиентами, CRM-системы в юриспруденции.

УДК 81' 37

Threats to the economic security of public catering enterprises and their prevention (using the example of the Perun restaurant in Tambov)

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Abstract
The study aims to identify factors that negatively affect the economic security of public catering enterprises, using the example of the Perun restaurant located in the city of Tambov. The most significant threats include: disruption of food supplies due to government sanctions, insufficient level of demand from consumers, cases of customer insolvency, there is a shortage of qualified personnel. Based on the results of the analysis, recommendations were developed to minimize the identified risks.
Keywords: threats**,** economic security, public catering, catering industry, political risks, economic risks, social risks, industry-specific threats, company-specific threats.

Introduction

The problem of the development of the catering sector in the modern economic conditions of Russia is of particular theoretical and practical interest, since the catering market is an important element of the economy. Catering is one of the key socially significant industries in the context of ensuring the economic security of the state.

The economic security of an enterprise is the protection of the vital interests of an enterprise (entrepreneur) from threats, which allows to preserve and effectively use the material, financial and human resources. A large number of scientists agree with this definition. But the list of threats to economic security and their prevention raises many questions.

Earlier, this problem was raised in the work of N. P. Vasilyeva and V. S. Zhikhareva. The authors investigated the threats and assessed the economic security of public catering enterprises. [1] V. V. Shalabin in his work considered the problem of the development of the catering industry in modern economic conditions. [2]

The purpose of the article is to identify threats, compile a list of measures to reduce threats to economic security and justify their expediency for the Perun restaurant.

Materials and methods

There are threats that refer to the entire catering industry; they are divided into general and specific. They can be classified and presented in the form of a diagram shown in Fig.1. Possible general threats include:

- political risks that are a consequence of the policy pursued in the state;
- economic risks that are associated with the dynamics of such indicators as changes in the Central Bank's key rate, changes in the inflation rate and the exchange rate of foreign currency;
- social risks that are characterized by public opinion about the organization, the influence of the media, as well as the style and standard of living of citizens, the demographic situation in the country and its dynamics.

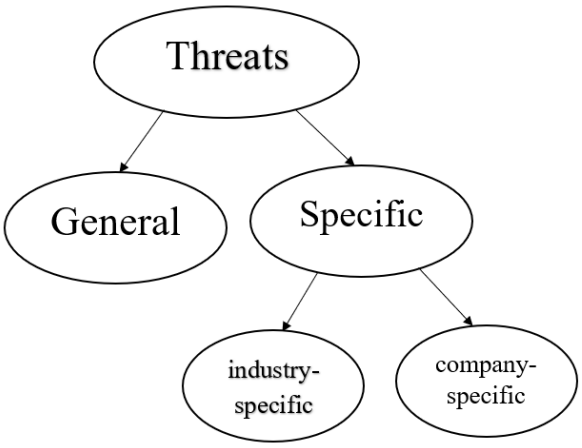

Figure 1 - Classification of threats in public catering.

Possible specific threats include:

- the risk of using low-quality raw materials and equipment;
- the risk of an ineffective marketing strategy that lies in the wrong choice of the target segment of a catering establishment.

Specific threats are divided into industry-specific: seasonality and possible failure of product supplies, sales growth of an alternative product; and company-specific: food contamination, disruption of the technological process, and harm to the environment.

Results and discussion

Many catering enterprises face problems and factors that previously had little effect on their activities, but in reality served as a threat to the existence of organizations. The main threats to the economic security of the restaurant under study are listed below.

1) interruptions in food supplies due to the introduction of state sanctions;
2) insufficient demand from the population;
3) insolvency of consumers of services;
4) staff shortages;

The sanctions have affected the interaction with suppliers, prices and logistics. There are foreign partners who today refuse to work with buyers from the Russian Federation. There were problems with making the payment. Due to difficulties with logistics, the cost of products began to increase. The main measures to combat the risk of *possible disruptions of food supplies due to the imposed state sanctions* are to expand the list of potential exporting suppliers in advance, refocused on more favorable long-term terms of food supply contracts, or to cooperated with domestic manufacturers providing analogues of products. It is necessary to urgently revise the menu – exclude some items that have become scarce.

Insufficient demand of the population leads to a decrease in turnover, an increase in the level of costs and, accordingly, to inefficient functioning of enterprises, which in market conditions means their bankruptcy. This risk can be eliminated by developing effective loyalty programs, including discounts and happy hour services. Constant changes in the assortment of the offered menu and studying a systematically customer needs.

The decline in household incomes has a negative impact on the catering market. In such circumstances, people tend to save money, switch their attention to cheaper alternatives, reduce the number of visits to restaurants. This leads to a reduction in catering facilities. Given the *drop in real incomes* of the population, in order to retain customers, it is necessary to temporarily reduce the trade margin to the lowest possible (margin), the possible introduction of budget business lunches.

The shortage of employees has a negative impact on the level of service: waiting time increases, the quality of service decreases. *Staff shortages* are a threat that can be reduced by increasing wages and incentive bonuses, reviewing the working hours and training personnel at the enterprise.

Conclusion

As a result of the study, it was revealed that the Perun restaurant is threatened by the following risks: interruptions in the supply of food due to sanctions, insufficient demand from the population, consumer insolvency and staff shortages. The identified threats pose a danger and can lead to loss of profits and customers. In turn, a well-thought-out risk management system and the connection of all available resources will allow the restaurant to continue its activities in the current political situation.

References

1. N. P. Vasilyeva, V. S. Zhikhareva. Sovremennye podhody k organizacii bezopasnosti predpriyatij sfery obshchestvennogo pitaniya v Ural'skom regione [Modern approaches to the organization of the safety of public catering enterprises in the Ural region]. Ural, 2016. 143 p. (in Russ.)
2. V. V. Shalabin. Obespechenie bezopasnosti dlya predpriyatij pitaniya na baze Vysshej shkoly kulinarnogo masterstva [Ensuring safety for food enterprises on the basis of the Higher School of Culinary Skills]. St. Petersburg, 2018. 155 p. (in Russ.)

Угрозы экономической безопасности предприятий общественного питания и их предотвращение (на примере ресторана "Перун" в Тамбове)

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Аннотация. Рассмотрены факторы, негативно влияющие на экономическую безопасность предприятий общественного питания, на примере ресторана "Перун", расположенного в городе Тамбове. К наиболее значимым угрозам относятся: перебои с поставками продовольствия из-за правительственных санкций, недостаточный уровень спроса со стороны потребителей, случаи неплатежеспособности клиентов, нехватка квалифицированного персонала. По результатам анализа были разработаны рекомендации по минимизации выявленных рисков.

Ключевые слова: угрозы, экономическая безопасность, общественное питание, индустрия общественного питания, политические риски, экономические риски, социальные риски, отраслевые угрозы, угрозы для компаний.

УДК 338.2

The new deal – Roosevelt's program against the great depression

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Abstract
The paper provides an overview of a set of reforms known as the New Deal program proposed by Franklin Delano Roosevelt to fight the greatest economic crisis in the history of the United States in the 20th century, the Great Depression, and examines the reasons that lead to this crisis.
Keywords: New Deal, Great Depression, US economic history.

Introduction

After the end of World War I, the United States experienced one of the most vibrant periods in its history, the Roaring Twenties. It was a time of transition to a peaceful life, dynamism in the arts and culture, and technological progress. The frivolous spirit of the era was also present in the economic sphere of life.

However, in the fall of 1929, the harmony in American society came to an end in the form of an economic crisis known as the Great Depression. Overcoming the economic and social consequences of this crisis required the U.S. government to develop new approaches to governing the country.

In 1932, after becoming president, Franklin Delano Roosevelt introduced the New Deal, a set of reforms designed to save America from financial disaster. This paper will examine the reasons why a new economic policy was needed in the United States, and give an overview of the reforms of the 32nd President of the USA.

The United States in the 1920s - Setting the Stage for the Great Depression

The U.S. economy boomed in the 1920s, with national income rising from $32 billion in 1913 to $89.7 billion in 1927. Money earned during the war years from munitions, transportation, and food shipments to Europe was invested in building and equipping factories and plants with the latest technology. As a result, production became more profitable, dividends increased, and stock prices rose.

However, the stock market crash would not have happened without problems on the stock market. The number of shareholders increased. The value of securities issued in the United States in the 1920s exceeded $50 billion. Buying and selling stocks was so profitable that investors preferred to buy them on the secondary market rather than invest in production. The growth of lending to portfolio investors was facilitated by low interest rates set by commercial banks. The overvaluation of assets reached a maximum and the stock market situation caused financial "overheating". The U.S. economy in 1929 provided a vivid example of a financial "bubble", as economists P. Samuelson and W. Nordhaus later called it [3].

The crash and its aftermath

The beautiful idyll of the "Roaring Twenties" was shattered on October 24, 1929, and the country was plunged into darkness. Four "black" days were followed by four "black" years that went down in history as the Great Depression. On that day, the world's oldest stock market indicator, the Dow Jones Industrial Average, fell 9%. The following week, the decline was 17.3%. The total value of companies fell by $14 billion.

The financial sector was the first to feel the crisis. Many stocks fell by 100 points or more. U.S. bank assets fell sharply as depositors sought to withdraw deposits. Most bank assets were securities and securities loans, but the crisis devalued them. Real estate mortgages lost value, making loans uncollectible. The U.S. banking industry was almost completely destroyed during the Great Depression. Between 1929 and 1932, 5,760 banks with total deposits of $3.5 billion ceased to exist [3].

The industrial sector also suffered. As consumer spending began to decline, demand fell and production levels dropped significantly. Many companies went bankrupt because of debt they could not repay, and layoffs began. By 1933, U.S. industry had shrunk by 46% [1].

The most serious problem was the situation in agriculture. Prior to the crisis, agriculture had contributed about 12% of the U.S. GNP and employed 25% of the country's labor force. As the purchasing power of the population decreased, the prices of agricultural products also fell: corn became 2.7 times cheaper, cotton - 3 times cheaper. During the Great Depression, about 1 million farms went bankrupt.

During the depression, the volume of GNP in current prices decreased almost 1.9 times. The production of capital goods decreased more than that of consumer goods. According to the data presented in the collective work "Recent Social Trends in the United States", initiated by the then President of the United States Herbert Hoover, the indicators of the GDP of the USA fell by 8.5% in 1930, and two years later, in 1932 - by 12.9%.

Looking for solutions - policies of H. Hoover

All of the above problems undoubtedly required a centralized solution with government intervention. The 31st President of the United States, Herbert Hoover, elected in early 1929, faced a difficult task. Contrary to popular opinion that Hoover did not try to save the nation's economy in any way, the president did take some action. He injected huge sums of money into the banking system in an attempt to prevent bankruptcies, which did not help - the banks continued to fail. Hoover was also active in tax policy, raising the marginal income tax rate from 25% to 63%.

In 1932, Hoover created the Reconstruction Finance Corporation (RFC), which functioned as a parallel central bank, empowered by Hoover to lend to businesses in need without reporting to Congress. In its first year, the Corporation issued $2.3 billion in loans [5].

To some extent, the policies of the next U.S. president, F.D. Roosevelt, called the New Deal, were not entirely unique, but served as a continuation of Hoover's policies.

F.D. Roosevelt and the New Deal

In 1932, Franklin Delano Roosevelt won the election with 57% of the vote, winning all

but six states, and began to implement his program. The New Deal was not a well-planned system of political action. Rather, Roosevelt relied on a radical approach. To maximize productivity, the president persuaded Congress to grant him emergency powers. The central role of government was to maintain business activity and industrial production.

Roosevelt began his anti-crisis policy with the so-called "100 days," a period that began with his inauguration on March 4, 1933. One of his first major actions was to declare a "bank holiday" on March 5, 1933. From March 6 to March 10, U.S. banks were closed for four days, during which an emergency issue of $2 billion in currency was made. On March 12, only the most viable banks approved by Roosevelt were allowed to reopen. 40% of the banks were liquidated. The Reconstruction Finance Corporation, created under Hoover, took over the functions of the failed banks.

New legal norms were introduced. To protect depositors' funds, only special investment banks were allowed to issue shares for industrial companies. In May 1933, the Securities Act was enacted, making the issuing company fully responsible for the accuracy of information about its condition and affairs.

Roosevelt's fiscal policy was aimed at helping the hardest hit populations - farmers and the unemployed. Government agencies purchased raw materials, equipment, and supplies to restore production. For people who had lost their jobs, the government carried out public works that cost a total of $12 billion by 1939. The result of such a heavy use of the federal budget was a deficit, but the president considered this an acceptable price to pay for economic growth.

Monetary policy was the most expansionary: supply grew by more than 10%, while output grew by 8%. Federal Reserve policy under Roosevelt shifted from buying government bonds to expanding Treasury operations in the gold market. The gold purchases triggered an influx of money from Europe into the United States, creating a supply-shock effect in the U.S. money market [4].

The key to restoring the nation's economic stability was undoubtedly the revival of manufacturing. In June 1933, the National Industrial Recovery Act (NIRA) was passed, establishing practices to regulate government production. The act comprised The Codes of Fair Competition which enforced production output and minimum price levels. Higher wage rates were also introduced [2].

Infrastructure projects were also developed. Thanks to government investment under the New Deal, 480 airports, 78,000 bridges, 780 hospitals, 572,000 miles of highways, and more than 15,000 schools, hospitals, courthouses, and other public facilities were built in the United States. As a result of F.D. Roosevelt's actions, 2.5-3 million Americans were employed annually.

Conclusion

It is debatable how successful the New Deal was, but it certainly improved the lives of Americans who lost their finances and jobs in 1929. Franklin Delano Roosevelt not only reformed the economic system, but he also tried to integrate all public areas to combat the crisis. Thus, the New Deal was an important step in the formation of the U.S. economy, although the final "salvation" of the country from the Great Depression was World War II,

during which the U.S. re-entered the world market and supplied European countries with everything they needed for the war.

References
1. Historical Statistics of the United States. Colonial Times to 1970. – Washington: U.S. Department of Commerce, Bureau of Census, 1975. URL: https://fraser.stlouisfed.org/files/docs /publications/histstatus/hstat1970_cen_1975_v1.pdf (Accessed 25 February 2025)
2. National Industrial Recovery Act, 1933. URL: https://www.archives.gov/milestone-documents/national-industrial-recovery-act (Accessed 25 February 2025)
3. Nureev R.M., Latov Yu.V. et al. Velikaya depressiya i velikaya reforma: Uspekhi i provably ekonomicheskoi politiki Ruzvelta (Great Depression and the Great Reform: Successes and Failures of Roosevelt's Economic Policy). Moscow, INFRA-M, 2016. – 224 p. (in Russian)
4. Romer C. D. What Ended the Great Depression? // Journal of Economic History. 1992. Vol. 52. P. 757–784. URL: https://eml.berkeley.edu/~cromer/Reprints/What%20Ended%20the%20Great%20Depression.pdf (Accessed 25 February 2025).
5. Usanov P.V. Novyi kurs F. Ruzvelta: reviziya politiki i eyo rezultatov (FDR's New Deal: An Alternative View on Policies and Their Results) // Ekonomicheskaya Politika. 2018. No. 5. pp. 176-199. (in Russian) URL: https://cyberleninka.ru/article/n/novyy-kurs-f-ruzvelta-reviziya-politiki-i-ee-rezultatov (Accessed 25 February 2025).

«Новый курс» Рузвельта в борьбе против Великой депрессии

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Аннотация. В статье рассматривается серия реформ, известных как «Новый курс», которые были предложены Франклином Делано Рузвельтом для борьбы с крупнейшим экономическим кризисов в истории США в 20 веке, Великой депрессией. Также кратко анализируются причины, которые вызвали этот кризис.
Ключевые слова: новый курс, Великая депрессия, экономическая история США.

УДК 336.743.4

Threats to economic security of an individual when using cryptocurrency

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Abstract
The study aims to identify the factors affecting human economic security when using cryptocurrency. One of the threats is the abuse of anonymity, which can lead to deception of traders and unpunished financing of shadow services, which contributes to illegal transactions. Another threat is currency fluctuations that cause loss of finances, the third threat is the lack of government regulation of wallets, which leads to vulnerabilities in software and makes assets vulnerable to fraudsters. As a result of the conducted research, recommendations were formed to minimize threats to personal safety.
Keywords: anonymity of transactions; bitcoin; cryptocurrency, personal security; fluctuations in exchange rates; economic security of the individual; the lack of regulation of wallets by the state.

Introduction

In the modern world, cryptocurrencies have become an integral part of the global economy. Bitcoin, Ethereum and other digital assets attract the attention of millions of people around the world. The relevance of the chosen research topic lies in the fact that the scale of cryptocurrency use is expanding every year. However, one of the main problems is the anonymity provided by cryptocurrencies. It also makes investigations more difficult, as it becomes difficult to identify those involved in criminal activity [1].

The creation of a new, previously unknown payment system through which global transactions take place is of concern to regulators. The revolutionary nature of this type of currency made it impossible to take immediate legislative and enforcement measures.

The concept of economic security of an individual has drawn the attention of many researchers. In [2], D.V. Valko and D.O. Klimov systematized the opinions of different authors on the key components of determining the economic security of an individual. Based on the analysis performed, it can be concluded that the authors define the concept of economic security of an individual in different ways. It can be concluded that the existing definition vary in content and scope.

The economic security of an individual can be defined a state of human activity characterized by the presence of interrelated legal, social and economic protections, movement in a system of sustainable social and personal development and guaranteeing conditions for the protection of vital interests. At the same time, the economic security is understood as a guarantee of a necessary and sufficient level of well-being (for example, in the form of a minimum guaranteed income) [2].

Cryptocurrency is defined as “currency that exists only in electronic form, operates on a decentralized system of exchange, and uses advanced cryptography for security, or any individual currency of this” [3].

The purpose of the study is to identify threats to an individual security of an individual when using cryptocurrency and draw up measures to minimize threats.

Materials and methods

The object of the study is cryptocurrency as a means of payment and accumulation In order to identify threats to the economic security of an individual when using cryptocurrency, various methods were used in the study, in particular: citation analysis, the works of other authors were analyzed, on the basis of which conclusions were drawn. To achieve the goal, it is necessary to consider a number of tasks:

(1) to analyze the scale of the use of cryptocurrency as a means of payment;

(2) to analyze the anonymity factor in the use of transactions;

(3) to identify the main areas of cryptocurrency use.

Results and discussion

To confirm the relevance of the research topic, it is worth considering a map of the spread of cryptocurrency in the world. (Fig.1)

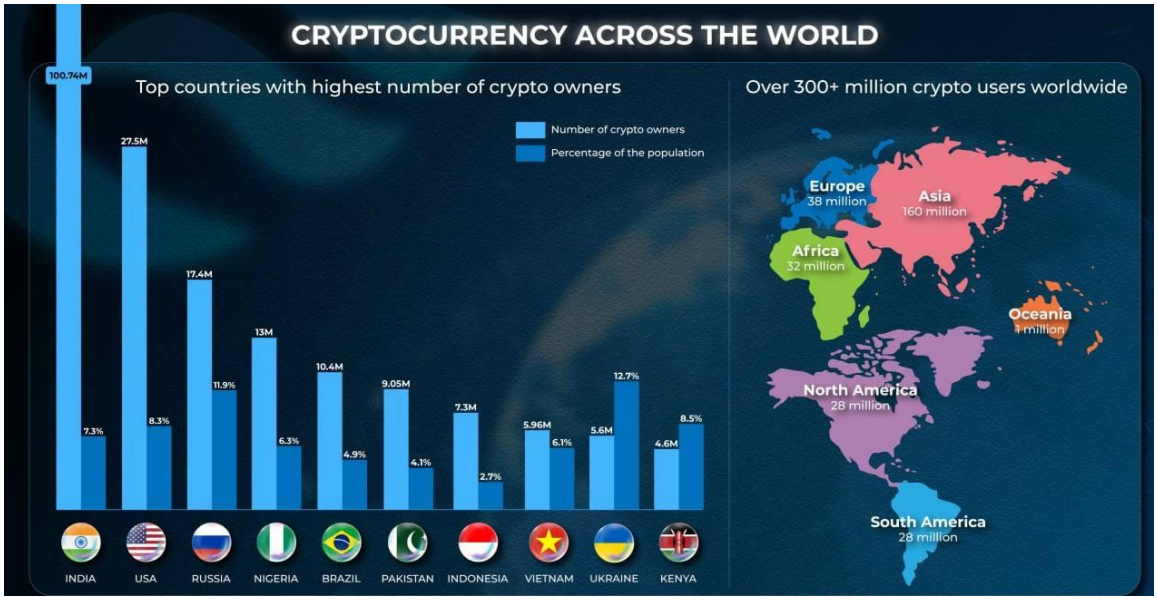

Figure1 - The scale of cryptocurrency turnover in the world (February 9, 2022)

Source: https://finomer.ru/%F0%9F%93%88-kolichestvo-polzovatelej-kriptovalyut-po-vsemu-miru-dostiglo-320-mln-%F0%9F%92%AA-liderom-po-kolichestvu-polzovatelej-kriptovalyut-ostayutsya-ssha-czifrovymi-aktivami-vladeyut/

The map shows that Russia is in 3rd place among the leading countries in the use of cryptocurrencies, while Asia uses cryptocurrencies the most actively, India is the absolute leader and accounts for more than half of users in Asia. The least number of users are concentrated in the Oceania region. It is worth noting that the number of consumers from Africa is ahead of users from North America, who surpass African countries in technology. The spread of cryptocurrencies leads to the emergence of new threats to the economic security of the individual due to the rapid growth of innovation and technology.

