MINISTRY OF EDUCATION
OF BELARUS
POLOTSK STATE UNIVERSITY

EUROPEAN
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DIMENSION
IN RESEARCH

TECHNOLOGY

Electronic collected materials
of XII Junior Researchers' Conference
(Novopolotsk, May 13 – 14, 2020)

Novopolotsk
2020

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In this Electronic collected materials "National and European dimension in research. Technology" works in the fields of geodesy, chemical technology, mechanical engineering, information technology, civil engineering, and radio-engineering are presented.

It is intended for trainers, researchers and professionals. It can be useful for university graduate and post-graduate students.

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ARCHITECTURE AND CIVIL ENGINEERING

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TRANSFORMATION OF THE ESTABLISHED OBJECT-SPATIAL ENVIRONMENT OF THE STUDENT HOSTEL

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The inconsistency of the existing subject-spatial environment of typical student dormitories, built in the XX century, with the modern requirements of students'socialization during their studies at the university is revealed. Improving the comfort of living without reconstruction of hostels is possible due to the transformation of the subject environment. The developed plans for minimum redevelopment of floors, subject filling of the spatial environment of living rooms, taking into account anthropological, ergonomic, environmental requirements, will provide students with comfortable living.

Keywords: *student dormitory, subject-spatial environment, design, transformation.*

Introduction The subject - spatial human environment, with unconditional compliance with the functional purpose, should provide comfort, contribute to the formation of a positive emotional and psychological background of life. Comfort for students living in a dormitory is especially significant. In the post-Soviet space and in the Republic of Belarus, a large number of dormitory buildings were built in the 70-80s of the last century. They are characterized by corridor and sectional layouts with living rooms on floors without built-in domestic, sanitary and technical equipment. Most of these buildings are still in use and do not meet the modern requirements for this category of housing. Reconstruction of hostels requires large financial costs and time. The purpose of this study is to increase the efficiency of the student home, its comfort with minimal redevelopment, which does not require a change in the structural design of the building and reconstruction of engineering equipment by transforming the subject environment using modular and transformable furniture, colorizing techniques, navigation, and the use of innovative materials and technologies.

Main part. Consider the prevailing spatial environment of four typical hostels using hostel No. 3 of Polotsk State University as an example.

– 5-storey buildings, frameless, corridor type, with load-bearing longitudinal brick walls. On the ground floor there are administrative, storage rooms, assembly and rehearsal rooms as well as male and female shower rooms.

– On the next four floors there are living rooms for 2 to 4 students, two kitchens, women's, men's toilets, a washroom, a general purpose room.

Subject - spatial environment analysis of the premises revealed:

– on the 11.8m^2 kitchens 2 gas stoves, 2 tables and 2 sinks are located, which is not enough for students living on the floor, the area of the room does not allow placing additional equipment;

– the location of male and female showers on the first floor of the hostel creates inconvenience in use, in addition, there are 5 showers in the female shower room, with more than 100 female people, this amount does not comply with hygiene standards;

– there are 4 cabins in the women's toilet rooms, for more than 30 female people living on the floor, this amount does not comply with hygiene standards;

– dormitories do not provide laundry rooms, rooms for classes and recreation;

– the area of the living quarters, as well as the filling with furniture, complies with the applicable requirements and standards [1,2], but they do not provide for the design of residential areas for recreational activities and meals.

In order to optimize the living conditions of students with a minimum change in space-planning decisions, the following developments were proposed.

1. On each residential floor, attach one living room with an area of 14m^2 to the area of the kitchen premises and place additional equipment taking into account ergonomic requirements, the correct selection of finishing materials and creation easy access to work surfaces.