The abuse of anonymity allows access to the shadow market in many countries and increases the risks of crime on all continents. The lack of control and abuse of anonymity

opens up access to the use of cryptocurrencies in the field of drugs, guns and human trafficking, which can negatively affect people's health and security. Anonymous transactions are difficult to track and stop, which allows criminals to act with greater confidence and anonymity. The anonymity provided by digital currencies also facilitates money laundering, terrorist financing, and the distribution of counterfeit goods and services.

Cryptocurrencies are convenient to use because of the high level of confidentiality, however, anonymity can become a tool for criminals who use cryptocurrencies for various illegal actions, such as: corruption in cryptocurrency, it is impossible to track the fact of handing over money here; financing criminal activities, for example, the purchase of drugs, weapons, documents and other illegal goods; theft of funds from wallets due to vulnerabilities in the system, as a result of which it is simply impossible to cancel the transaction, due to the lack of control from the state.

Crypto traders often face problems such as emotional dependence, increased risk appetite and burnout. Job failures can lead to significant financial losses, stress, depression, and even suicidal thoughts. Constant monitoring of the market causes irritability, fatigue and reduces socialization. Psychological stress has economic consequences: loss of funds due to rash decisions, market volatility or fraud, expenses for psychological help and medications.

Constant monitoring of cryptocurrency exchange rate fluctuations requires a lot of time and energy. People may feel stressed from having to constantly check the news and analyze the market situation. Due to the high volatility of the cryptocurrency market, some traders and investors may spend a lot of time in front of a computer or phone screen trying to track exchange rate changes around the clock. Lack of sleep leads to a decrease in concentration, memory impairment, and also increases the risk of developing cardiovascular diseases. This is one of the most stressful jobs and people can make unforeseen additional expenses for the help of psychologists, psychological courses, medicines.

To minimize risks, it is necessary to develop a set of measures and new bills controlling the use of cryptocurrencies, first of all, great attention and investment should be paid to IT technologies; develop the right investment strategy; avoid excessive risk.

In Russia, cryptocurrency is not recognized as legal property due to the lack of regulation. This makes it difficult to protect users and combat fraud, since the appropriation of crypto assets is not considered theft. The lack of regulation threatens the economic security of individuals, making them vulnerable to fraud and the financing of criminal activities. The introduction of comprehensive measures will help protect users and reduce the illegal use of cryptocurrencies. In the context of an unclear legal framework, taxation and anti-money laundering issues are becoming difficult. Without clear rules and standards, cryptocurrencies can be used to circumvent tax obligations.

To minimize risks, the following measures are necessary: the adoption of legislation defining the legal status of cryptocurrencies; mandatory verification of users to control transactions; international cooperation to combat the illegal use of assets; Search and blocking of illegal exchanges for the purchase of cryptocurrencies.

Conclusion

As a result of the study, it was revealed that the following factors threaten the economic security of an individual when using cryptocurrencies: abuse of anonymity; emotional reaction to losses in the event of a drop in the cryptocurrency exchange rate; falling into the trap of scammers and losing funds without consequences due to lack of control over assets by the state; becoming a victim of criminal organizations. Thus, when making changes to the current legislation and developing new competent laws, we will be able to avoid the risks and threats associated with the turnover of cryptocurrencies.

References

1.Mikhalev V.A. Problemy rassledovaniya prestupleniy, sovershennykh s ispolzovaniyem kriptovalyut [Problems of investigating crimes committed using cryptocurrencies]. Molodoy uchyoniy. Mezhdunarodnyy nauchnyy zhurnal. 2024, No. 4 (503). pp. 310-312.
2. Valko D.V., Klimov D.O. Ekonomicheskaya bezopasnost lichnosti: Sushchnost i struktura [Economic security of the individual: Essence and structure].Upravlenie v sovremennykh sistemakh. 2018. №4 (20). Pp.98-102. (In Russ.)
3. Dictionary.Com. https://www.dictionary.com/browse/cryptocurrency (Accessed: 18.11.2024)

Угрозы экономической безопасности личности при использовании криптовалюты

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Аннотация. Целью исследования является выявление факторов, влияющих на экономическую безопасность человека при использовании криптовалюты. Одной из угроз является злоупотребление анонимностью, которое может привести к обману трейдеров и безнаказанному финансированию теневых сервисов, что способствует незаконным транзакциям. Другой угрозой являются колебания валютных курсов, вызывающие потерю финансов. Третья угроза - отсутствие государственного регулирования кошельков, что приводит к уязвимостям в программном обеспечении и делает активы уязвимыми для мошенников. В результате проведенного исследования были сформированы рекомендации по минимизации угроз личной безопасности.

Ключевые слова: анонимность транзакций; биткоин; криптовалюта, личная безопасность; колебания обменных курсов; экономическая безопасность личности; отсутствие регулирования кошельков со стороны государства.

УДК 81.119

Pragmatisches Potenzial von Interjektionen

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Zusammenfassung
Der Artikel untersucht Interjektionen als sprachliche Mittel, die verschiedene Funktionen in der sprachlichen Interaktion darstellen. Die Palette der semantischen Interpretationen dieser Wortklasse ist recht vielfältig. Neben dem Ausdruck von Emotionen kann diese Wortklasse auch eine regulierende Funktion erfüllen. Der Artikel versucht, die typischsten davon anhand von Material aus der russischen und deutschen Sprache zu charakterisieren.
Schlüsselwörter: Interjektion, kommunikativ-organisierende Mittel, direktive Funktion, Vokativfunktion, Interrogativfunktion, Kommissionsfunktion.

Die Betrachtung der Sprache als Kommunikationssystem machte die Abhängigkeit der Sprache vom Gegenstand, den Bedingungen und Zielen der Kommunikation deutlich, was zu der Notwendigkeit führte, die Eigenschaften der Sprache unter Berücksichtigung der Aufgaben und Besonderheiten ihres Gebrauchs in Akten der Sprachkommunikation zu untersuchen. Die Untersuchung verschiedener Struktureinheiten als Träger einerseits propositionaler Informationen und andererseits als kommunikativ-organisierende Mittel ist relevant geworden.

Von besonderem Interesse als kommunikativ-organisierendes Mittel ist die Interjektion – eine der unzureichend untersuchten Wortarten im modernen Deutsch und Russisch, wie das Fehlen entsprechender Abschnitte in einer Reihe von Lehrbüchern und Lehrmitteln zur praktischen Grammatik zeigt. Die Fähigkeit, als eigenständige Äußerungen aufzutreten und eine kommunikative Funktion zu erfüllen, die derjenigen von Vollkomposita gleichkommt, bestimmt das Interesse an den kommunikativ-funktionalen Eigenschaften von Interjektionen, und insbesondere an Sprechakten der Kommunikation. Bei der Beschreibung einiger Arten illokutiven Bedeutungen, die durch Interjektionen ausgedrückt werden, weisen die Autoren darauf hin, dass die Letzteren spezifische Aussagen sind, die nicht auf Standard-Strukturschemata reduziert werden können und dadurch verständlich und natürlich werden, wenn bei ihnen ein besonderer semantischer Status berücksichtigt wird [1, 2].

Im Rahmen der theoretischen Forschung wurden Interjektionen zunächst im Hinblick auf die Bestimmung ihres Platzes in bestehenden Klassifikationen von Wortarten, ihrer Struktur und Semantik untersucht. Somit hat sich ein gewisses sprachwissenschaftliches Wissen über diese Wortart angesammelt. Gleichzeitig ist die Zahl der Arbeiten, die Interjektionen im Hinblick auf ihre Verwendung in der Sprache untersuchen, sehr gering.

Die Fokussierung der sprachwissenschaftlichen Forschung auf den Faktor der sprachlichen Kommunikation hat jedoch gezeigt, dass Interjektionen häufig eine wichtige

Rolle bei der Organisation des Kommunikationsprozesses spielen. Dabei kann eine Interjektion entweder die Hauptaussage begleiten und ihr nur eine gewisse Ausdrucksfarbe verleihen oder als Grundlage der Kommunikation dienen und den semantischen Umfang des gesamten Satzes haben.

Es ist anzumerken, dass bei der Untersuchung der kommunikativen Belastung bisher in der Regel das Hauptaugenmerk auf Verben gelegt wurde, deren Listen in der vorhandenen Literatur zur Pragmalinguistik häufig aufgeführt sind. Die Studie zeigte jedoch, dass Interjektionen sowohl in der Kontaktaufbau- als auch in der Feedback-Signalisierungsfunktion ein aktives Mittel darstellen, also Wörter, mit denen der Adressat im Dialog dem Sprecher zu verstehen gibt, dass er aufmerksam zuhört und auf die erhaltenen Informationen in bestimmter Weise reagiert (vgl.: *aha, nanu, hm; ага, ну да, гм*).

Interjektionen werden am häufigsten in den folgenden illokutiven Akten verwendet: direktiven, interrogativen, also Fragen an den Zuhörer, Vokativen, Kommissionsfunktionen und repräsentativen.

Die charakteristischste der genannten Funktionen für Interjektionen ist die **direktive Funktion**. Es ist kein Zufall, dass A. A. Schachmatov, V. V. Vinogradov und V. D. Devkin auf die Verwendung von Interjektionen in der Funktion hingewiesen haben [3], den Willen des Sprechers auszudrücken und den Sprecher aufzurütteln. Beim Handeln in einer direktiven Funktion drücken Interjektionen Motivationen, Bitten und Befehle aus. Die Zahl der Interjektionen, die diese Funktion erfüllen, ist relativ groß. Das sind „*husch-huch, kusch*“, Einwürfe, die nach Aufmerksamkeit rufen, zum Schweigen auffordern: „*pst*!“ ps! Zum Beispiel: „*Wenn das Wetter schwarz wird, haben Sie vor allem Angst. - Pst! Lasst uns alle gehen!*“ (J. R. Becher). Zum Rufen und Vertreiben von Tieren werden folgende Interjektionen verwendet: *rut-rut, tuck-tuck, , цып', 'цып, ти-ти'; biele-biele*, „*'тега-тега'“; meck-meck, schap-schap „'кать-кать*“ (eine Ziege, ein Schaf rufen); *tick-tick, gurre-gurre*, „*'гули-гули*“, *mieze-mieze, pus-pus* „*'кс-кс-кс'*“; „*'hüh' „но''*; „*тпру*“; „*hott“* „nach rechts“ (der Ruf der Pferde) usw.

Viele Interjektionen dieser Reihe sind dialektisch gefärbt und ihre Verwendung ist lokal begrenzt. Berücksichtigt man, dass Interjektionen eine offene Wortklasse darstellen, so können als Anreize die Wörter *fort, zurück, vorwärts* und die Lehnwörter *basta, bis, dacapo, kusch, apport, allez* verwendet werden. Im Russischen wird die direktive Funktion aktiv durch die Interjektionen *ну, на, ну-те, тпру, та, нате, на-ка, айда, брысь, цыц, кыш* ausgeführt. Zum Beispiel: "*Ну, ну, отворяй, что ль ворота! Отворяй – не держи, и так прозябли!*" (П. Н. Полевой).

Die Funktionsweise von Interjektionen in Anreden und Rufen ermöglicht es ihnen, eine **Vokativfunktion** zu erfüllen. Im Deutschen sind dies Appellativpronomen: *he, hallo, heda, holla, ahoi, hei, ei, eia, heia*. Zum Beispiel: „*Auto! He, Auto!" – brüllt der Riese plötzlich*“ (H. Fallada). Im Russischen ist die Vokativfunktion am typischsten für die Interjektionen *эй, э, алло*. Zum Beispiel: „*Из окон казармы глядели новобранцы."Эй, – кричали они, – сколько вам заплатили?*" (П. Н. Полевой).

In der **Interrogativfunktion** fungieren Interjektionen als Frage. Sie richten sich an den Zuhörer. Die Fragefunktion ist in der deutschen Sprache am typischsten für folgende

Interjektionen: *na? nu? ah? hm? he? hm?* Zum Beispiel: *„Na*? *Und was ist das?“ fragt Lämmchen gespannt* (N. Fallada). Im Russischen wird diese Funktion durch Interjektionen wie „*ну? ась? а?*“ erfüllt. *Выйдя на крыльцо, Серко и Золотарь помолчали, наконец, Кошевой понукнул: – "Ну?"* (П. Н. Полевой).

Die **Kommissionsfunktion** von Interjektionen drückt eine Drohung, ein Versprechen, eine Erlaubnis aus. In der deutschen Sprache wurden keine Fälle der Verwendung von Interjektionen in dieser Funktion gefunden. Im Russischen ist diese Funktion charakteristisch für Interjektionen: *у, эк, ну, но, то-то, ужо*. Zum Beispiel: *«Куда глядишь? Вот я те! у!" – говорил барышник с ласковой угрозой»* (И. С. Тургенев).

Interjektionen in der **repräsentativen Funktion**, die eine Beschreibung, eine Aussage ist, sind zugleich sprachliche Mittel, die eine propositionale Situation manifestieren. Diese Funktion ist typisch für lautmalerische Interjektionen, die in ihrem Wesen eindeutig sind und als Attribut, Umstand, Prädikat fungieren und jene Wörter ersetzen können, die am anschaulichsten, „bildlich“ dargestellt werden müssen. Zum Beispiel auf Deutsch: *Bums, Krach, Tick-Tack, Kikeriki*, *Klapp, Kling-Kling*; auf Russisch: *бац*, *ух, динь-динь-динь, фюить*, *бух* usw.

Mit den genannten Funktionen sind nicht alle pragmatischen Möglichkeiten von Interjektionen erschöpft. Im Kommunikationsprozess kommt es häufig zu einer Kombination kommunikativ-organisierender und emotional-bewertender Funktionen.

Interjektionen haben eine **emotional-bewertende Funktion** und drücken Freude, Schmerz, Angst, Bewunderung, Ärger, Unzufriedenheit, Empörung, Verlangen, Verachtung usw. aus. Gleichzeitig steht eine Interjektion nicht stellvertretend für eine Situation, sondern gibt an, wie der Sprecher diese Situation erlebt, wie er sie bewertet. Das Vorhandensein von Interjektionen weist in diesem Fall auf die Manifestation des emotionalen Operators hin. Interjektionen sind das einfachste sprachliche Mittel, um den Geisteszustand einer Person auszudrücken. Offenbar traten sie viel früher auf als andere lexikalische und grammatikalische Formen mit ähnlicher Bedeutung. Die Bandbreite emotionaler Bedeutungen ist recht groß. Sie enthält neben neutralen Bedeutungen, die die Ausgeglichenheit der geistigen Verfassung des Sprechers widerspiegeln, auch Bedeutungen, die auf einen Zustand emotionaler Anspannung hinweisen.

Für eine detaillierte Untersuchung der sprachlichen Mittel, die diese Gefühle in der Sprache darstellen, ist eine Taxonomie der psychologischen Zustände erforderlich. Eine solche Taxonomie wurde beispielsweise von J. Leech vorgeschlagen, in dessen System die Klassen der illokutionären Prädikate den psychologischen Prädikaten entsprechen, die auch Prädikate propositionaler Einstellungen genannt werden [4].

Emotionale Interjektionen sind normalerweise polysemantisch. Kontext und Intonation sind notwendig, um ihre Bedeutung zu verwirklichen. Nehmen wir als Beispiel die am häufigsten vorkommende Interjektion „*ach*“. Unter den vielen Gefühlen und Emotionen, die durch diese Interjektion ausgedrückt werden und in Wörterbüchern verzeichnet sind, gibt es polare Gegensätze, zum Beispiel den Ausdruck von Schmerz, Überraschung, Bedauern.

Ein ähnliches Bild ist bei den Bedeutungen anderer Interjektionen zu beobachten, zum Beispiel bei „*na*“. Wörterbücher geben uns jedoch keine Auskunft darüber, ob

Interjektionen im Kontext nur ein bestimmtes Gefühl ausdrücken können oder ob sich ihre Bedeutungen überschneiden können. Zum Beispiel: ... „*da verzog sich das metallene Gesicht im ekelhaften Spiel. Blauglühender Lichtblicke zum grinsenden Lächeln. Ach! es war ja das Apfelweib vom schwarzen Tor“!* (E. T. Hofmann). Die Interjektion ach drückt in diesem Fall Überraschung, Angst und Verwirrung aus.

So kann die Interjektion in einer bestimmten Situation mehrere Gefühle gleichzeitig ausdrücken, und es ist sehr schwierig, das vorherrschende herauszupicken. Daher stehen bei der Untersuchung von Interjektionen der Kontext und die konkrete Situation im Vordergrund. Eine Interjektion ist eine Wortart, die nicht in Wörterbüchern untersucht werden kann, da Wörterbücher den Synkretismus ihrer Bedeutungen nicht berücksichtigen und Interjektionen oft mehr Bedeutungen haben, als die, die in Wörterbüchern angegeben sind. Der festgestellte Synkretismus ist nicht nur für die üblichen Bedeutungen von Interjektionen charakteristisch, sondern auch für ihre funktionalen Bedeutungen, d. h. die Erfüllung kommunikativ organisierender Funktionen durch Interjektionen wird ausdrucksstark gefärbt. Sie sind nicht typisch für den formellen Geschäftsstil.

Literaturverzeichnis

1. Bergel'son, M. B. Pragmaticheskij “princip prioriteta” i ego otrazhenie v grammatike yazyka / M. B. Bergel'son, A. E. Kibrik // Izv. AN SSSR. Ser. lit. i yaz. – 1981. – № 4. – S. 343–355. (in Rus.)
2. Sharonov, I. A. Mezhdometie v yazyke, v tekste i v kommunikacii : avtoref. dis. … d-ra filol. nauk: 10.02.01 / I. A. Sharonov ; Ros. gos. gumanit. un-t. – Moskva, 2009. – 36 s. (in Rus.)
3. Devkin, V. D. Osobennosti nemeckoj razgovornoj rechi / V.D. Devkin. – M.: Mezhdunar. otnosheniya, 1965. – 318 S. (in Rus.)
4. Leech, G. N. Principles of Pragmatics. London etc, 1983. – Текст: электронный // URL : http://www.i-u.ru/biblio/archive/arshinov%5Fsinergetika/02.aspx (дата обращения: 04.03.2025).

Прагматический потенциал междометий

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Аннотация. В статье рассматриваются междометия как языковые средства, репрезентирующие различные функции в речевом взаимодействии. Палитра смысловой интерпретации данного класса слов довольно разнообразна. Наряду с выражением эмоций, данный класс слов может осуществлять регулирующую функцию. В статье предпринята попытка охарактеризовать наиболее типичные для них на материале русского и немецкого языков.
Ключевые слова: междометие, коммуникативно-организующее средство, директивная функция, вокативная функция, интеррогативная функция, комиссивная функция.

УДК 81-23

Intrusion of Ukrainian culture in modern Russian military political discussion

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Abstract
The purpose of this study is to analyze how Ukrainian words and culture are used in the Russian language from the beginning of 2022 to the current day. An analysis of some political and near-political channels, as well as cases of Russian military bloggers is given. The relevance of this study is that any modern language, including Russian, is actively developed with the influence of other languages, political events and other various factors. The result of this study is the analysis of how Russian language transformed throughout the course of special military operation.
Keywords: cognitive warfare, information warfare, language interference, psychological and information operations Russian language, Ukrainian language.

Introduction

Within the scope of the special military operation of the Russian Armed Forces, the Ukrainian government's actions towards Russia became significantly radicalized. In addition, the so-called “United News” telethon took over the Ukrainian television, which is classified as an act of censorship even by Western regimes, as reported by the most pro-Ukrainian “mass-media”.

While Russia is protecting the interests of the people closest to its sphere of interests, who have embraced two “worlds” - the so-called “Galician”, i.e. West Ukraine (Lviv, Ternopil), and the “Russian” that prevails in the South-East of Ukraine (Kyiv, Kharkiv, Odesa) - inevitable transformations are taking place not only socially but also culturally. Cultures and perceptions of the current events are mixed: for example, several Ukrainian civilians I interviewed are assured that the lack of censorship in the Ukrainian information field in the first months has had irreversible consequences. At the same time, there is also a point of view shared both by Russian government and by many pro-Western sources – today Ukrainian regime is a dictatorship in the worst sense of the word, lacking not only freedom of speech, but also a freedom of an individual.

The war against the Russian Federation is a hybrid conflict: Western “Third Reich” states – the author is assured that this term is correct for state NATO-bloc countries and their satellites – are trying to win the war not only on the conventional battlefield, but also in the so-called “cognitive space” or “space of ideas”. I will stick with the following definition for scientific purposes: cognitive space is *the order of thinking, ideas, values and cultural and historical code of a particular society*.

Earlier in 2024, I conducted a study of the techniques and means of modern cognitive warfare. The usual scenario was to create a collaborationist (so-called “democratic”) government on the territory of a modern state by evoking strong negative emotions through resonant events. If we look through this prism at information-psychological operations (hereinafter psyop) of the Armed Forces of Ukraine in Russia, it can be noted

that the enemy is trying to put pressure on the most hot spots of our society. For example, the pressure in the migration and migrants theme increased since Krokus terrorist attack, which, according to the official version, was committed with the support of Ukrainian special services, and the pressure on the subject of mobilization in Russia became stronger after the partial mobilization in September 2022.

However, even with the Ukrainian psyop forces more advanced and integrated into the state system, the aggressive influence on our society remains low, to the point that any suspicious information is being laughed at as the information from a "neighboring state" (Rus. *«сопредельное государство»,* an ironic naming for Ukraine used in Russian pro-government mass-media). Due to frequent interaction with this data, the Russian language has been enriched with new words and terms.

In addition to the obvious aphorisms and memes used in the Russian near-war media space since 2014 ("Taras, Mykola" to reflect the collective image of a Ukrainian; *"Нас-то за що?"* (ukr. "Us for what?") to express the emotion of Ukrainians' misunderstanding of why they are being attacked; *"зрада"* (zrada, ukr. "betrayal") and *"перемога"* (peremoga, ukr. "victory") to ironically reflect the attitude towards the subject of discussion), since 2022, our language has been enriched with some Ukrainian words. One of these is the word *"бавовна"* (bavovna, ukr. "cotton"), and the history of the appropriation of this word is curious. "Democratic" media, including Ukrainian ones, mocked official reports of bombings by Russian authorities, where the news said "хлопок" referring to the explosions and since 2022 any terrorist attack by the neo-Nazi regime against Russia has been mocked in this way. *In Russian «хл**о**пок» (as a cotton) and «хлоп**о**к» (as an explosion) are written the same, yet the semantic emphasis is different, this difference is stated in bold italic.* Nevertheless, in the course of cultural appropriation, Russians began to use this word in the context of the explosion at this or that AFU objects.

Another "appropriated" word is the word *"потужно"* (potuzhno, ukr. "powerful"). It is used both by Ukrainian opposition communities in Telegram regarding the speeches of junta leader Zelensky and by Russian military experts. Initially, this word was intended to emphasize the power of the illegitimate president of Ukraine regarding "plans of peremoga", but with the passage of time and the obvious inability of the Kiev regime to gain military superiority, it began to acquire an ironic context throughout not only Russian Telegram, but also Ukrainian Telegram itself.

Another word widely used in Russia is *"джерело"* ("dzherelo", ukr. "source"). With the course of the SMO and the disclosure of Ukrainian fakes and disinformation, the patriotic community has a need to clarify that a particular news item is fake. For this purpose, the word mentioned was appropriated: it is one of the most frequently associated with the enemy side in this conflict. I should note that the term *"інсайд"* (ukr. "insider information") has suffered a similar fate, but in a different context: it is now used mainly to highlight information that was posted by a pro-Russian, but Ukrainian, or a source close to it, and which is not reliable. A vivid example of an "інсайд" news is the information coming from Ukrainian citizen Anatoliy Shariy in his Telegram channel on a regular basis.

In addition, the word “фортеця” (Ukr. “fortress”, “stronghold”) is actively used in Russian speech. This is how Ukrainian terrorists actively referred to the town of Bakhmut (Artyomovsk, Donetsk’s People Republic, Russia), for which there was a harsh fight in 2023. After the settlement was liberated by the Russian Armed Forces, the Russian mass-media began to ironically refer to every town about which the Ukrainian commanders said in the spirit of “we lose this town, we lose Ukraine” as a “fortress”.

Figure 1 - “Zelensky’s handshake”

In addition to the replenishment of the Russian language, the Russian political and near-political culture was also somewhat updated during the war. There are several memes used in Russian political discourse. One of them is the “Zelensky handshake” - according to this theory, all leaders who shook hands with the Ukrainian president or interacted with him would eventually lose their posts. A picture with handshakes of leaders of different countries usually illustrates this, on which they are crossed out (Fig. 1).

Another “curse”, which became a major political meme in the Russian segment of the Internet and even went beyond the political discourse, is also connected with the personality of the usurper of Ukrainian power: all cities in which Zelensky appears, sooner or later surrender to the Russian Armed Forces. The power of this superstition turned out to be so great that even the Ukrainians themselves ask the occupant “not to come to their cities” to avoid their subsequent surrender.

In the current state, with the West's full-scale war against Russia going on for almost three years and the routinization of the conflict, it is not surprising that certain things become a cause for laughter. To constant it, the aggression waged against Russians since the early 20th century is increasingly becoming a gamified and “joke” conflict waged somewhere in the background. It is important for Russians to remember that the success of

Russian actions and Russians' attitude to the enemy will determine whether Russia will be able to live in peace for several more decades or whether they will have to defend themselves against the official military intervention of the "triple pact" of the 21st century in the form of NATO - not by the hands of proxies, but by the hands of American and British puppeteers.

References

1. https://meduza.io/feature/2024/10/14/oni-vosprinimayut-zhurnalistov-kak-domashnih-zhivotnyh-u-kotoryh-est-hozyain (Accessed 15 October 2024) // the resource is blocked in Russian Federation.
2. URL: https://t.me/boris_rozhin/142218 (Accessed 27 October 2024)
3. https://www.unian.ua/war/fortecya-z-zhivih-lyudey-zelenskiy-prokomentuvav-situaciyu-u-bahmuti-12146370.html (Accessed 2 November 2024).
4. https://t.me/ua_tribunal/4786 (Accessed 10 November 2024)

Проникновение украинской культуры в современный российский военно-политический дискурс

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Аннотация. Цель данного исследования - проанализировать, как украинские слова и культура используются в русском языке с начала 2022 года по сегодняшний день. Анализируются некоторые политические и околополитические каналы, а также кейсы российских военных блогеров. Актуальность данного исследования заключается в том, что любой современный язык, в том числе и русский, активно развивается под влиянием других языков, политических событий и других различных факторов. Результатом данного исследования является анализ того, как трансформировался русский язык в ходе проведения специальной военной операции.

Ключевые слова: информационная война, информационно-психологические операции, когнитивная война, языковая интерференция, русский язык, украинский язык.

УДК336.2

Cryptocurrency and the future of global economy: opportunities, challenges and transformations

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Abstract
The article analyzes the impact of cryptocurrencies on the global economy, their opportunities and challenges. Financial inclusion, reduction of transaction costs and development of DeFi are considered. The study is based on the analysis of scientific publications and industry reports (2015–2023). Three aspects are highlighted: economic benefits, regulatory issues and development prospects in the context of CBDCs and other coins. It is noted that the lack of regulation and volatility make it difficult to integrate cryptocurrencies. The development of central bank digital currencies is considered as a possible solution but requires further study. The conclusion emphasizes the need for further research to assess their impact on monetary policy and financial stability.
Key words: Bitcoin, blockchain, cryptocurrency, economic transformation, financial inclusion, global economy, regulation.

Introduction

The rise of cryptocurrencies as an alternative to traditional financial systems has brought in new challenges and opportunities for innovation. For this reason, these currencies have been extensively studied, as they have the potential to revolutionize economic policy, promote inclusivity, and reduce transaction costs. Rainer Böhme, for example, seems to have shown great foresight in analyzing the economic and technical characteristics of Bitcoin. He argued that the decentralization of the Bitcoin financial system could have positive effects but also took into account the potential volatility and regulatory risks that Bitcoin carries [1]. Similarly, Anne Haubo Dierberg sought to enrich portfolios by showing how Bitcoin can be used as a hedge against traditional financial markets [3]. This paper intends to expand on their analyses and look at the prospects of cryptocurrencies with their challenges and opportunities as well as their consequences on economic systems around the globe.

The use of cryptocurrencies has gained more and more prominence over the years. This prominence has led to debates about the adoption of cryptocurrencies around the world and how they can solve problems such as high fees, slow transactions, and even limited access to banking services. For example, cryptocurrencies have become an inclusive tool for people in developing countries, helping those without access to traditional banking services to participate in the global economy. Additionally, the lack of centralized governance and the transparency and security of blockchain technology poses the threat of these currencies being used for illegal activities, and there are no proper

systems in place to protect innocent consumers. There are also concerns that energy-intensive activities such as Bitcoin mining could become quite wasteful due to the Proof-of-Work (PoW) consensus mechanism, leading to even more damage to the environment. Experts have pointed out how currencies could become less harmful to the environment by implementing alternatives such as Proof-of-Stake (PoS). Additionally, with the emergence of new government-backed digital currencies such as central bank digital currencies (CBDCs), competition has emerged to provide decentralized cryptocurrencies with a complement that broadens the debate.

In addition to economic and technical considerations, the impact of cryptocurrency on society must also be considered. Cryptocurrencies have given individuals greater financial power in society, allowing them to manage their wealth without the control of a central authority. This step toward financial autonomy is also important in other places with weak currencies or strict financial controls. During Venezuela's hyperinflation, for example, Americans, primarily concerned with preserving their wealth, sought help from cryptocurrencies.

Furthermore, the introduction of cryptocurrencies into primary financial markets has led to the emergence of new business areas and new industries. For example, DeFi platforms have created new industry streams, replacing intermediaries with automated systems, making lending, borrowing, and trading much more intuitive. However, the massive proliferation of cryptocurrencies has also highlighted problems such as the lack of comprehensive protection and anonymity in smart contracts and pointed to the need for stream regulation.

Methods

A thorough analysis of the literature showcases that this particular research focuses on examining the effects of cryptocurrencies on the economy by taking a qualitative approach to the literature review. The analysis stems from an evaluation of relevant academic published literature such as articles, sectoral reports and case studies available from the year 2015 up to the year 2023. The articles selected were evaluated based on their relevance to the research problem particularly in the implications of cryptocurrencies in the modern economy, especially in the financial systems, monetary

The analysis focused on three key areas:

1. Economic opportunities: Addressing how cryptocurrencies can improve the inclusivity of finances, minimize payment costs, and aid in international payments.
2. Challenges: Issues regarding the lack of legislation, abrupt changes in the market, and the adoption of cryptocurrency… change in environmental sustainability.
3. Future trends: The shifting functions of cryptocurrencies in international economic systems with the rise of CBDCs and DeFi developments.

This study attempts to combine the existing literature to analyze the role of cryptocurrencies and the implications it has on the future of the global economy.

Results

The benefits of cryptocurrencies include improved opportunities to promote financial inclusion, reduced transaction costs, and the expansion of decentralized finance (DeFi) systems. However, lack of regulation, market volatility, and environmental concerns associated with mining continue to pose significant obstacles. While the emergence of central bank digital currencies (CBDCs) and stablecoins offers hope of addressing volatility and regulation issues, their long-term impact remains controversial.

The analysis also underscores the role of cryptocurrencies in promoting innovation and entrepreneurship. By lowering barriers to entry, digital currencies have enabled startups and small businesses to access global markets and secure funding through initial coin offerings (ICOs) and tokenization. This has democratized access to capital, particularly for companies in developing countries that traditionally have difficulty-securing financing through traditional channels.

Furthermore, the study shows that cryptocurrencies have the potential to increase transparency and reduce corruption in financial transactions. The blockchain technology underlying most cryptocurrencies provides an immutable and publicly accessible ledger, making it unlikely that fraudulent activity will go undetected. This feature is particularly valuable in regions where corruption is widespread, as it can help build trust in financial systems and promote economic stability.

However, the lack of a unified regulatory framework remains a serious problem. While some countries have embraced cryptocurrencies, others have instituted strict regulations or outright bans, creating a fragmented global environment. This inconsistency not only hinders the growth of the cryptocurrency market but also complicates cross-border transactions and international cooperation.

Another key finding is the growing role of cryptocurrencies in money transfers and international payments. Traditional money transfer systems are often expensive and slow, especially for migrant workers sending money to their families in developing countries. Cryptocurrencies, with their low transaction fees and near-instant transfer times, offer a viable alternative. Platforms such as Stellar and Ripple, for example, were specifically designed to facilitate cross-border payments, highlighting the potential of digital currencies to revolutionize the remittance industry.

Additionally, the study highlights the importance of education and awareness when adopting cryptocurrencies. Despite their growing popularity, many people and businesses remain hesitant to use digital currencies due to a lack of understanding of, or misconceptions about, their functionality and security. To close this knowledge gap and promote wider adoption, educational initiatives and user-friendly platforms are needed.

Conclusion

This study emphasizes the innovation of cryptocurrencies and how it could shape the global economy. Cryptocurrencies possess vast opportunities, such as improving financial inclusion, lowering transaction fees, and accelerating the advancement of decentralized finance (DeFi). On the other hand, barriers to adoption remain critical such as government regulations, market volatility, and environmental issues linked to mining.

The development of digital currencies through central banks (CBDCs) and the issuance of stable digital coins are steps in the right direction to mitigate volatility and focus on regulations, but their effects on monetary policy and financial stability need more examination time.

References

1. Böhme R., Christin N., Edelman B., Moore T. Bitcoin: Economics, Technology, and Governance.. [Journal of Economic Perspectives], 2015, Vol. 29, No. 2, pp. 213-238.
2. Catalini C., Gans J.S. Some Simple Economics of the Blockchain. [MIT Sloan Research Paper], No. 5191-16, 2016.
3. Dyhrberg A.H. Bitkojn, zoloto i dollar – analiz volatil'nosti s ispol'zovaniem GARCH. Bitcoin, Gold and the Dollar – A GARCH Volatility Analysis [Finance Research Letters], 2016, Vol. 18, pp. 1-7.
4. Nakamoto Bitcoin: A Peer-to-Peer Electronic Cash System. [Available from: https://bitcoin.org/bitcoin.pdf], 2008. (Accessed: 10.10.2023).

Криптовалюта и будущее мировой экономики: возможности, вызовы и трансформации

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Аннотация. В статье анализируется влияние криптовалют на мировую экономику, их возможности и вызовы. Рассматриваются финансовая инклюзия, снижение транзакционных издержек и развитие DeFi. Исследование основано на анализе научных публикаций и отраслевых отчетов (2015–2023). Выделены три аспекта: экономические преимущества, проблемы регулирования и перспективы развития в контексте CBDCs и стейблкоинов. Отмечается, что отсутствие регулирования и волатильность затрудняют интеграцию криптовалют. Развитие цифровых валют центральных банков рассматривается как возможное решение, но требует дальнейшего изучения. В заключении подчеркивается необходимость дальнейших исследований для оценки их влияния на денежно-кредитную политику и финансовую стабильность.

Ключевые слова: биткоин, блокчейн, глобальная экономика, доступ к финансовым услугам, криптовалюта, регулирование, экономическая трансформация

УДК 336

Innovative technologies in the banking sector

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Abstract
This article describes some trends in the banking system. The development of innovative technologies such as the fast payment system, digital national currencies, blockchain technology and mobile banking are now some of the leading trends in the world of banks. This article reviews a small range of financial technologies in the banking environment. The purpose of the article is to present key financial technologies in the banking environment and processes that are associated with them.
Keywords: bank, innovation, artificial intelligence, technology, digitalization, economics.

Introduction

Recently, we have seen significant changes in the financial market, in the banking system and in almost all spheres of human life. The banking infrastructure is constantly changing, new payment solutions are emerging that meet the changing needs and expectations of the population, business and the state.

Adapting innovative technologies to the banking sector is becoming increasingly important, as fintech solutions enhance competition, contribute to revenue growth, thereby profits, and improve the efficiency of operations [1]. It is very important to study this topic in order to understand what technologies are currently trending and how they affect the banking environment. At the same time, do not forget to analyze the change in attitudes towards classic banking products.

Modern innovative technologies strongly influence the transformation of banks, providing customers with increased comfort and efficiency. L.A. Petrova's article entitled "Digitalization of the banking system: digital transformation of the environment and business processes" focuses on the need for the introduction of technologies such as artificial intelligence, blockchain and mobile applications. These innovations not only improve the quality of service but also optimize internal processes in commercial banks. Petrova highlighted important aspects of the formation of the banking sector in the context of digital changes, including the development of technologies, changes in business processes, banking products and services under their influence, which is confirmed by articles by other authors. When discussing new technologies, attention should be paid to potential "doors", disadvantages and consequences.

The purpose of the article is to explore the technologies in demand in the banking sector and determine their impact on each other. It is necessary to analyze how technologies are being improved in banks, make comparisons between countries and find out which Fintech solutions are most common within Russia and internationally.

Review of the existing banking technologies

The Internet, smartphones and digital products have become an integral part of human daily life. Even in remote regions of the Russian Federation, an Internet connection is being introduced; computers and necessary gadgets are being purchased. New banking technologies should not only meet the needs of clients, but also anticipate their expectations; this requires an analysis of current trends and forecasting the future. Maintaining consumer confidence, improving security and quality of services are important aspects in the context of widespread cyber threats.

In the modern world, there are indeed many directions for the development of financial technologies in a bank, and for each direction technologies are being developed to help employees to provide banking services faster and better. Some of the currently popular types of innovative technologies in the banking system are as follows.

Fast Payment System. This platform, developed in Russia and implemented by the Central Bank in 2019, allows instant non-cash transfers between bank accounts of individuals and legal entities 24/7. Thanks to this, users can send money at any time convenient for both the sender and the recipient.

Digital national currencies. More and more countries are exploring the possibility of introducing digital national currencies in a pilot mode. This is aimed at increasing the independence, convenience and speed of payments, as well as increasing the transparency of banking processes. Currently, Russia is conducting pilot testing of the digital ruble, similar to how it has already been implemented in Jamaica, the United Arab Emirates and Nigeria.

Blockchain technology. Blockchain is a decentralized database in which information is stored in the form of a chain of linked blocks. This technology provides a high degree of security and transparency of banking operations, since changing data in one block is impossible without changing the entire chain.

Mobile banking. Mobile banking provides customers with the ability to remotely manage their financial transactions through applications on smartphones. This reduces the need to visit physical bank branches, and allows you to perform actions such as transfers, bill payments and account management, anytime and anywhere.

Artificial intelligence. Artificial intelligence (AI) is becoming an important and powerful tool for improving the quality of bank services. It facilitates the analysis of large amounts of information, helps to find out patterns and offer individual recommendations to clients.

The integration of these technologies into the banking sector not only improves the quality of services provided, but also increases the competitiveness of banks. Russia is indeed demonstrating high rates of innovation and development of non-cash payments, and the Bank of Russia actively supports these initiatives. Digitalization is changing not only the banking sector itself, but also consumer behavior, which opens up new horizons for financial services.

Conclusion

It turns out that the banking services and operations sector is progressing rapidly, the use of new technologies in it really creates many opportunities to improve the quality, convenience and security of customers. However, this process also creates challenges for the state, commercial banks, and customers, which require adaptation, habituation, and investments in modern technologies.