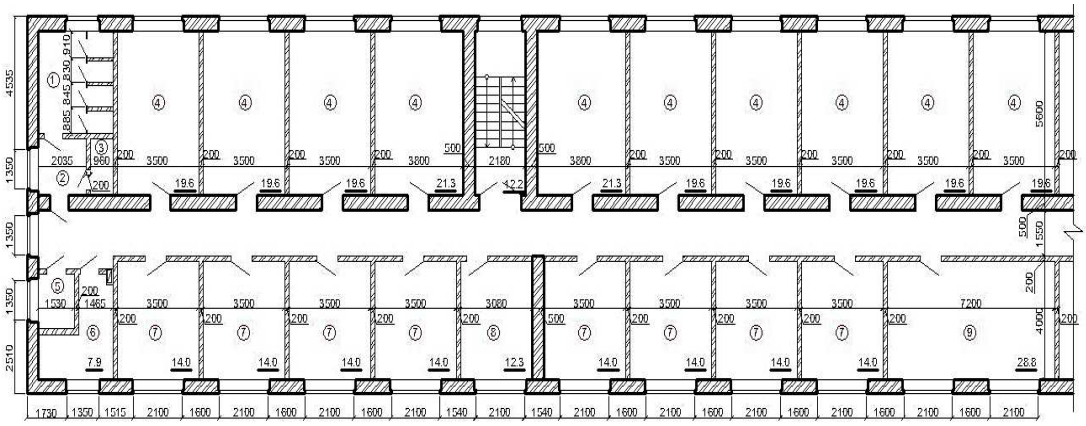
2. Place shower rooms on each residential floor by remodeling a 19.6m living room^2 located near the toilet rooms, the necessary plumbing equipment with accession to existing risers.

3. To increase the area of women's toilets on each residential floor to accommodate additional toilet cabins, combining the area of toilets, airlock and a toilet for staff, using materials that have high requirements for abrasion, shock, hygiene. The toilet for staff should be moved to the 1st floor.

4. On each residential floor, combine one living room with an area of 14m^2, with rooms for washing, storage of equipment, to convert the obtained space for the laundry room, placing 3 washing and drying machines with accession to existing risers.

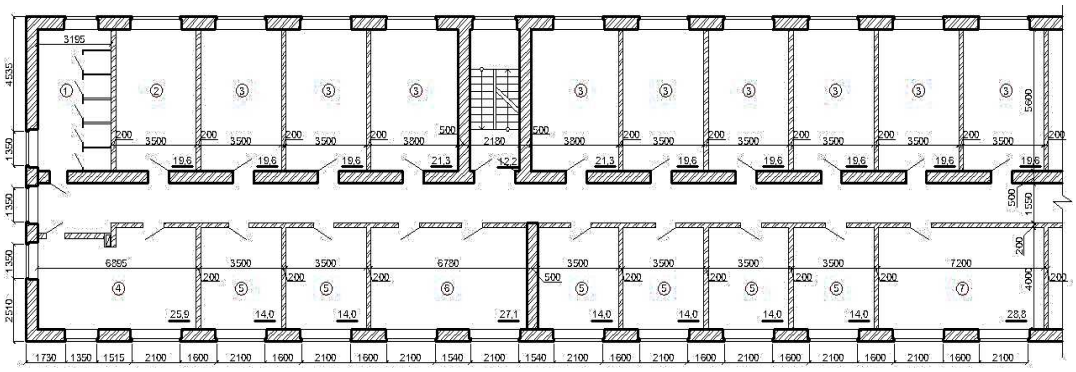
5. At each residential area, re-equip storage facilities with an area of 28.8 m^2 into common rooms and studies.

Changes in space-planning decisions are presented in (Fig. 1.2).



1 - female toilet; 2 - vestibule-airlock; 3 - toilet for staff; 4 - living room;
5 - room for storage of inventory; 6 - female washroom; 7 - living room; 8 - kitchen;
9 - living room

Figure 1. – Left (female) wing of a typical dormitory floor before redevelopment



1 - female toilet; 2 - female shower; 3 - living room; 4 - laundry;
5 - living room; 6 - kitchen; 7 - room for classes

Figure 2. – Left (female) wing of a typical dormitory floor after redevelopment

Design-engineering of living rooms was based on the fulfillment of the main social function of the home - to give everyone living a sense of comfort, taking into account functional, hygienic, functional, psychological and aesthetic requirements [3].