The task of banks is not only to apply new technologies, but also to integrate them effectively into existing business processes. This will require banks to be flexible and ready for changes, as well as training employees to work with new systems.

Expanding access to innovative technologies throughout Russia will be a key factor in increasing the competitiveness of the domestic banking sector. Successful implementation of digital technologies will ensure banks' resilience to future challenges by creating a more efficient and reliable financial system.

References

1. Medvedeva S. N. Tendentsii tsifrovoy transformatsii v bankovskom sektoreekonomiki [Trends in digital transformation in banking]. Nauchnyyvestnik: finansy, banki, investitsii. 2020. №2 (51). Pp.89-94 (in Russ.)
2. OkhlopkovA.V. Innovatsii v sfere predostavleniya bankovskikh uslug: avtoref. dis. kand. ekonom. nauk [Innovations in the provision of banking services: abstract of the dissertation of the Cand.of Econ. Sci.]. Moscow, 2011. .12 p. (in Russ.)
3. Petrova L.A. Cifrovizaciya bankovskoj sistemy: cifrovaya transformaciya sredy i biznes-processov [Digitalization of the banking system: digital transformation of the environment and business processes]. Scientific Journal, Pp.91-101 (in Russ.)

Инновационные технологии в банковской сфере

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Аннотация. На современном этапе происходит стремительное развитие банковской системы. Одним из таких направлений является развитие инновационных технологий, таких как системы быстрых платежей, цифровые национальные валюты, технология блокчейн и мобильный банкинг. В данной статье представлен обзор финансовых технологий в банковской среде. Цель этой статьи - выявить важные финансовые технологии в банковской среде и понять все связанные с ними процессы.

Ключевые слова: банк, инновация, искусственный интеллект, технологии, цифровизация, экономика.

УДК 336.77.01

Bankkarten als modernes Instrument für bargeldlose Zahlungen

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Zusammenfassung
Der Artikel beleuchtet die Rolle von Bankkarten im bargeldlosen Zahlungssystem und untersucht auch die aktuelle Lage des Plastikkartenmarktes in der Russischen Föderation. Es ist die Struktur des analysierten Marktes untersucht und die Hauptprobleme der Entwicklung dieses Bereichs berücksichtigt sowie eine Reihe von Empfehlungen zur Verbesserung des untersuchten Bankprodukts vorgeschlagen.
Schlüsselwörter: Markt, Bankkarte, Konto, Geschäftsbank, Provision, Zinsen, Überweisung.

Bankkarten sind für Banken sowohl auf dem Territorium der Russischen Föderation als auch im Ausland ein durchaus lukratives Instrument. Die Bankkarte hat sich als grundlegendes Zahlungsmittel im bargeldlosen Zahlungsverkehr bereits fest im Leben der modernen Gesellschaft etabliert.

Die Einführung von Plastikkarten ist ein sehr wichtiger Schritt in der Entwicklung der Informationstechnologie, einer der Indikatoren für schnelle Fortschritte nicht nur im Bankensektor, sondern auch im Leben der Gesellschaft insgesamt. Bankplastikkarten werden nicht nur als Hilfsmittel für bargeldlose Zahlungen, sondern auch als Mittel zur Kreditaufnahme genutzt. Der größte Vorteil dieses Bankprodukts ist natürlich die Zahlungsgeschwindigkeit. Die Karte ermöglicht den schnellsten Geldumschlag und minimiert gleichzeitig die Kosten.

Ein charakteristisches Merkmal der Entwicklung des Plastikkartenmarktes in Russland ist, dass russische Banken heute auf der Grundlage von Karten ausländischer bargeldloser Zahlungssysteme zunehmend mit inländischen Zahlungssystemen interagieren [1]. Ich halte es für notwendig, die bekanntesten internationalen Zahlungssysteme in Russland zu berücksichtigen (Abb. 1).

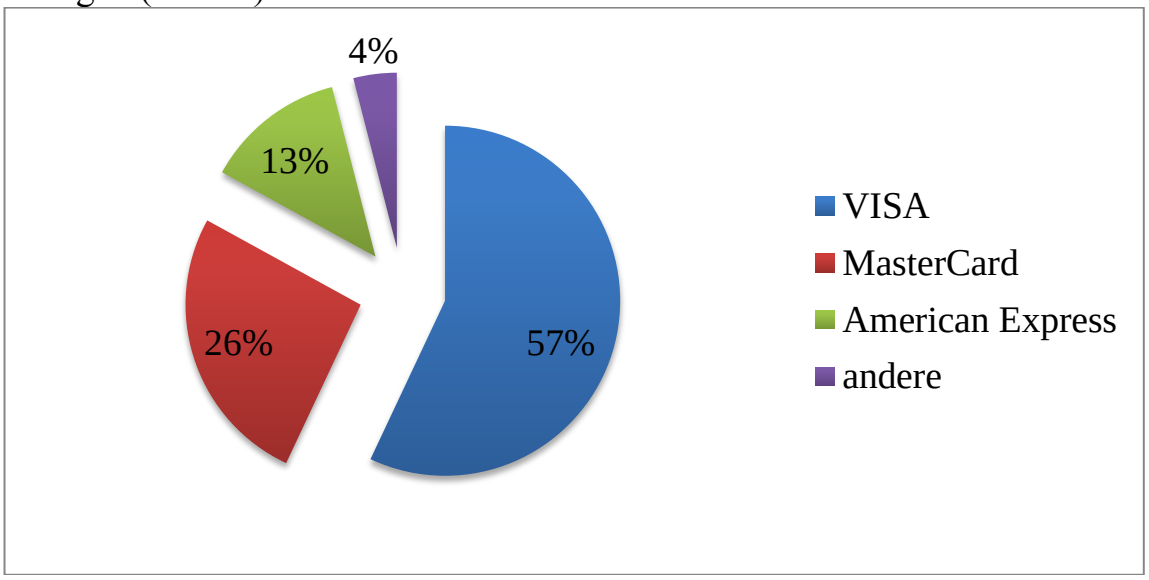

Abb.1 - Struktur des Anteils internationaler Zahlungssysteme

Die führenden Positionen unter den internationalen bargeldlosen Zahlungssystemen nehmen VISA und MasterCard ein. Visa-Karten haben ein breites Anwendungsgebiet. Dabei handelt es sich um Einzelhandelsgeschäfte verschiedener Art in mehr als 200 Ländern. Es ist diese Organisation, die eine wichtige Rolle bei der Entwicklung innovativer Zahlungsprodukte und -technologien spielt.

MasterCard Incorporated ist ein führendes System, das es geschafft hat, eine Vereinigung von 22.000 Finanzinstituten in 210 Ländern zu werden. Der Zweck seiner Gründung besteht darin, das globale Geschäft schnell zu koordinieren und zu verwalten, die Förderung der eigenen Marken auf den Märkten sicherzustellen und neue Technologien und Standards zu entwickeln.

Banken geben Debit- und Kreditkarten aus Plastik sowohl an juristische als auch an natürliche Personen aus (Abb. 2). Auch virtuelle Karten haben in letzter Zeit einen gewissen Marktanteil gewonnen. Dies kann nicht nur positiv für die Umwelt, sondern auch als Katalysator für das schnelle Wachstum der Finanzkompetenz der Bevölkerung gesehen warden.

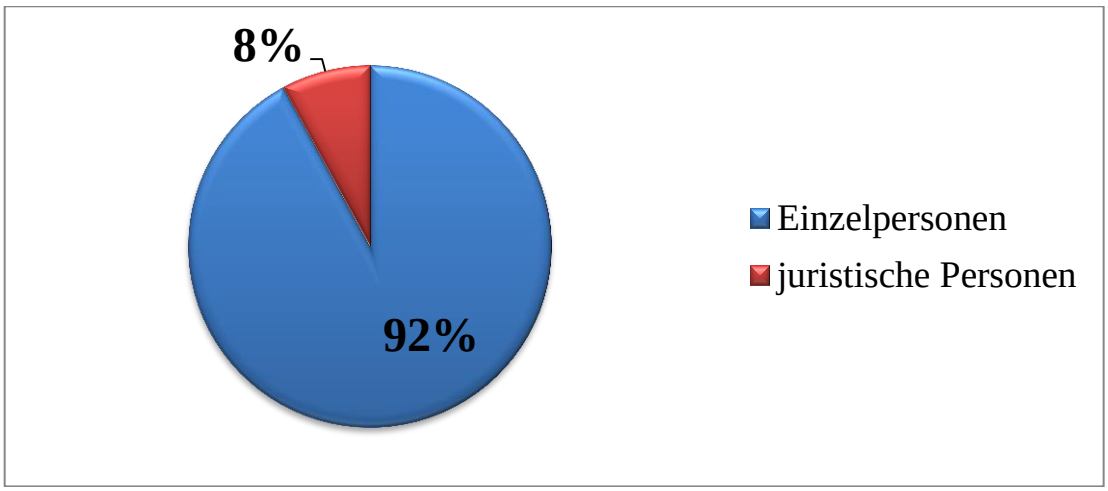

Abb. 2 - Aufbau von Plastikkartenhaltern.

Die Hauptnutzer von Bankkarten sind Privatpersonen, die etwa 92,9 % aller Karteninhaber ausmachen. Die Zahl der juristischen Personen, die Kreditkarten besitzen, ist deutlich geringer und bleibt mit minimalen Anpassungen seit mehr als fünf Jahren stabil (7,1 %). Diese Ungerechtigkeit ist vor allem darauf zurückzuführen, dass es heute etwa drei bis vier Karten pro Person gibt.

Der Anstieg der Zahl der Bankkartennutzer ist auf mehrere Faktoren zurückzuführen.

Erstens ist der Treiber der Entwicklung des Plastikkartenmarktes die einfache Ausgabe, aufgrund derer viele Nutzer von Bankdienstleistungen eine etablierte Tendenz haben, mehrere Karten gleichzeitig mit unterschiedlichen Nutzungsbedingungen zu öffnen. Erwähnenswert sind auch die „positiven“ Auswirkungen der Pandemie auf den Markt für bargeldlose Kartenzahlungen. Aufgrund der Selbstisolation begann die Bevölkerung zunehmend, im Internet einzukaufen (Tab. 1). Es ist zu beachten, dass derzeit die Implementierung von Karten des inländischen Zahlungssystems „Mir“ im Gange ist, was dazu beiträgt, den Kundenstamm in kurzer Zeit und in relativ großen Mengen zu

erweitern [2]. Derzeit ist es dem russischen Zahlungssystem bereits gelungen, etwa 75 % des Gesamtwerts der in der Russischen Föderation betriebenen Zahlungssysteme zu erobern (Abb. 3).

Tabelle 1 – Struktur des Zahlungsverkehrs per Bankkarte im Internet

Zahlungskategorie/Alter	12-17 Jahre	18-24 Jahre alt.	25-34 Jahre alt.	35-44 Jahre alt.	45-55 Jahre
Mobilfunk	60,3	82,6	88,7	90,1	87,6
Bestellungen in Online-Shops	48	80,8	86,1	85,8	79,9
öffentliche Versorgungsunternehmen	26,5	60,3	79,7	81,6	81,4
Transport	26,8	62,6	65,1	62,1	60,7
Überweisungen innerhalb der Russischen Föderation und ins Ausland	26,5	67	55,4	58	55,2
Bußgelder, Steuern, staatliche Abgaben	14,8	40,7	59,8	60	53,4
Essenslieferung	25,3	60,5	64	53,1	36,7
Taxi	21,3	63,9	62,8	49,8	39
Kreditrückzahlung	15,9	29,7	52,4	47,7	35
Online-Spiele	29,9	29,3	30,2	22,3	18,1

Die beliebteste Art, Bankkarten für Zahlungen im Internet zu nutzen, ist die Bezahlung der Mobilfunkkommunikation, unabhängig von der Altersgruppe der Nutzer. Wenn wir von der Nutzeraktivität sprechen, nutzen Menschen im Alter von 18 bis 44 Jahren relativ häufig diese Zahlungsmethode.

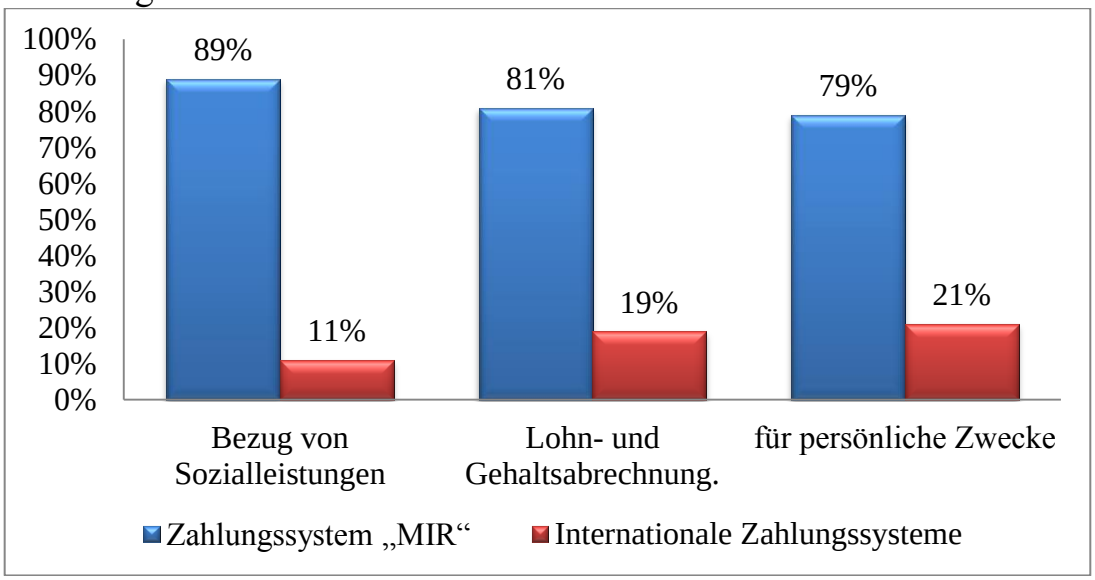

Abb. 3 – Das Verhältnis von MIR-Karteninhabern und internationalen Zahlungssystemen in der

Russischen Föderation.

Auf der Grundlage der oben dargestellten Daten können wir den Schluss ziehen, dass der effektivste Weg zur Einführung von Karten des MIR-Zahlungssystems auf dem heimischen Markt für Bankprodukte darin besteht, dass Bürger Karten erhalten, um ihnen Sozialleistungen zu überweisen. An zweiter Stelle steht das sogenannte „Gehaltsprojekt". Bemerkenswert ist, dass die Bevölkerung für den persönlichen Gebrauch immer noch Karten internationaler Zahlungssysteme bevorzugt. Der Vorteil internationaler Zahlungssysteme ist unbestreitbar, da aufgrund der verschärften wirtschaftlichen und politischen Lage in der Welt die Einsatzgeographie der Karten des MIR-Zahlungssystems erheblich eingeschränkt ist, was den Eintritt in die internationale Arena in der nahen Zukunft nicht ermöglicht.

Wie bereits erwähnt, entwickelt sich der Markt für Plastikkarten sowohl in Russland als auch weltweit rasant. Der Geschäftsführer von BCG (einem internationalen Unternehmen, das sich auf Managementberatung und Unternehmensstrategieberatung spezialisiert) Max Hauser wies darauf hin, dass von 2014 bis 2020 ein rasanter Anstieg (30-fach) der Zahl bargeldloser Kartentransaktionen in der Russischen Föderation zu verzeichnen sei. Im Laufe der Jahre ist sie fast um das 30-fache gestiegen – von 5,9 auf 173 pro Person und Jahr. BCG stellt fest, dass Russland dank des „russischen Wunders" zum größten Markt in Europa in Bezug auf das Transaktionsvolumen mit digitalen Geldbörsen und zum weltweiten Spitzenreiter bei der Anzahl bargeldloser Transaktionen geworden ist.

Die Popularisierung des „Kunststoff"-Marktes ist mit einer Vielzahl von Angeboten von Geschäftsbanken für verschiedene Bevölkerungsgruppen verbunden. Aber bei alledem dürfen wir die Probleme dieses Bereichs nicht vergessen. Das Hauptproblem bei der Entwicklung des Plastikkartenmarktes in der Russischen Föderation liegt in der ursprünglichen russischen Mentalität. Das Vertrauen in Bargeld ist bei älteren Generationen immer noch recht hoch. Daher handelt es sich bei einem Großteil der Kartentransaktionen um Abhebungen vom Konto. Dies gibt der Bank nicht die Möglichkeit, die im Kapitalumlauf befindlichen Mittel zu nutzen und entsprechend Gewinne zu erzielen. Eine Lösung für dieses Problem sehen Banken darin, ihren Kunden verschiedene Bonus- und Treueprogramme anzubieten, die ihnen die Möglichkeit geben, Rabatte und Boni zu erhalten.

Generell wird sich der Plastikkartenmarkt in Russland laut Experten und Forschungsergebnissen weiterhin recht rasant entwickeln. Im Zuge dieser Entwicklung wird die Funktionalität der Bankkarte deutlich zunehmen. Zukünftig könnte die Karte vielfältige Leistungen beinhalten: ein Fahrticket, eine Passerkennung, eine Treuekarte und vieles mehr.

Das Ergebnis dieses Prozesses wird im Idealfall der Verzicht auf Plastik und der Übergang zum immer beliebter werdenden System des schnellen Bezahlens und der Verwendung virtueller Karten sein.

Obwohl SBP ein relativ junges System ist (gegründet von der Bank of Russia und dem JSC National Payment Card System am 28. Januar 2019), ist es ihm in nur drei Jahren

seines Bestehens gelungen, sowohl bei Organisationen als auch bei Einzelpersonen beliebt zu werden. Das System ermöglicht es, Einkäufe über einen QR-Code zu tätigen und Zahlungen von Organisationen zu erhalten sowie Interbank- und andere Überweisungen per Telefonnummer praktisch ohne Provision durchzuführen:

1 bis 100.000 - 0 %, über 100.000 - 0,5 %, jedoch nicht mehr als 1.500 Rubel. zur Übersetzung für Bürger;

2 bis 0,7 % für Unternehmen;

3 von 0,05 bis 3 Rubel. für Übertragungen von natürlichen auf juristische Personen und umgekehrt.

Das schnelle Zahlungssystem wurde von so großen Banken wie Sberbank, VTB Bank, Gazprombank, Alfa-Bank, Rosselkhozbank und vielen anderen unterstützt. Der Anteil der Überweisungen in der VTB Bank über SBP beträgt heute etwa 41 %, bei der Post Bank übersteigt dieser Wert nach Angaben ihres Vertreters 50 % der Gesamtzahl aller externen Überweisungen [3]. Bis Ende 2025 plant die Bank von Russland, das Volumen der Geldtransfers zwischen Privatpersonen über SBP von derzeit 27 % der Gesamtzahl der Interbanktransfers um 10 % zu erhöhen.

Seit der Gründung des SBP bis heute haben rund 36 Millionen Menschen über dieses System Überweisungen im Gesamtbetrag von mehr als 4,2 Billionen getätigt.

Im nächsten Jahr ist die Einführung eines Dienstes geplant, der die Abwicklung von Zahlungsvorgängen zugunsten der Bundeskasse ermöglicht. Es ist auch geplant, im Jahr 2025 grenzüberschreitende SBP-Überweisungen umzusetzen.

Es ist jedoch noch sehr früh, von einer vollständigen Akzeptanz dieses Systems in allen Bevölkerungsschichten zu sprechen, da dieser Prozess einen erheblichen Zeitaufwand erfordert, da selbst Plastik noch nicht richtig im Leben der Russen Fuß fassen konnte.

Literaturverzeichnis

1. Annenkova E.A. Innovacionnye trendy razvitiya rossijskih bankovskih produktov i uslug // Intellekt. Innovacii. Investicii. – 2019. – № 6. – S. 18-24. (in Rus.)
2. Revtova O.A. Vliyanie pandemii na bankovskij sektor // Yunost' i znaniya – garantiya uspekha – 2020: sb. nauch. tr. 7 Mezhdunar. molodezhnoj nauch. konf. : v 3 t. – Kursk, 2020. – S. 184-188. (in Rus.)
3. Shevchenko A. A. Analiz sovremennogo rynka bankovskih kart v Rossijskoj Federacii // Nauka, tekhnika i obrazovanie. 2020. № 1 (65). S. 42. (in Rus.)

Банковские карты как современный инструмент безналичных расчётов

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Аннотация. В статье раскрыта роль банковских карт в системе безналичных расчётов, а также рассмотрено современное состояние рынка пластиковых карт в Российской Федерации. Была изучена структура анализируемого рынка и рассмотрена основная проблематика развития данного направления, а также предложен ряд рекомендаций по совершенствованию изучаемого банковского продукта.

Ключевые слова: рынок, банковская карта, счет, коммерческий банк, комиссия, процент, перевод.

УДК 004:34

Digitalization of prosecution services

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Abstract
In the modern world, characterized by the rapid development of information technologies, the effective work of government agencies is impossible without the widespread use of digital solutions. Today, digital technologies are being introduced into all areas of government activity, the use of electronic systems in the work of the prosecutor's office is becoming especially important. These systems help simplify document processing for employees and ensure effective monitoring of the situation on the Internet. This allows for quick identification and prevention of offenses. The article discusses the use of electronic interaction systems in the Prosecutor's Office of the Russian Federation, their role and results, and provides data confirming the effectiveness of these systems.
Keywords: Russian Federation, Prosecutor General's Office, information technology, electronic interaction systems, digitalization.

Introduction

The introduction of digital technologies in the prosecutor's office is carried out in accordance with the instructions of the President of Russia dated September 7, 2017 and the order of the Prosecutor General dated September 14, 2017 No. 627 [1], which approved the "Concept for the digital transformation of prosecutor's offices and organizations until 2025." This concept provides for the implementation of modern technologies to make prosecutorial supervision more effective and organize the coordinated work of law enforcement agencies.

The concept is divided into three stages, which are logically linked to each other. The tasks of the first stage (2017) and the second stage (2018–2020) have already been completed. One of the key results is the active use by the prosecutor's office of the information system of interdepartmental electronic interaction (IS MEI), developed by the Prosecutor General's Office. This system helps to reduce the volume of paper documents, facilitate the collection of information from different departments and speed up the work process. For example, through the system, you can obtain data from the Federal Tax Service (FTS of Russia). This includes information on the income of citizens, their participation in the activities of organizations, the presence of bank accounts and other financial information.

Discussion

In 2021, prosecutors made more than 4.5 million requests through electronic systems (for comparison, in 2020 there were about 2.5 million such requests). Most of these requests are related to the fight against violations related to corruption. For example, the Amur Region Prosecutor's Office processed almost 63 thousand requests. Of these, more than 12 thousand requests were sent to Rosreestr, about 10 thousand to the Ministry of Internal Affairs, and almost 40 thousand were related to tax authorities [2].

In addition, through the IS MEW system, it became possible to receive data from other

departments, such as Rosleskhoz and Rosfinmonitoring. This makes the work of the prosecutor's office faster and more accurate, which is especially important for the timely detection and prevention of violations.

Every year, work with general information available from open sources improves. Prosecutors can now find the necessary data without requesting individual documents. This makes checks faster and easier. For example, through the resources "Spark", X-Compliance and "Marker" allow you to quickly obtain complete information about companies and entrepreneurs, including information about their activities, management, financial status and judicial history. X-Compliance also helps to check whether laws on combating corruption and money laundering are being observed.

However, the Information Letter of the Prosecutor General's Office of the Russian Federation dated 04.04.2022 No. 113–03–2022/Ip8916 states that some prosecutor's offices make mistakes in their work. For example, data is not always transferred to the Prosecutor General's Office on time, verification of documents on the delivery of equipment for public procurement is delayed, and external information resources such as Spark, X-Compliance, and Marker are not used actively enough [3]. These shortcomings require improvement and modernization of existing processes to ensure higher levels of efficiency and transparency in the work of the relevant authorities.

The third stage of the implementation of the Digital Transformation Concept is currently underway, which is planned for 2021-2025. During this stage, it is planned to combine all control measures into one register, improve the automated systems of the prosecutor's office, introduce a single secure data transmission network, and much more. One of the important projects of this stage will be the State Automated System of Legal Statistics (GAS PS). It will contain complete and transparent data on crimes - from the reported crime to the court decision. A specialized service for receiving electronic applications from citizens to law enforcement agencies will operate on the basis of the system. Submission of an application is ensured by automated registration with assignment of a unique number and subsequent referral to the appropriate agency. The applicant will be able to track the status of their application, which will increase the level of interaction between citizens and government agencies and improve trust in law enforcement agencies. Thus, these steps are not only aimed at eliminating current shortcomings, but also create the basis for more effective and modern law enforcement in the future.

O. S. Kapinus believes that the introduction of modern technologies simplifies daily work and helps save money [4].

Conclusion

The launch of new technologies in the prosecutor's office and other law enforcement agencies is a complex but important process that helps improve the efficiency of their work.

The introduction of new technologies in the prosecutor's office and other law enforcement agencies is a complex but extremely important process that plays a key role in improving the efficiency of their work. This process is not limited to the introduction of software or hardware, but includes major changes in organizational structures, processes and methods of interaction both within the agencies themselves and with citizens. In

addition, the use of technology helps reduce bureaucracy, improves access to information and simplifies interaction with citizens. Ultimately, such transformations are aimed at creating a fairer and more effective legal system, where every action of law enforcement agencies will be supported by modern tools of analysis and management, which will allow for a more prompt and adequate response to the challenges of the time. Thus, the introduction of new technologies is a goal that will certainly justify itself in the long term, ensuring a significant improvement in the work of law enforcement agencies, including the prosecutor's office, and strengthening public trust in them.

References

1. Ob utverzhdenii Koncepcii cifrovoj transformacii organov i organizacij prokuratury do 2025 goda [On Approval of the Concept of Digital Transformation of Prosecutor's Office Bodies and Organizations until 2025]. Legality, 2017, No. 12. (Rus)
2. Cifrovaya transformaciya organov prokuratury [Data from the official website of the Prosecutor General's Office of the Russian Federation]. Avialable from: https://epp.genproc.gov.ru/web/gprf/expert_advice/news?item=620980. (Accessed 12.12.2024). (Rus)
3. O rezul'tatah analiza raboty po realizacii meropriyatij cifrovoj transformacii organov prokuratury Rossijskoj Federacii [On the results of the analysis of work on the implementation of digital transformation measures of the prosecutor's office of the Russian Federation]. Legality, 2022, No. 113-03-2022. (Rus)
4. Kapinus O. S. Cifrovizaciya deyatelnosti organov prokuratury: nastoyashchee i budushchee. [Digitalization of the activities of the prosecutor's office: present and future. Legality, 2018, No. 4(66), pp. 5–10. (Rus)

Цифровизация органов прокуратуры

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Аннотация. В современном мире, характеризующемся стремительным развитием информационных технологий, эффективная работа государственных органов невозможна без широкого применения цифровых решений. Сегодня цифровые технологии внедряются во все сферы государственной деятельности, использование электронных систем в работе прокуратуры становится особенно важным. Такие системы помогают облегчить работу сотрудников с документами и обеспечивают эффективный мониторинг ситуации в сети Интернет. Это позволяет быстро выявлять и предотвращать правонарушения. В статье обсуждаются вопросы использования систем электронного взаимодействия в прокуратуре Российской Федерации, их роль и результаты, а также приводятся данные, подтверждающие эффективность работы этих систем.

Ключевые слова: Российская Федерация, Генеральная прокуратура, информационные технологии, системы электронного взаимодействия, цифровизация.

УДК 341

Some aspects of the interaction of international and domestic law

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Abstract
The article examines the issue of the relationship between international and domestic law. The concepts of such a relationship, as well as the positions of scientists who have expressed an opinion on their relationship are analysed. The conclusion is drawn that there is an active interaction between domestic and international law today.
Keywords: domestic law, interaction of international and domestic law, international law.

Introduction

Speaking about the interaction of international and domestic law, it is necessary to note the importance of this legal phenomenon, taking into account their belonging to different legal systems. National and international law dynamically interact with each other, exerting mutual influence, which is subject to changes due to the development of international relations.

Normative acts of international law establish rights and obligations exclusively for its subjects, that is, for different countries. Official institutions, as well as individuals and legal entities within the State, are not directly affected by the norms of international law. In order to ensure the fulfillment of international obligations, States are taking measures to transform international legal norms into their domestic laws and regulations. For this reason, there is a principle in the legislation of many countries according to which the norms of international law take precedence over domestic legal acts.

According to legal scholars, at the time of its inception, until the second half of the 20th century, international law had little influence on the domestic laws of states and most international agreements did not concern the domestic policy of the country. Based on their sovereignty, states freely declared their right to use force and wage war, which led to the consolidation in international practice of the theory that domestic law is superior to international law. This theory was based on the ideas of Hegel, who claimed that the national state is the "absolute power on earth" and has the right to change both international and domestic laws at its own discretion. [1, p. 141].

Discussion

The gradual development of the countries and society, as well as the interrelations between different countries, led to an understanding of the importance of limiting the right of states to wage war and implementing this limitation. In addition, there was an understanding of the importance of protecting certain categories of civilians. Subsequently, the norms of international law began to have a noticeable influence on the formation of national legal systems. This fact became fundamental for the dualistic concept, which many scientists became adherents of. According to this concept,

international and domestic law are considered as separate but interrelated systems. The essence of dualism lies in the fact that each of these areas of law operates according to its own principles but also interacts and influences the other. [2, p. 162].

If we consider this concept more broadly, we can note that the interaction between international and national law has its own characteristics. Domestic legislation must be consistent with international norms for their effective implementation. When it is necessary to develop domestic norms to meet international legal requirements, the content of international norms is "transferred" to the level of national legislation.

According to the legal position of many countries, the norms of international treaties are an integral part of their national legislation. In addition, these international legal norms may be the highest legislative norms of some countries. An example is the US Constitution (where this principle is enshrined in Article 6). Other examples include the 1976 Greek Constitution, which enshrines this provision in Article 28, and the 1978 Spanish Constitution (Article 96). Another striking example of the assertion of the priority of international norms over domestic legislation is the 1958 French Constitution (Article 55) and the Constitution of the Netherlands, which enshrines this provision in Article 94. However, when analyzing the issue of the relationship between international and domestic law, we cannot ignore the judicial practice of a number of countries, focusing only on the legislative norms of international treaties. Countries such as the United States, for example, may refer to the norms of customary law when resolving specific court cases and consider it an integral part of their legal system. For example, according to a 1900 ruling by the US Supreme Court, in the absence of relevant international treaties or legislation, decisions must be made on the basis of generally accepted international law. This practice exists and is actively used in the US, UK and a number of other countries.

A significant modern legal conflict has its roots in the Habeas Corpus Act. In 2006, the U.S. Congress passed the Military Commissions Act, which allowed for the suspension of habeas corpus for individuals classified as enemy combatants. Critics argued that the suspension violated the terms of the Constitution, since the country was not in a state of invasion or rebellion.

Currently, there are several legal positions that reveal the specifics of the interaction of international and domestic law. Thus, D.B. Levin says "that international and domestic law are two legal systems that differ in all their basic elements: in the object of law, in the subjects of law, in the structure of legal relations and in the sources of law. The objects of law only partially coincide. This is precisely what brings to life the very problem of the correlation between international and domestic law. In practice, this problem, since it refers to the legal relationship of both systems, primarily boils down to the ways of implementing the norms of international law within a given state" [3, p. 39]. V.V. Gavrilov's idea that the category of "legal system" is not only a national but also an international projection is interesting in the context of this issue [4, p. 7].

International and domestic law functions in close interrelation, not representing independent systems. National legal systems influence the process of norm-setting in international law, while international norms, in turn, are reflected in national legislation. In some States, international law is integrated into the domestic legal system, becoming an

integral part of it.

Conclusion

Currently, it is noticeable how international law and national legislation actively interact, approaching each other and exerting mutual influence. Modern international law shows a clear tendency to expand the scope of its jurisdiction.

International and national law do not operate independently of each other. National legal systems influence the process of rulemaking in international law. At the same time, international law also influences national legislation. In many countries, laws stipulate that in the event of conflicts between provisions of national law and international obligations, the latter take precedence.

References

1. Matvienko E.A. Vzaimodeystviye vnutrigosudarstvennogo i mezhdunarodnogo prava v voprosakh obespecheniya prav cheloveka. V kn.: Puti povysheniya effektivnosti upravlencheskoy deyatel'nosti organov gosudarstvennoy vlasti v usloviyakh sotsial'no-ekonomicheskogo razvitiya territoriy. Materialy VII Mezhdunarodnoy nauchno-prakticheskoy konferentsii [Interaction of domestic and international law in matters of ensuring human rights. In: Ways to increase the effectiveness of management activities of public authorities in the context of socio-economic development of territories. materials of the VII International Scientific and Practical Conference]. Donetsk, 2023. pp. 140-144.
2. Asanova A.R. Formy vzaimodeystviya vnutrennego i mezhdunarodnogo prava [Forms of interaction between domestic and international law]. Bulletin of Kyrgyzstan, 2024, No. 1-1, pp. 161-165.
3. Posazhennikova E.A. Vzaimodeystviye vnutrigosudarstvennogo i mezhdunarodnogo prava. V kn.: Studencheskaya nauka – vzglyad v budushcheye. Materialy XVIII Vserossiyskoy studencheskoy nauchnoy konferentsii. [Interaction of domestic and international law. In: Student science is a look into the future. Materials of the XVIII All-Russian Student Scientific Conference]. Krasnoyarsk, 2023. pp. 38-40.
4. Gavrilov V.V. Teoreticheskiye problemy sootnosheniya mezhdunarodnogo i vnutrigosudarstvennogo prava. V kn.: Problemy ukrepleniya gosudarstvennosti i obespecheniya zakonnosti. Materialy yubileynoy nauchno-prakticheskoy konferentsii, posvyashchennoy 45-letiyu nepreryvnogo yuridicheskogo obrazovaniya v DVGU [Theoretical problems of the correlation of international and domestic law. In: Problems of strengthening statehood and ensuring the rule of law. Materials of the jubilee scientific and practical conference dedicated to the 45th anniversary of continuing legal education at DVSU]. Vladivostok, Publishing House of the Far East. un-ta. 2003. pp. 3-12.

Некоторые аспекты взаимодействия международного и внутригосударственного права

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Аннотация. В настоящей статье рассматривается вопрос о соотношении международного и внутригосударственного права. Анализируются концепции такого соотношения, а также позиции ученых, которые высказывали мнение об их соотношении. Делается вывод об активном взаимодействии внутригосударственного и международного права на сегодняшний момент.

Ключевые слова. взаимодействие международного и внутригосударственного права, внутригосударственное право, международное право.

УДК 341

International legal features of the fight against drug trafficking

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Abstract. The problem of countering the spread of drugs is relevant for all mankind living on our planet. Taking into account the pace of development of globalization, the legislation and actions of the authorities of various States in the framework of this struggle should be coordinated. Taking into account the above circumstances, the international community has adopted international legal acts aimed at combating illicit proliferation, which are currently subject to revision.
Keywords: drugs, narcotic drugs, psychotropic substances, illicit trafficking, struggle, convention, problem.

The threat of illegal drug distribution has long been hanging over the whole world. Due to the importance of the problem, it is necessary to create a global counteraction system that would allow controlling the drug situation around the world. The cooperation of national law enforcement agencies, which are called upon to combat illicit trafficking in narcotic drugs and psychotropic substances, is based on the international legal system of norms.

Many national anti-drug programs and laws are based in accordance with the following UN international agreements: the Single Convention on Narcotic Drugs of 1961 [1], the Convention on Psychotropic Substances of 1971 [2] and the Convention against Illicit Traffic in Narcotic Drugs and Psychotropic Substances of 1988 [3].

The Single Convention on Narcotic Drugs was signed in New York and combines many agreements that were adopted earlier. The States recognized that persons who committed acts that contradict the provisions of the Convention will be criminally liable, as well as the confiscation of illegal substances and equipment that served as a means of their manufacture. The same convention gave rise to the International Narcotics Control Board.

The Convention defines four lists of narcotic drugs, which establish a different level of control from each other. The first list contains those drugs that can be used for medical and scientific purposes with special permission. The second list lists drugs issued under a numbered prescription with strict accountability, again for medical and scientific purposes. Drugs of the third list are issued only according to prescriptions of strict reporting for medical and research purposes. The fourth list contains those funds that can be obtained for medical reasons upon presentation of a prescription. It follows from this conclusion that every drug that is in these four groups cannot be freely sold and they are withdrawn from free circulation.

Psychotropic substances can also affect a person's mental functions and cause addiction. Usually, these drugs are created artificially and used for medical purposes. In order to control the trafficking of psychotropic substances, the Convention on

Psychotropic Substances was adopted in 1971. It also contains four lists that set different control modes. The substances included in the list are established by the World Health Organization and approved by the Commission on Narcotic Drugs. As for liability for violations of the provisions of the agreement, the list of crimes in the text is incomplete, but they are, in general, identical to the crimes in the 1961 Convention. The main type of sanction is imprisonment and confiscation of illegal substances and their destruction. Complicity in a crime and an attempt on it is also punishable [4, p. 432].

In 1988, the Convention on Combating Illicit Trafficking in Narcotic Drugs and Psychotropic Substances was published. Unlike its predecessors, it contains control measures and sanctions for all forms of crimes in the field of drug trafficking.

Despite the fact that international legislation on combating drug trafficking was thought out in sufficient detail at the time, there are still a number of specific problems that arise during implementation.

The first is the legalization of illegally obtained income. In our opinion, it is possible to solve this problem by strengthening control over banking operations, borrowing the experience of foreign countries that have succeeded in this area.

The second problem is the decriminalization of drugs. This issue is truly controversial, since, on the one hand, strict criminal regulation makes it possible to prevent drug use and trafficking through fear of punishment, but on the other hand, it affects human rights, since drug addicts need treatment, not repression. Moreover, there is an experience, often controversial, that in some States the decriminalization of light drugs has had a positive effect.

The third problem is the inaccuracy of the classification of narcotic drugs and psychotropic substances, which is actively manifested at the present time. The erroneous distribution really complicates law enforcement, because the degree of danger does not correspond to the degree of punishment.

Thus, international legal norms should be further developed and improved in the field of combating drug trafficking.

References

1. Yedinaya konventsiya o narkoticheskikh sredstvakh 1961 goda s popravkami, vnesennymi Protokolom 1972 goda o vnesenii izmeneniy v Yedinuyu konventsiyu o narkoticheskikh sredstvakh ot 30 marta 1961 goda [The Single Convention on Narcotic Drugs, 1961, as amended by the 1972 Protocol amending the Single Convention on Narcotic Drugs of 30 March 1961]. Available from: http: //www.consultant.ru/document/cons_doc_LAW_135628/ (Accessed 06.12.2024). (Rus)

2. Konventsiya o psikhotropnykh veshchestvakh ot 21.02.1971 g [Convention on Psychotropic Substances of 21.02.1971]. Available from: http: //www.consultant.ru/document/cons_doc_LAW_121091/ (Accessed 06.12.2024). (Rus)

3. Konventsiya Organizatsii Ob"yedinennykh Natsiy o bor'be protiv nezakonnogo oborota narkoticheskikh sredstv i psikhotropnykh veshchestv ot 20.12.1988 g. [United Nations Convention against Illicit Traffic in Narcotic Drugs and Psychotropic Substances of 20.12.1988]. Available from: http: //www.consultant.ru/document/cons_doc_LAW_121092/ (Accessed 06.12.2024). (Rus)

4. Kolosov Yu.M., Kuznetsov V.I. Mezhdunarodnoye pravo: uchebnik [International law: textbook]. Moscow, Mezhdunarodnye otnoshenija, 1994. 608 p. (Rus)

Международно-правовые особенности борьбы с незаконным оборотом наркотиков

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Аннотация. Проблема противодействия распространению наркотиков является актуальной для всего человечества, проживающего на нашей планете. С учетом темпов развития глобализации законодательство и действия органов различных государств в рамках указанной борьбы должны быть скоординированными. С учетом названного обстоятельства мировым сообществом приняты международно-правовые акты, направленные на борьбу с незаконным распространением, которые в настоящее время подлежат доработке.
Ключевые слова: наркотики, наркотические средства, психотропные вещества, незаконный оборот, борьба, конвенция, проблема.

УДК 378-14

Application of choice architecture techniques to the high educational settings

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Abstract
Students frequently experience decision-making difficulties during their studies. The most overwhelming choices are usually not connected with academic, but organizational tasks. To ease this process for students, we provide suggestions on implication of choice architecture techniques described by Münscher et al.'s (2015) to the course selection, extracurricular activities, and bureaucratic aspects. In most of the cases changing the way information presented to the students can change their starting behavior to the targeted one.
Keywords: choice acrchitecture, behavior change, intervention application, higher education institution, nudge.

Introduction

Higher education institution students face the necessity to make choices regarding not only their studies but the organizational aspects of education as well. These choices are able to affect their future and have an influence on their academic success, which puts an extra burden on them. The challenge to choose the "best" among an extraordinary variety of options can lead some students to *choice overload* and even *decision aversion* (Iyengar & Lepper, 2000). This fact negatively impacts the motivation and academic success of the students. To prevent such consequences, there is a need for an external force that will make the process of choosing easier and will nudge them toward healthy decisions. *Choice architecture* appears to be such a force. It is the process of designing the choice settings by which architects are able to influence the behavior of a person or a group of people toward the desired decisions, still leaving the free choice (Thaler et al., 2012). The role of choice architects in higher education institutions is to provide more accessible and easier choices for students, allowing them to focus more on the academic workload rather than the organizational aspects of education.

Choice architecture is aimed at assisting people while they are choosing by using different techniques that were divided into three categories by Münscher et al. (2015): *decision information, decision structure, and decision assistance*. This paper aims to analyze decision-making problems frequently encountered by students and to provide suggestions for the implementation of choice architecture techniques in order to solve them. The issues taken into consideration are *course selection, extracurricular activities,* and *bureaucratic factors* such as tuition payments, requests, petitions, etc.

Methods

While writing the research paper, we focused on exploring the literature relevant to the

topics of choice architecture, decision-making processes, and their impact on the students' academic success. Throughout the literature review, it was found that little evidence was provided on the application of choice architecture techniques to higher education institutions and their students (Bachelor's and Master's degrees). In addition to this, the field lacks concrete measurable results as well as any suggestions and possibilities for methodology application to educational settings. Taking this into consideration, our aim was to analyze current prevalent problems encountered by university students related to decision-making processes and to provide adequate solutions by applying the theories and concepts described by Münscher et al. (2015) and Thaler et al. (2012). This paper focuses on providing a theoretical basis for further empirical exploration in this field.

Explanation of the techniques' classification

Before diving into the application part, the techniques used in this paper, their division, and the purpose of use should be viewed and explained. According to Münscher et al.'s (2015) taxonomy, reframing, simplifying, providing feedback, making the external information visible, and referring to opinion leaders are included in the *decision information* category, meaning these techniques are related to the change and transformation of the information to influence the choice. Decreasing physical/cognitive effort, grouping, and changing the social consequences of behavior are part of the *decision structure* category. This section is responsible for the rearrangement of options presented to nudge people toward the targeted behavior. *Decision assistance* incorporates reminders and provides third-party assistance to stay consistent with the selected choice. Further on, the application of the techniques in different situations will be described.

Course selection activities

The course selection process involves much mental effort as it requires several steps: finding appropriate courses, analyzing their content and class schedule, etc. If accurate information or feedback is not provided, the student fails to choose the course according to his needs. For instance, students applying to the "Filmmaking" class may be expecting to get practical experience during this course, while in fact they are facing the necessity of writing theoretical essays, causing confusion. Therefore, techniques such as *simplifying* information, meaning changing the presentation of the content by converting it into more understandable pieces of information, could be applied (Münscher et al., 2015). Moreover, *grouping* courses based on the similarity of the content, the field of study, or the lecturer holding the course will provide a visible scheme of available options through which it will be easier to navigate. Making the *external information visible* is also a crucial part. Spreading the information during the course selection period by publishing on the website or local institution's automation systems used by students is essential. By using these techniques, higher education institutions can provide comprehensive course descriptions, including workload, required skills, and grading criteria. Furthermore, providing *feedback* about the course from the students who previously took the class would set realistic expectations for the upcoming students.

Extracurricular activities

Extracurricular activities such as student clubs, additional training, volunteering programs, and events are common for many higher education institutions. The aim of the administrative staff is to invite students to active participation in community life. The possible reasons for failure to attract students can lie in misinformation or poor information flow, lack of organizational efforts, or inability to target students' interests and needs, etc.

To tackle these problems, choice architecture techniques should be applied. For example, *making external information visible* by using bright-colored flyers and posters, visual aids, and web publications can provide greater information flow and inform about upcoming events. *Reframe* information by focusing on the students' needs. Instead of attracting attention to general benefits, e.g., "earning a certificate," present information in a more personal and student-oriented manner, e.g., "acquiring practical skills useful for the marketing field to attract employers." This technique will help to provide students with necessary details and enable the change in their perception of the event. *Simplifying* information by breaking down long texts into bullet points or small paragraphs and using plain, understandable language helps process the information by reducing cognitive overload and constraints in cognitive capacity (Münscher et al., 2015). After presenting the information to the students, there is a need to nudge them to take the targeted action (signing up for extracurricular activities). To do so, choice architects can *change social consequences,* meaning providing additional social validation for those who took the action. Expressing gratitude to the participants of the volunteering program on the official website of the institution can be an example.

Bureaucratic aspects

Bureaucratic processes such as document requests and submissions, tuition payments, accommodation registration, etc. are presented as overwhelming procedures with loads of paperwork that lack transparency and clear instructions. To reduce physical and cognitive efforts, new systems can be applied. *Decreasing physical effort* techniques can be applied in the form of digital checklists. For instance, making such directories for exchange program applicants available on the website could remove the complexities from the process by collecting the information about required steps, documents, office locations, and office hours in one place. *Providing reminders* via email or SMS to notify about upcoming deadlines for document submission or payments. Adopting these adjustments would minimize the physical and mental burden, making the procedures more efficient.

Discussion and limitations

To summarize everything mentioned above, the importance of the information should be taken into consideration. Most of the techniques explained and suggested for application involve work with the information (transformation and distribution) provided to the students. Since choices in the educational environment are mostly intangible, physical rearrangement of options will not work for most of the situations. Continuing

with the possible limitations, the research paper provides theoretical basis for further empirical and qualitative research. The research faces the limitations of applicability as it proposes generalized ideas. Therefore, the application can vary depending on the institutional structure, cultural aspects, and academic and administrative stuff. Moreover, the scope of study is limited only to course selection, extracurricular activities, and bureaucratic factors thus new areas of application need further exploration. In addition, the effects of choice architecture interventions have to be measured and observed to provide concrete data for analysis.

References

1. Iyengar, S. S., & Lepper, M. R. (2000). When choice is demotivating: Can one desire too much of a good thing? Journal of Personality and Social Psychology, 79(6), 995–1006. https://doi.org/10.1037/0022-3514.79.6.995

2. Münscher, R., Vetter, M., & Scheuerle, T. (2015). A Review and Taxonomy of Choice Architecture Techniques. Journal of Behavioral Decision Making, 29(5), 511–524. https://doi.org/10.1002/bdm.1897

3. Thaler, R. H., Sunstein, C. R. S., & Balz, J. P. (2012). Choice Architecture. Available from: https://doi.org/10.13140/2.1.4195.2321 (accessed 14.03.2025)

Применение методов архитектуры выбора в высших учебных заведениях

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Аннотация. Студенты часто сталкиваются со сложностями выбора в течение учебы. Наиболее сложные решения в основном связаны не с академической деятельностью, а с организационными проблемами в работе высших учебных заведений. В данной статье предлагается применение техник архитектуры выбора, описанных и систематизированных Р. Мюншером и др. (Münscher et al.) для упрощения процесса принятия решений во время выбора предметов, внеучебной деятельности и бюрократический аспектов обучения. Наш анализ показывает, что преобразование способов подачи и распространения информации может изменить исходное поведение на целевое.

Ключевые слова: архитектура выбора, изменение поведения, вмешательство, подталкивание, высшие учебные заведения.

УДК 004.853

Revolution of educational activities: the introduction of reinforcement learning

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Abstract
The article focuses on the potential revolutionary impact of reinforcement learning on the educational environment. Methods based on reinforcement learning offer personalized approaches to learning, which allow increasing student engagement and motivation. The article highlights the potential of using reinforcement learning to create innovative educational technologies and platforms that can provide a more personalized and effective learning process, including using virtual reality and interactive simulators.
Keywords: agent, artificial intelligence, learning process, personalization**,** reinforcement learning.

Introduction

In a reinforcement learning system, an agent makes decisions by performing actions that can affect the state of the environment. This approach includes a reward and punishment system, in which the agent learns to make optimal decisions by maximizing the reward and minimizing the punishment. It has been successfully applied in various fields, such as robotics, games, finance, and healthcare.

The method has its roots in behavioral psychology, where the ideas of reward and punishment were studied using animals as examples. These principles were later transferred to computer science: in the 1950s, psychologists and engineers began developing the first mathematical models describing learning behavior.

Key Characteristics of Reinforcement Learning

An agent can be either a software or a physical object. It receives feedback in the form of rewards or penalties. Based on this information, the agent learns to make decisions about which actions are appropriate for a given situation. Its goal is to maximize the expected reward.

Look at an example: a robot learns to play a video game where you need to collect coins and avoid enemies. The robot is an RL agent, and the game space is the learning environment. For each coin it collects, it gets points (a reward), and if it runs into an enemy, it loses points (this is a punishment). At first, the robot makes a lot of mistakes, but gradually understands which actions bring more points and remembers the correct strategy.

In reinforcement learning, agents can be of different types:

- a rule-based agent (uses predefined rules to make decisions);
- Q-learning agent (memorizes Q (quality) values for each state-action pair);
- Markov decision process (MDP) (the agent only considers the current state of the environment when making decisions);

– Partially observable Markov decision process (POMDP) (the agent does not have complete information about the state of the environment and must use probabilistic models to make decisions) [1].

The main goal of reinforcement learning is to maximize the reward, which is also called value.

Formally, the concept of value in reinforcement learning is represented as a value function:

$$V^{\pi}(s_t) = E_{\pi}\{\sum_{k=0}^{\infty}(\gamma^k r_{t+k+1})\}$$

In this case, the function takes into account the discounted future rewards starting from a particular state according to the set policy. It is also known as the state value function for a given policy [2].

In model-based algorithms, the agent can predict the reward for an outcome and takes actions to maximize the reward. This is an algorithm in which the decision is entirely based on maximizing the reward points. It is used in situations where we have complete information about the environment and the results of actions in this environment. For environments that are fixed or static in nature, model-based algorithms are more suitable.

In model-free algorithms, the agent performs many actions multiple times and learns from the results. Based on the learning experience, it tries to determine a policy or strategy for performing actions in order to obtain optimal reward points. This type of algorithm should be used in dynamic environments for which there is no complete information. An example of reinforcement learning is driving cars in a dynamic environment where routes change greatly. In such situations, model-free algorithms are more suitable. Fig. 1 shows the structural diagram of the algorithms.

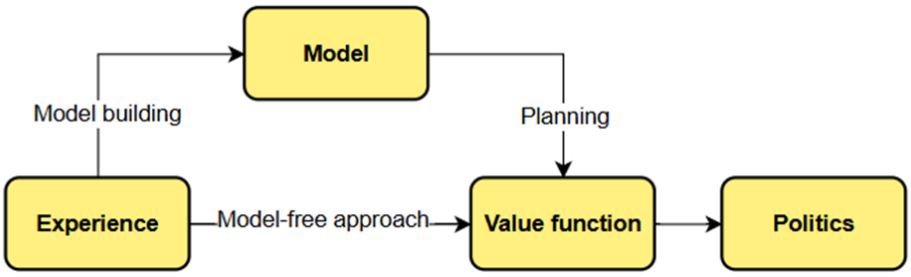

Figure 1 - Model-based and model-free reinforcement learning

In recent years, much attention has been paid to the application of reinforcement learning in the educational environment. Reinforcement-based learning methods have the potential to revolutionize the education system by increasing student engagement, motivation, and learning outcomes. Providing a personalized learning experience can help students reach their full potential. In traditional teaching methods, students are given a set of instructions and are expected to memorize them.

One of the key differences between traditional teaching methods and reinforcement-based methods is the level of personalization. The former are often based on a one-size-fits-all approach that does not suit all students. The latter, on the contrary, can be tailored to the needs of individual students. Reinforcement learning algorithms rely on large

amounts of data to make accurate predictions.

Collecting high-quality data in education is challenging because it requires access to hard-to-find student performance data. In addition, reinforcement learning algorithms can be complex, and it can be difficult for educators to understand how the model led to a particular decision. As a result, this can make it difficult to adjust teaching strategies. Another limitation of the teaching methods under consideration is that they are not suitable for all students. Some may prefer traditional teaching methods and react negatively to the mechanisms used in AI-based teaching [3].

Conclusion

In the near future, reinforcement learning can be used to develop new educational technologies and platforms that will provide a more engaging, personalized learning experience. For example, virtual reality platforms, interactive simulators that help students visualize complex concepts can be developed.

Due to the circumstances noted earlier, reinforcement learning has the potential to revolutionize the education system. Educational games, personalized learning platforms, and intelligent tutoring systems are just a few examples of how reinforcement learning can be applied in education to improve student learning outcomes.

References

1. Method of Multi-Agent Reinforcement Learning in Systems with a Variable Number of Agents / V. I. Petrenko, F. B. Tebueva, M. M. Gurchinsky, A. S. Pavlov // Mechatronics, Automation, Control. – 2022. – Vol. 23, No. 10. – P. 507-514. – DOI 10.17587/mau.23.507-514. – EDN VDMJEQ.
2. Survey on Practical Reinforcement Learning: from Imitation Learning to Offline Reinforcement Learning / D. Lee, Ch. Eom, S. Choi [et al.] // The Journal of Korean Institute of Communications and Information Sciences. – 2023. – Vol. 48, No. 11. – P. 1405-1417. – DOI 10.7840/kics.2023.48.11.1405. – EDN AGURIG.
3. Zilenkov A.A. Sravnitel'nyi analiz sistem glubokogo obucheniia s podkrepleniem i sistem obucheniia s uchitelem / A. A. Zilenkov, A. A. Silkin, M. IU. Serebriakov, S. V. Kolesova // Izvestiia Tul'skogo gosudarstvennogo universiteta. Tekhnicheskie nauki. – 2022. – Vol. 10. – P. 109-112. – DOI 10.24412/2071-6168-2022-10-109-112. – EDN THDWCA. (Rus)

Революция образовательной деятельности: внедрение обучения с подкреплением

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Аннотация. В статье акцентируется внимание на потенциальном революционном влиянии обучения с подкреплением на образовательную среду. Методы, основанные на обучении с подкреплением, предлагают персонализированные подходы к обучению, позволяющие повысить вовлеченность и мотивацию учащихся. Подчеркивается перспективность применения обучения с подкреплением для создания инновационных образовательных технологий и платформ, которые могут обеспечить более персонализированный и эффективный процесс обучения, в том числе с использованием виртуальной реальности и интерактивных симуляторов.

Ключевые слова: агент, искусственный интеллект, обучение с подкреплением, персонализация, процесс обучения.

УДК 338.2

The impact of urban planning decisions on investment attractiveness

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Abstract
Urban planning plays a major role in shaping the physical, social and economic landscape. Its impact on investment attractiveness cannot be overestimated, it influences decisions in many sectors, from real estate and infrastructure to technology and tourism. This article analyzes the multifaceted relationship between urban planning decisions and investment attractiveness and shows how strategic planning can promote economic growth and prosperity, while ineffective planning can lead to stagnation and decline.
Keywords: businesses, people, urban, city, transport, zoning rules.

Introduction

A reliable and well-planned infrastructure network is the cornerstone of investment attractiveness. Efficient transport systems, including roads, public transport, airports and seaports, facilitate the movement of goods, services and people, reducing the operating costs of enterprises and improving the quality of life of residents. [3] High-speed Internet access and reliable utilities such as electricity, and water supply are equally important in today's digital economy. Investments in smart city technologies, including intelligent traffic management and environmental monitoring systems, further enhance efficiency and sustainability by attracting companies seeking innovation and a visionary approach. [1]

Urban planning solutions are particularly effective, in which priority is given to connections both within the city and with adjacent regions. A well-designed road network that minimizes congestion and facilitates access to key economic centers can significantly reduce transportation costs for businesses [2]. Similarly, efficient public transport systems can attract skilled labor by providing convenient and affordable commuting options.

Rules for land use planning and zoning

Land use planning and zoning rules are powerful tools that determine the spatial distribution of activities in a city. By allocating specific areas for residential, commercial, industrial and recreational purposes, urban planners can create a more organized and functional urban environment. Clear and predictable zoning rules provide certainty for investors, allowing them to make informed decisions, about land acquisition and development. Flexible zoning rules allowing for mixed-use development can help create lively and walkable areas that attract both businesses and local residents. [3]

However, strict or outdated, zoning regulations can stifle innovation and hinder economic growth. Rules that limit building heights, population densities, or land use types can artificially limit the supply of land suitable for development, raising prices and

discouraging investment. Similarly, complex and bureaucratic procedures for obtaining permits can lead to delays and increased costs for developers, which makes the territory less attractive for investment. [3]

Quality of life and human capital

Investment attractiveness goes beyond physical infrastructure and economic considerations. The quality of life offered by the city is playing an increasingly important role in attracting businesses, and skilled workers. Urban planning solutions, which give priority to green areas, parks and recreation areas, contribute to the creation of a healthier and more attractive living environment. Investments in cultural facilities such as museums, theaters and art galleries increase the cultural activity and attractiveness of the city.

Stability and resilience

In modern conditions and increasing awareness of the urban environment, sustainability and resilience are becoming increasingly, important factors in making investment decisions. Urban planning, which includes environmentally friendly construction, energy efficiency improvement, and reduction of carbon dioxide emissions. These methods can attract environmental enterprises and large investors. Investments in renewable energy sources, solar energy, wind energy, can increase the sustainability of the urban environment. This also includes resilience to natural disasters and other tragedies. [1] Urban planning solutions, where the bias towards protecting the population from natural disasters and reducing the risk of emergencies prevails, also have a beneficial effect on the attractiveness for investments and their savings. Also, investments in green infrastructure help the city cope better with climate change, and the weather improves. And as a result, the standard of living is improving.

Public-private partnership and public participation

Successful urban planning works when there is cooperation between the public and private sectors. Public-private partnerships (PPPs) can use the expertise and resources of both sectors to finance and implement major infrastructure projects. The involvement of the urban community in the planning process is also important. The contribution of society can help ensure that development projects meet the needs and priorities of residents, strengthening a sense of belonging and increasing social cohesion. Transparent planning processes based on the broad participation of the city's citizens should strengthen trust between government, business and residents. This will create a more favorable environment for investments. [2]

Conclusion

Competent urban planning solutions are extremely important for the city and its attractiveness in terms of investment. If we rely on the importance of infrastructure development, the development of proper laws and regulations, then this will help attract

large investments. Also stimulating economic growth and creating a thriving urban society. And in particular, if the city is poorly planned, illiterate management can lead to congestion, environmental degradation, social inequality and economic decline.

Therefore, strategic and visionary urban planning is essential to create dynamic, viable and prosperous cities that attract investment and improve the quality of life of all residents. [1] A holistic approach that takes into account the interconnection of various factors, from transport and land use to social justice and environmental sustainability, is crucial to maximize investment attractiveness and achieve long-term economic success. By introducing innovative planning methods and strengthening cooperation between government, businesses and local communities, cities can reach their full potential and create a brighter future for all.

References

1. Gutnov A. E., Glazychev V. L. Mirovaya arhitectura [World Architecture]. Moscow: Molodaya Gvardiya, 1990. (Rus)
2. Vladimirov V. V. Goroda I okruzhayshaya sreda [The city and the environment]. Moscow: Stroyizdat, 1982. (Rus)
3. Merlin P. Gorod. Kolichestvennye metody isledovaniya [City. Numerous research methods]. Moscow: Progress, 1977. (Rus)

Анализ влияния градостроительных решений на инвестиционную привлекательность территории

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Аннотация. Городское планирование играет важную роль в формировании физического, социального и экономического ландшафта. Его влияние на инвестиционную привлекательность трудно переоценить, оно влияет на решения во многих секторах, от недвижимости и инфраструктуры до технологий и туризма. В этой статье проанализирована многогранная взаимосвязь между градостроительными решениями и инвестиционной привлекательностью и показано, как стратегическое планирование может способствовать экономическому росту и процветанию, в то время как неэффективное планирование может привести к стагнации и упадку.
Ключевые слова: город; люди, правила зонирования, предприятия, транспорт.

УДК 330.101

Economic security: criteria for business survival and growth

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Abstract
In today's volatile business environment, economic security is no longer a luxury - it's a necessity. This article dives into what economic security truly means, breaking it down into its core components: protection against external threats and the ability to adapt to internal challenges. From defining the concept through the lens of experts like V.K. Senchagov to exploring its two key aspects - general (big-picture management) and specific (day-to-day problem-solving) - the article provides a comprehensive guide to understanding and implementing economic security. It also highlights the essential principles behind building a robust security system, emphasizing adaptability, efficiency, and balance.
Keywords: Economic security, external and internal threats, financial stability, planning and control.

The aim of the article is to explore the issues of economic security in entrepreneurship and why this criterion is crucial for building a business of any scale. As an entrepreneur with years of experience in running a business, I can assert that managing and developing one's own enterprise is currently one of the most challenging tasks. Fierce competition, global economic and political instability, and the ever-changing situation in foreign markets force companies of all sizes—whether small commercial enterprises or large state-level corporations—to feel the impact of even the slightest market fluctuations. For businesses, maintaining stability in an era of global transformation and existential economic challenges is essential. One of the key structures within the framework of national security that helps address these challenges is economic security in its broad sense, and more specifically, economic security in entrepreneurship.

From my perspective, economic security in entrepreneurship, put simply, is about how to protect your business, maintain its stability, and prepare it for further growth under conditions of increasing uncertainty. We can view it as both a shield against external threats such as economic downturns or unfair competition and as a toolkit for internal resilience, including competent resource management and strategic planning. But when analyzing various definitions of economic security of entrepreneurship, I concluded that there is no universal definition. Scientists and experts from different countries are deeply interested in this issue and continue to discuss various problems, which makes the topic quite popular and interesting.

For instance, V.K. Senchagov defines economic security as "a state of the economy and government institutions that ensures the guaranteed protection of national interests [1]." However, this definition is broad in scope. Based on this, I propose an additional interpretation: economic security in entrepreneurship can be considered the ability to protect various business resources from direct and indirect threats. Technologies, personnel, production capacities, finances, and other assets always require protection. However, economic security is not just about defense; it is also about adaptability. The key question arises: can your business adjust when economic processes are constantly evolving? This is the real challenge for entrepreneurship.

When discussing economic security in entrepreneurship, I suggest dividing it into two main categories: general and specific.

- The general aspect refers to macro-level management and how well-structured your business is in addressing external and internal challenges. This category can be compared to the foundation of a building. If it is strong, the rest of the structure will hold tightly with the possibility of further improvement.

- The specific aspect represents the practical side, dealing with the identification and resolution of daily business problems. These include cash flow difficulties, supply chain disruptions, internal security system malfunctions, protection against external cyberattacks, and more. This aspect can be likened to the technical maintenance of a car; however, business maintenance needs to be performed daily to keep all mechanisms functioning efficiently. In my opinion, these two aspects together form a comprehensive approach to economic security in entrepreneurship.

In continuation of my article, I highlighted the principles of economic security of business, which can be, in a way, a plan for success. If the economic security of entrepreneurship were a recipe, then the principles would become its ingredients and, as in any good recipe, it is important to choose the right combination. Below is a classification of these principles:

- Systemic Principle: Think big. This aspect is about thinking bigger and the approach you take should be comprehensive, interconnected and adaptive. The world of entrepreneurship is constantly moving and your strategies should be in some kind of flux.

- Functional Principle: Flexibility is a key. Business management methods should be reassessed based on external and internal factors. A well-structured security system must be autonomous, multifunctional, and regularly updated.

- Structural Principle: A clear, well-coordinated structure with defined roles and responsibilities is the basis of any successful system. It is important to avoid cumbersome and unwieldy structures so that there is room for quick maneuver.

- Target Principle: Set clear and realistic goals. Establishing specific tactical and strategic objectives while avoiding vague ambitions ensures effective planning and execution.

- Operational (Process) Principle: Focus on efficiency. Monitoring business operations allows for continuous improvement and seamless functioning. Balancing prevention and reaction is crucial—it is better to prevent a crisis than to extinguish fires once they occur.

- Confidentiality Principle: Balance transparency and secrecy. While openness is important, safeguarding sensitive information from competitors is vital for business security [2].

When discussing economic security in business, one cannot overlook the financial component. Finance is the lifeblood of any economy, and without a solid financial foundation, even the most well-thought-out plans can collapse at any moment. Therefore, the financial component of economic security in entrepreneurship is critically important.

Below are the key aspects:

1. Financial Stability: The foundation of any successful business. Competent financial planning helps weather crises, seize opportunities, and maximize benefits in any situation.

2.Credibility with Creditors: It is no secret that businesses often require additional funds for development. A strong financial reputation makes it easier to secure loans and attract investments.

3. Cash Flow Management: Effective financial management and the proper allocation of cash flows according to business needs are crucial.

4. Strategic decision making. In this case, objective financial analysis provides data for making informed and balanced decisions.

Ultimately, economic security of entrepreneurship is not just a beautiful and bright phrase, but a whole survival strategy, an action plan for the present and for the future. It helps to protect the business, optimize resources and act proactively. The path to balanced security is not easy, but it is worth paying great attention to, because in a world full of uncertainties it is vital to have an action plan.

Economic security in entrepreneurship is not just a buzzword; it is a mindset and a lifeline for businesses navigating daily turbulence. This universal tool serves as a shield against external threats, a set of competencies for internal resilience, and a roadmap for sustainable growth. Whether it is adapting to market fluctuations, defending against cyberattacks, or maintaining a healthy cash flow, economic security ensures that businesses do not merely survive but thrive. Strategic thinking, such as setting long-term goals, combined with practical actions like managing daily risks, brings businesses closer to a healthier internal ecosystem. Additionally, financial stability must not be overlooked; proper planning, control, and analysis play a pivotal role in success.

In today's fast-changing and unpredictable world, the best defense is not just a strong offense but thorough preparation. The future of entrepreneurship largely depends on it.

References

1. Senchagov V.K. Ekonomicheskaya bezopasnost' Rossii. Obshchij kurs. [Economic security of Russia. General course]. Edited by Senchagov V.K. 6th ed. Moscow: Laboratory of knowledge, 2020, 818 p. (Rus)

2. Belovitsky K. B. Ekonomicheskaya bezopasnost [Economic security]. Belovitsky K. B., Bulatenko M. A., Kuzovleva N. F., Mikaeva A.S. Moscow: Publishing and trading corporation "Dashkov and Co", 2023, 586 p. (Rus)

Экономическая безопасность: критерий выживания и роста бизнеса

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Аннотация. В сегодняшней нестабильной деловой среде экономическая безопасность больше не роскошь — это необходимость. В этой статье мы рассмотрим, что на самом деле означает экономическая безопасность, разбив ее на основные компоненты: защиту от внешних угроз и способность адаптироваться к внутренним вызовам. От определения концепции до изучения двух ее ключевых аспектов - общего (управление общей картиной) и конкретного (решение повседневных проблем) - статья представляет собой комплексное руководство по пониманию и внедрению экономической безопасности. В ней также освещаются основные принципы построения надежной системы безопасности, подчеркивая адаптивность, эффективность и баланс.

Ключевые слова: Внешние и внутренние угрозы, планирование и контроль, финансовая устойчивость, экономическая безопасность.

УДК 336.2

The impact of digitalization on small and medium-sized enterprises

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Abstract
Small and medium enterprises (SMEs) can gain many benefits from digitalization, such as increased productivity and efficiency, and most importantly, increased competitiveness. In this article, I will focus on the impact analysis of digitalization, including components such as e-commerce, cloud services, and data mining systems applied to SMEs. The study is based on a review of existing literature and case studies and aims to demonstrate the benefits of digitalization. These include increased business efficiency, increased international market participation, and closer relationships with customers. However, the article also highlights some critical challenges such as the high cost of digital transformation, lack of necessary skills, and cybersecurity threats.
Keywords: digitalization, small and medium-sized enterprises, digital technologies, e-commerce, cloud computing, competitiveness, cybersecurity.

Introduction

The global economy is changing with digitalization and so challenging the processes in place, especially for small and medium enterprises. Digitalization has increased the automation of many processes at SMEs which saves time, money, and brings in additional business. However, high spending, low digital competencies of employees, and the high risk of cyberattacks are some of the impediments that come with digitalization. In their pioneering work, Brynjolfsson and McAfee (2014) demonstrated how small and medium-sized enterprises (SMEs) are using digital technologies to improve productivity and bring innovative products and services to market. Their study shows that digital tools such as cloud computing, data analytics and automation enable SMEs to streamline operations, reduce costs and increase customer loyalty. Although digitalization offers significant benefits, its implementation is not without challenges, including financial constraints, skills gaps and cybersecurity risks. Kagermann et al. (2013) further explored this topic by examining digital transformation as a holistic process that enables companies to remain competitive through new business models. Their study highlights that digitalization is not only about adopting new technologies, but also about restructuring organizational processes and strategies to realize their full potential. For example, small and medium-sized enterprises that integrate Industry 4.0 principles such as the Internet of Things and artificial intelligence can optimize their supply chains and personalize customer service, thereby gaining a competitive advantage.

This research project aims to address the insufficient academic information regarding the impact of digitalization on SMEs growth possibilities and implementation problems. The study aims to answer the question of how SMEs can thrive through policy and institutional measures that maximize the benefits of digital transformation.

Methods

This study reviewed literature examining the impact assessment of digitalization on small and medium-sized enterprises (SMEs). The research methodology included the following steps:

1. Identification of central challenges: The challenges related to SME digitalization that were prevalent included: technology adoption, execution challenges, and available government support.

2. Comparative study: SME cases from different fields and areas were carefully studied to identify common and distinctive challenges.

3. Synthesis of results: Relevant literature was reviewed and integrated to analyze the impact of digitalization on SMEs.

4. Data collection and analysis: To ensure a comprehensive understanding of the topic, both qualitative and quantitative data were collected from multiple sources. These included academic journals, industry reports, case studies, and government publications. Qualitative data provided insights into the experiences and perceptions of SME owners and managers regarding digitalization, while quantitative data provided measurable indicators such as growth rates, cost reductions, and productivity increases after digitalization. Data analysis included thematic coding for qualitative information and statistical methods for quantitative data to identify trends and patterns.

5. Stakeholder interviews: Semi-structured interviews were conducted with key stakeholders, including SME owners, digital transformation consultants, and others. The objective of these interviews was to gain firsthand insights into the benefits, challenges, and barriers of digitalization.

Results

The impact of digitalization on small and medium enterprises (SMEs) has been studied in detail. The key findings of the analysis are as follows:

1. Improved operational efficiency: Adoption of digital technologies such as automation and cloud computing helps SMEs achieve greater cost savings and operational efficiency.

2. Wider market reach: SMEs gain access to global markets through e-marketing and e-commerce, which further enables them to reach a wider customer base.

3. Financing challenges, lack of digital competencies, and cybersecurity threats continue to be some of the most pressing challenges associated with the digital transformation of SMEs.

4. Government policies and financing programs have been shown to significantly facilitate the digitalization of SMEs, especially in emerging economies.

These findings indicate that while digitalization has benefits, it also poses some challenges for SMEs.

Conclusion

The digitalization process enables small and medium-sized enterprises to improve their position, whether in terms of economic efficiency, market penetration and competitive

advantage. But problems such as lack of funds, skilled labor and cybersecurity issues still need to be addressed. Government policies and support are aimed at helping SMEs to digitally transform, especially in developing countries. More research is needed on the impact and influence of digitalization on SMEs to help SMEs develop faster and better using increasingly growing digital technologies.

The impact of digitalization on small and medium-sized enterprises (SMEs) is examined in detail. Key findings from the analysis:

One of the main benefits is increased operational efficiency. By implementing digital technologies such as automation and cloud computing, SMEs can achieve greater cost savings and improve the efficiency of their operations. Many companies report faster processes and fewer errors after implementing these tools.

Another important outcome is increased market reach. SMEs gain access to global markets through e-marketing and e-commerce. This allows them to communicate with more customers than ever before. Online platforms help even small businesses compete with large companies.

Despite the benefits, challenges remain. Financing digital transformation is a challenge for many SMEs. They often lack the necessary funds to invest in new technologies. Another challenge is the lack of digital skills among employees and managers. Without the appropriate training, it is difficult to use new tools effectively. Cybersecurity threats are also a major risk. Many SMEs struggle to protect their data from hackers and online attacks.

Government support plays a major role in this. Policies and funding programs have been shown to significantly help small and medium-sized enterprises (SMEs) in digitalization. This is especially true in emerging economies. Governments can provide grants, training, and other resources to facilitate the transition.

These results show that digitalization brings with it both opportunities and challenges. While it helps a company grow and enter new markets, it also requires careful planning and investment. To fully leverage the benefits of digital tools, SMEs must overcome challenges related to financing, skills, and security. At the same time, support from governments and other organizations can facilitate this process.

Another key finding is the role of customer expectations. Digitalization has changed the way customers interact with companies. Many SMEs noted that customers now expect faster responses and better online services. To stay competitive, SMEs had to improve their digital presence. This included creating user-friendly websites and providing online support.

Collaboration also proved to be key. SMEs often lack the resources to manage digital transformation on their own. Partnering with technology providers or joining industry networks helped them share knowledge and reduce costs. Some SMEs even collaborated with universities to gain new ideas and expertise.

Another focus was employee onboarding. While digital tools offer benefits, they also require learning new skills. Some SMEs experienced employee resistance to change. Successful companies invested in training programs and promoted a culture of continuous learning. This made it easier for employees to familiarize themselves with new systems.

The study also revealed differences between industries. Retail companies have benefited greatly from e-commerce platforms. On the other hand, small and medium-sized enterprises in the manufacturing sector are more focused on automation and supply chain improvements.

References

1. Brynjolfsson E., McAfee A. The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies [W.W. Norton & Company], 2014.
2. Kagermann H., Wahlster W., Helbig J. Recommendations for implementing the strategic initiative INDUSTRIE 4.0. [Final report of the Industrie 4.0 Working Group], 2013.
3. Parida V., Westerberg M., Frishammar J. Inbound Open Innovation Activities in High-Tech SMEs: The Impact on Innovation Performance. Journal of Small Business Management, 2012, T. 50, № 2, s. 283-3094.
4. Ghobakhloo M., Hong T.S IT Resources and Organizational Capabilities to Create Business Value: A Resource-Based Perspective. Industrial Management & Data Systems, 2014, T. 114, № 4, pp. 529-549.

Влияние цифровизации на малые и средние предприятия

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Аннотация. Малые и средние предприятия (МСП) имеют возможность добиться значительных успехов благодаря внедрению цифровых технологий, что позволяет им повысить производительность, эффективность и, прежде всего, конкурентоспособность. В данной статье проведён анализ влияния таких цифровых решений, как электронная коммерция, облачные сервисы и системы анализа данных, на деятельность предприятий малого и среднего бизнеса. Также рассмотрены результаты недавних исследований, которые продемонстрировали положительное воздействие цифровизации на бизнес: увеличение эффективности операций, доступ к международным рынкам и более тесное взаимодействие с клиентами. В статье также освещаются проблемы, с которыми сталкиваются компании, такие как высокая стоимость процесса цифровой трансформации, нехватка необходимых навыков и угрозы кибербезопасности.
Ключевые слова: цифровизация, малые и средние предприятия, цифровые технологии, электронная коммерция, облачные вычисления, конкурентоспособность, кибербезопасность.

УДК 330.541

Einschätzung der Lage der deutschen Wirtschaft im Lichte der makroökonomischen und Aussenhandelsindikatoren im Zeitraum 2017–2022

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Zusammenfassung
Der Artikel analysiert die wirtschaftlichen und die Außenhandelszahlen Deutschlands der letzten sieben Jahre. Die Analyse der Wirtschaft konzentriert sich hauptsächlich auf den Zeitraum von 2017 bis 2022. Angesichts der jüngsten weltpolitischen Ereignisse erfolgt die Einschätzung der Lage der deutschen Wirtschaft im aktuellen Zeitraum und ihre Prognosen für das nächste Jahr. Ziel dieser Arbeit ist es, die wichtigsten Faktoren und Trends zu ermitteln und die Auswirkungen dieser Veränderungen auf die Wirtschaft des Landes und seine Position im internationalen Handel zu bewerten.
Schlüsselwörter: makroökonomische Indikatoren, Außenhandelsindikatoren, Export, Import, Handelsindizes, Handelsquoten, Bruttoinlandsprodukt.

Einführung.

Deutschland nimmt als eine der weltweit führenden Volkswirtschaften einen wichtigen Platz im globalen Wirtschaftssystem ein. Ihre nachhaltige Entwicklung bestimmt maßgeblich die Stabilität sowohl des europäischen als auch des globalen Marktes. Eine Analyse der makroökonomischen und außenwirtschaftlichen Indikatoren des Landes für den Zeitraum von 2017 bis 2022 ermöglicht es uns, seine wirtschaftliche Dynamik nachzuvollziehen und wichtige Trends und Faktoren zu identifizieren, die seine Entwicklung beeinflussen. Darüber hinaus trägt es dazu bei, die Widerstandsfähigkeit Deutschlands gegenüber globalen wirtschaftlichen Herausforderungen einzuschätzen.

Deutschland ist einer der größten Exporteure von Gütern und Dienstleistungen weltweit und zugleich ein wichtiger Importeur von Rohstoffen und Gütern. Deutschland hat im Berichtszeitraum seine Handelsbeziehungen zu anderen Ländern, insbesondere zu China, den USA und der Europäischen Union, verstärkt.

Das Jahr 2019 war geprägt von einer Reihe wirtschaftlicher Krisen wie COVID-19, der Energiekrise, politischer Instabilität und Handelskriegen, die von Deutschland verlangten, sich an neue Bedingungen anzupassen und Widerstandsfähigkeit zu beweisen. Insgesamt lässt sich sagen, dass das Land die wirtschaftlichen Herausforderungen recht gut bewältigt und sich von einer kleinen Krise erholt hat.

Analyse der makroökonomischen Indikatoren Deutschlands für den Zeitraum 2017–2022

Tabelle 1. präsentiert Daten zum deutschen BIP zu Marktpreisen (aktuelle und konstante Preise von 2015), den Deflatorindex, den Anteil des deutschen BIP am weltweiten BIP, das BIP pro Kopf und die Bruttowertschöpfung zu Basispreisen für den

Zeitraum 2017–2022 sowie das durchschnittliche absolute Wachstum und die durchschnittliche Wachstumsrate dieser Indikatoren für den ausgewählten Zeitraum [1]. Das deutsche BIP zu Marktpreisen (aktuelle Preise) belief sich im Jahr 2022 auf 4.082,5 Milliarden US-Dollar pro Jahr, ein Anstieg um 391,7 Milliarden US-Dollar gegenüber 3.690,8 Milliarden US-Dollar im Jahr 2017. Das deutsche BIP pro Kopf stieg im Jahr 2022 im Vergleich zu 2017 um 4 Milliarden US-Dollar. Den Daten in Tabelle 1 zufolge steigen die Indikatoren für Deutschland jedes Jahr an, was auf eine positive Dynamik der wirtschaftlichen Entwicklung des Landes hindeutet.

Tabelle 1 – Deutschlands BIP 2017–2022

	Maßeinheit	2017	2018	2019	2020	2021	2022	Abs. durchschnitt. Wachstum (Kette)	Die Wachstumsrate durchschnitt. (Kette)
BIP in Marktpr. (aktuelle Preise)	Milliarden Dollar	3690.8	3974.4	3889.2	3887.7	4278.5	4082.5	78.34	2,03%
BIP in Marktpr. (konstant. Preise 2015)	Milliarden Dollar	3524.4	3559.0	3597.3	3459.6	3569.1	3633.6	22.74	0.61%
Deflatorindex, 2015 = 100	%	102.9	104.9	107,1	103.0	100.8	97.6		
Anteil des BIP des Landes am weltweiten BIP	%	4.5	4.6	4.4	4.5	4.4	4.0		
BIP pro Kopf	Milliarden Dollar	44625	47939.3	46805.1	46749.5	51426.8	48718	818.6	1.77%
Mehrwertsteuer in Hauptpreisen	Milliarden Dollar	3325.8	3581.5	3504.6	3525.2	3875.1	3695.8	74.06	2.13%

Quelle: 1) Weltentwicklungsindikatoren. – URL: https://databank.worldbank.org/source/world-

2) Bruttoinlandsprodukt Deutschlands, 1970–2022. — Text: elektronisch // [Website]. — URL: https://be5.biz/makroekonomika/gdp/de.html

Das deutsche Bruttonationaleinkommen stieg von 3.778,8 Milliarden Euro im Jahr 2017 auf 4.235,5 Milliarden US-Dollar im Jahr 2022, was einem durchschnittlichen absoluten Anstieg von 91,34 Milliarden US-Dollar pro Jahr entspricht. Auch das Bruttoinlandsprodukt (BNR) Deutschlands stieg von 3,218 Milliarden US-Dollar im Jahr 2017 auf 3,289 Milliarden US-Dollar im Jahr 2022, was einem durchschnittlichen absoluten Anstieg von 3,1 Milliarden US-Dollar pro Jahr entspricht.

Deutschlands Nettokreditaufnahme war zwischen 2017 und 2019 positiv, das Land war also ein Nettogläubiger. Seit 2020 ist Deutschland ein Kreditnehmer, da dieser

Indikator negativ geworden ist. Im Jahr 2017 belief sich die Nettokreditvergabe (-aufnahme) auf 19 Milliarden Euro und im Jahr 2022 auf 115,9 Milliarden Euro [2]. Der durchschnittliche absolute Anstieg der Nettokreditvergabe (-aufnahme) betrug -38,3 Milliarden Euro pro Jahr. Was die Bevölkerung des Landes betrifft, so ist in diesem Fall ein steigender Trend zu beobachten, der auf eine Zunahme der Zahl der Migranten im Land hindeutet.

Analyse des Zustands und der Dynamik des deutschen Außenhandels für die Jahre 2017–2022.

Tabelle 2. Deutschlands Außenhandel 2017–2022

	2017	2018	2019	2020	2021	2022
Außenhandelsumsatz des Landes (Mio. USD)	3219.8	3518.2	3434.8	3154.8	3814.7	4077.5
Export (Mio. USD)	1740.7	1880.3	1832.9	1690.3	2022.8	2078.9
Import (Mio. US-Dollar)	1479.1	1637.9	1601.9	1464.5	1791.9	1998.6
Handelsbilanz (in Mio. USD)	261,6	242,4	231	225,8	230,9	80,3
Deckungsgrad (in %)	117,7	114,8	114,4	115,4	112,9	104,0
Anteil des Landes an den Weltexporten (in %)	7,5	7,4	7,3	7,5	7,2	6,6
Anteil des Landes an den Weltimporten (in %)	6,6	6,6	6,6	6,7	6,6	6,5
Anteil des Landes am Außenhandel der europäischen Region (in %)	28,2	28,21	28,1	27,7	27,8	29,2

Quelle: 1) Deutschland | Import und Export | Die ganze Welt | Alle Produkte | Preis (USD) und Preisänderung, YoY (%) | 2012 - 2023. — Text: elektronisch // eurostate: [site]. — URL: https://trendeconomy.ru/data/h2/Germany/TOTAL

2) UN-Handels- und Entwicklungszusammenarbeit. – URL: https://unctadstat.unctad.org/datacentre/dataviewer/US.TermsOfTrade

Die wichtigsten Indikatoren, die die Dynamik des deutschen Außenhandels charakterisieren, sind Umsatz, Export, Import und Handelsbilanz.

Tabelle 2 stellt Daten zum deutschen Außenhandel ebenfalls von 2017 bis 2022 dar [2]. Der gesamte Außenhandelsumsatz des Landes stieg in diesem Zeitraum von 3.219,8 Milliarden USD im Jahr 2017 auf 4.077,5 Milliarden USD im Jahr 2022 [3]. Dies zeigt, dass Deutschland weiterhin aktiv am Welthandel teilnimmt und seinen Anteil daran

ausbaut.

Auch die deutschen Exporte stiegen in diesem Zeitraum und erreichten im Jahr 2022 2.078,9 Milliarden US-Dollar, 56 Millionen US-Dollar mehr als im Jahr 2021. Dies deutet darauf hin, dass deutsche Waren und Dienstleistungen auf dem internationalen Markt weiterhin gefragt sind. Deutschlands Importe 2017–2022 stieg im Jahr 2022 auf 1.998,6 Milliarden US-Dollar, ein Anstieg von 519,5 Millionen US-Dollar gegenüber 2017. Dies zeigt, dass Deutschland zur Deckung des Bedarfs seiner Wirtschaft weiterhin Waren und Dienstleistungen aus anderen Ländern konsumiert. Die positive Handelsbilanz über den gesamten Betrachtungszeitraum hinweg deutet wiederum auf einen Überschuss der Exporte gegenüber den Importen hin. Allerdings ist ein Abwärtstrend zu verzeichnen. So betrug die Handelsbilanz im Jahr 2017 261,6 Millionen US-Dollar und sank im Jahr 2022 auf 80,3 Millionen US-Dollar. Angesichts der stabilen Entwicklung der deutschen Wirtschaft muss das Land keine Angst vor einer Importabhängigkeit haben, diese Dynamik könnte jedoch dazu führen, dass einige Branchen ausschließlich auf den Export umsteigen.

Im Jahr 2017 lag der deutsche Exportwertindex bei 109,2 % (Basisjahr 2015) und stieg im Jahr 2022 auf 126,4 %, was darauf hindeutet, dass die Preise für exportierte Waren und Dienstleistungen gesunken sind. Der durchschnittliche deutsche Exportpreisindex stieg von 106,3 % im Jahr 2017 auf 129,4 % im Jahr 2022, was auf einen deutlichen Anstieg der Durchschnittspreise für exportierte Waren und Dienstleistungen hindeutet. Der physische Volumenindex der deutschen Exporte lag 2017 bei 102,7 % und sank im Jahr 2022 auf 97,6 %.

Im Jahr 2017 lag der durchschnittliche Importpreisindex für Deutschland bei 104,6 %, im Jahr 2022 stieg dieser Wert auf 132,6 %. Dies deutet darauf hin, dass die Durchschnittspreise für importierte Waren und Dienstleistungen recht deutlich gestiegen sind. Der Index des physischen Importvolumens Deutschlands stieg von 105,7 % im Jahr 2017 auf 113,6 % im Jahr 2022. Diese Ergebnisse zeigen, dass das Volumen der Importe von Waren und Dienstleistungen im analysierten Zeitraum zugenommen hat.

Im Jahr 2017 lag der Net Terms of Trade-Index bei 101,6 %, was 4 % höher ist als der Net Terms of Trade-Index im Jahr 2022 – 97,6 %. Dieser Rückgang könnte auf steigende Preise für Importwaren zurückzuführen sein.

Der Brutto-Terms-of-Trade-Index lag im Jahr 2017 bei 97,2 %. Im Jahr 2022 lag der Brutto-Terms-of-Trade-Index bei 85,9 %, ein Rückgang von 11,3 % gegenüber 2017. Dies bedeutet, dass sich die Terms of Trade insgesamt verschlechtert haben.

Schlussfolgerung

Durchgeführte wirtschaftliche und statistische Analyse der makroökonomischen Indikatoren Deutschlands für den Zeitraum 2017–2022 ermöglichte es, eine Reihe von Faktoren zu identifizieren, die die wirtschaftliche Entwicklung des Landes beeinflussen.

Insgesamt hat die deutsche Wirtschaft ihre Widerstandsfähigkeit gegenüber externen Schocks unter Beweis gestellt und in den letzten Jahren ein stabiles Wachstum verzeichnet. Das BIP zu Marktpreisen (aktuelle und konstante Preise von 2015) steigt, was

darauf hindeutet, dass sich die Wirtschaft des Landes entwickelt, und der Deflatorindex sinkt, was darauf hindeutet, dass die Inflation in Deutschland niedrig ist. Der Anteil Deutschlands am globalen BIP bleibt stabil. Diese Tatsache bestätigt, dass Deutschland weiterhin eines der führenden Länder der Weltwirtschaft ist.

Auch der deutsche Außenhandel weist ein stetiges Wachstum auf. Der Außenhandelsumsatz des Landes steigt und Deutschland nimmt weiterhin aktiv am Welthandel teil. Im Vergleich zu anderen EU-Ländern, die sich hauptsächlich auf den Import von Waren konzentrieren, versucht Deutschland, sowohl Importe als auch Exporte zu entwickeln, wie die Veränderung der Handelsbilanz von positiv zu negativ innerhalb eines Jahres zeigt.

Der Anteil Deutschlands an den weltweiten Exporten und Importen bleibt stabil und verdeutlicht die wichtige Rolle des Landes im Welthandel. Insgesamt zeigt die Analyse der Tabellen, dass die deutsche Wirtschaft ein stabiles Wachstum aufweist und weiterhin zu den stärksten Volkswirtschaften der Welt zählt.

Die deutsche Wirtschaft steht somit vor der Herausforderung, sich an ein verändertes globales Umfeld anzupassen. Unter unstabilen Bedingungen sind aktive Maßnahmen erforderlich, um die Widerstandsfähigkeit zu stärken und die wirtschaftliche Anpassung zu beschleunigen.

Literaturverzeichnis

1. Weltentwicklungsindikatoren. – URL: https://databank.worldbank.org/source/world-development-indicators
2. Bruttoinlandsprodukt Deutschlands, 1970–2022. — Text: elektronisch // [Website]. — URL: https://be5.biz/makroekonomika/gdp/de.html
3. Deutschland | Import und Export | Die ganze Welt | Alle Produkte | Preis (USD) und Preisänderung, YoY (%) | 2012 - 2023. — Text: elektronisch // eurostate: [site]. — URL: https://trendeconomy.ru/data/h2/Germany/TOTAL
4. UN-Handels- und Entwicklungszusammenarbeit. – URL: https://unctadstat.unctad.org/datacentre/dataviewer/US.TermsOfTrade

Оценка положения экономики Германии в свете макроэкономических и внешнеторговых показателей за период 2017-2022 гг.

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Аннотация. В статье анализируются экономические и внешнеторговые показатели Германии за последние семь лет. Экономический анализ сосредоточен в первую очередь на периоде с 2017 по 2022 год. В свете последних мировых политических событий оценивается положение экономики Германии в текущий период и ее прогнозы на следующий год. Целью данной статьи является выявление основных факторов и тенденций, а также оценка влияния этих изменений на экономику страны и ее положение в международной торговле.

Ключевые слова: макроэкономические показатели, показатели внешней торговли, экспорт, импорт, торговые индексы, торговые квоты, валовой внутренний продукт.

УДК 343.611.1

Factors to identify a serial killer on social networks

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Abstract
The purpose of this research is to examine the childhood upheavals and traumas that influenced the development of known serial offenders. The study of these events and contemporary cyberspace has contributed to the compilation of a number of causes and factors that influence people with a homicidal or suicidal disposition on social media.
Keywords: maniac, maniacal behavior, murder, serial killer, suicide.

Introduction

Daily interactions with people from diverse social backgrounds and observing them in crowds and groups do not allow for accurate analysis of their mental states or intentions. Assessments based solely on external characteristics can provide insights into a person's outward appearance but fail to capture their internal inclinations or propensity for criminal actions. Serial murders committed by maniacs form the central subject of this study, where certain behaviors might aid in identifying individuals susceptible to violent criminal conduct.

This study emphasizes the historical prevalence of serial killers, the roots of which go back to ancient times. In particular, in the context of Russian imperial history, we can mention such personalities as Daria Saltykova, known for her extreme cruelty towards serfs, and Nikolai Radkevich, infamous for the murders of young women.

Materials and methods

We analyzed the following criminal cases: Chikatilo, Golovkin, Bundy, and the Blue Whale game. The following methods were used in this study: analysis, synthesis, method of induction.

Discussion

One of the most resonant criminal cases of this century involving serial killers was the case of Alexander Pichushkin, infamously known as the ‘Bittsevsky Maniac’. At an early age, Pichushkin faced a serious psychological trauma: his father, who suffered from alcoholism, left the family when the child was not even a year old. The child was brought up by his grandfather, and his mother, arranging her personal life, remarried and gave birth to a daughter [1]. Undoubtedly, this period was an important factor in Pichushkin's development as a murderer. He was often harassed because of his unsociability. His speech defects (Pichushkin confused hissing sounds) only added to the reasons for bullying. ‘There was a lot of negativity in my life. I felt like an outsider. And I was alive, I wanted a holiday. And everyone pushed me away,’ is how Pichushkin describes his

childhood. As a teenager, Alexander himself attacked younger boarding school pupils, fearing to be rebuffed. Later he entered vocational school and composed poetry in his spare time. His passion for poetry also contributed to bullying from his classmates. To overcome these taunts, Pichushkin decided to win the favour of his peers through generosity: he lent money to anyone who asked for it. However, before giving the money, he promised a classmate that he would kill him in case of non-payment. Later on, Alexander really started killing people. The victims of this maniac were forty-nine people murdered in Bittsevsky Park. The maniac's goal was a number of murders equal to the number of squares on a chessboard, sixty-four. He failed to achieve his goal, was arrested by the police and, following a review of the case, sentenced to serve a life sentence in the special regime colony «Polar Owl», where he is kept to this day, periodically giving interviews where he expresses his desire to start killing people again after a possible release from prison as part of a parole application.

The case of Sergei Golovkin was also a famous criminal case, but already of the last century. This maniac was nicknamed “Fisher” by the investigation. A difficult childhood played a pivotal role in shaping the personality of the killer. Sergei grew up in a family where his father, although outwardly friendly and cheerful, was extremely cruel to those close to him. Suffering from alcohol addiction, he resorted to physical violence against his son during his bouts of drinking [2]. Another significant aspect that influenced the formation of the personality of the future criminal was frequent illnesses, which his parents preferred not to treat with conventional methods, opting in favour of methods to strengthen the immune system. Golovkin resented male peers who were popular with girls, as he lacked similar success. His first criminal act involved abusing a neighborhood cat, whose body he subsequently mutilated. Upon starting college, Sergei was assaulted by a group of teenage bullies, who severely beat him. The age of these attackers influenced Fisher's perception of his victims [2], leading him to discover a perverse enjoyment in tormenting younger teenagers. After this realization, Golovkin started killing people. The victims were eleven teenage children, aged between ten and sixteen, who were killed with particular cruelty and torture. This criminal case is currently the last in the history of Russia to be punished by the death penalty. According to journalists, even the most humane people involved in the investigation were expecting the death penalty in this case.

No less interesting in the framework of this study will be the foreign experience of investigations of serial murders committed by maniacs. One of the most famous investigations in foreign history was the Ted Bundy case. At the time of the court hearings, this case had been discussed in over 250 different publications. Like the previously mentioned criminals, Bundy also had childhood traumas. He was born in an asylum hospital in 1946. To avoid shame and public judgement, his mother decided to impersonate his older sister and Ted's grandparents as his biological parents. Bundy only learnt the truth about his parents during his university studies. It is important to note, Ted's grandfather, whom he considered his father, was despotic and often mistreated the household, used physical violence against children. The grandmother of the future killer suffered from clinical depression, often resorting to treatment with electroshock therapy,

which also influenced the formation of the personality of the maniac. Later his biological mother moved away, starting to live with a man, but with his stepfather Bundy also did not get along, long considering his grandfather his real father. Finding out the truth about his mother during his college years was very disillusioning and gave him additional mental trauma, which also had a clear impact on him becoming a murderer.

Bundy's first violent behavior was discovered by his mother when the boy was three years old. The would-be killer collected all the knives he could find in the house and placed them around his sleeping cousin so that all the blades were pointed at her [3]. During his school years, his tendencies escalated: Bundy was a shy and quiet student, but despite this, he was not an outcast. However, he still preferred to be alone. Bundy's manic qualities reached their maximum aggravation, in our opinion, during his university studies. At that moment he was dating a girl named Stephanie, who rejected him, which put the final imprint on the already beginning to form the personality of a maniac in Bundy. Promising himself to get revenge on her he embarked on a path of crime. Even though Stephanie was not his victim, her image formed Bundy's victim profile: he sought out girls who looked like Stephanie and then killed them by abusing their bodies. His victims were thirty girls, five of whom survived. Bundy also distinguished himself by taking parts of his victims' bodies home after committing murder and acts of body abuse, leaving them as souvenirs. During the investigation, Bundy tried to get away with it by relying on his own charm and escape attempts. Several such attempts were successful. Not only was Bundy able to get the jury to commute his sentence by influencing them with his charm, but he also escaped from custody several times. However, this did not save him from punishment, and he was still sentenced to death in the electric chair.

Nowadays, when technology is developing very fast, it has become possible to monitor people's mental state and inclinations in the virtual sphere as well. A few years ago, such a phenomenon as death groups in social networks became popular. Later this phenomenon would be called the ‘Blue Whale’ game. Administrators of these communities drove teenagers, participants of the game, to suicide, giving them various tasks related to self-harm. According to the researchers, these groups did not have a unified structure and each acted separately. We believe that such behaviour may well be considered as a continuation of serial killers, but committed in virtual space. This is confirmed by real criminal cases against the administrators of these communities, who exerted psychological influence on teenagers and drove them to suicide. The perpetrators were sentenced to three to six years imprisonment. In contrast, many journalists questioned the existence of the death groups and called the criminal cases an unsuccessful cruel joke.

Communities that promote violence actively exist on the Internet, and a study of user profiles may indicate potential deviant tendencies. Regardless of the veracity of stories about violent groups, it should be noted that there are many communities forming on the global network that not only discuss but also actively promote violence against both humans and animals. Internet users regularly share similar content on their pages.In our opinion, acts of cruelty to animals, accompanied by their recording on video, indicate the presence of human characteristics typical of possible maniacs. Moreover, by analysing the

user's profile in social networks, it is possible to draw conclusions about his predispositions, although such analysis does not provide grounds for a definitive statement about his involvement in a series of murders. In this case, important indicators of potential manic tendencies of a person, in our opinion, will be the social network user's preoccupation with various shocking materials related to acts of cruelty to people and animals, propaganda of self-harm on personal pages, as well as preoccupation with materials of depressive nature. Despite this, it should be noted that all these factors do not indicate that a person belongs to the maniacs, but only give an understanding of his potential inclinations.

Conclusion

To summarize, are several key findings. The psychological traumas of childhood had a significant impact on each of the serial killers mentioned. These traumas resulted from problems in their families, bullying by peers and parents, and the subsequent emotional disturbances resulting from these experiences.We believe that these events were decisive in shaping their identity as offenders, influencing their choice of victims as well as their methods of committing the offences.We can also conclude that these shocks and events can contribute to the definition of a serial killer in society, although they do not give an absolute and unambiguous answer whether a person is a maniac or not. The lack of unambiguity is due to the fact that many people are subject to problems with society, but most of them have not taken the path of a killer.

References

1. My hand remembers the hammer well. The Bittsevo maniac imitated Chikatilo and kept Muscovites in fear. Forty-nine people died at his hands Available from: https://lenta.ru/articles/2020/01/19/pichushkin (accessed: 22.11.2022) (Rus)
2. Have you heard of Fisher? That's me 25 years ago, Russia carried out its last death penalty. A killer of 11 children was shot in MoscowAvailablefrom: https://lenta.ru/articles/2021/09/02/fisher (ccessed: 22.11.2022) (Rus)
3. Ted Bundy is a charismatic maniac (18+). Available from: https://diletant.media/articles/28711147/(accessed: 23.11.2022) (Rus)

Факторы, помогающие выявить серийного убийцу в социальных сетях

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Аннотация. Целью данной статьи является изучение детских потрясений и травм, оказавших влияние на становление известных серийных убийц. Изучение данных событий и современного киберпространства поспособствовало составлению ряда причин и факторов, которые влияют на людей, имеющих расположенность к убийству или самоубийству, в социальных сетях.
Ключевые слова: маньяк, маниакальное поведение, убийство, серийный убийца, самоубийство.

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