Were determined functional processes inherent to the housing of this purpose, conditional division into multifunctional zones is performed.

The filling of the subject environment was based on the method of transformation, which allows combining furniture into modules with a multifunctional purpose, corresponding to vital processes, the style of minimalism with a minimum of decorative elements in accordance with the average anthropometric features of the hu-

man body. Detachable furniture modules have been developed that allow for replacement blocks, change the function of the module: a module combining the entrance, dressing room and dining area with the design of a transformable table, modules with the transformation of the desktop block into a berth (fig. 3).

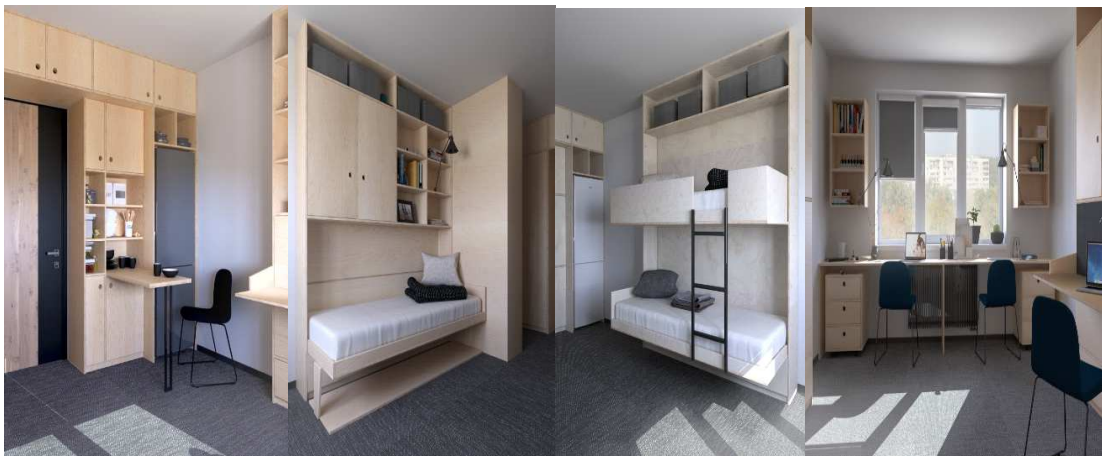


Figure 3. – 3D visualization of the content of the transformable furniture of the spatial environment of the living rooms of the hostel

Conclusion. The prevailing subject-spatial environment of hostels built in the 20th century and operated up till now does not satisfy the needs of modern students.

Design solutions developed without reconstruction and replacement of utility networks for a typical residential floor of a hostel, subject filling of the spatial environment of living rooms, taking into account functional, psychological, aesthetic, hygienic, anthropological, environmental aspects will significantly affect the socialization of students during their studies at the university.

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UDC 32.01+72.01

ARCHITECTURE AND ART AS A KEY ELEMENT OF POLITICAL CULTURE OF THE SOCIETY

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The problem of political culture and the influence of art and architecture on it in the form of basic symbols and markers as a basis that determines the identity of its carriers are analyzed in the article. The importance of preserving one's own culture, dominant and repressive cultures in the modern world by means of restoration of historical heritage as symbols of political culture itself, is emphasized.

Today, the world is again on the verge of new disasters, crises and wars. It must be accepted that the ideas of globalization, that people set their hopes on, were not realized. In essence, we returned to the starting positions, the echoes of the stages passed, which philosophers and scientists wrote about in their works. Here we can recall O. Spengler, J. Ortega y Gasset, E. Fromm, D. Orwell, H. Marcuse, H. Arendt, A. Huxley. One way or another, they all wrote about a crisis in society, the emergence of a mass person, the rise to power of authoritarian and totalitarian regimes, and the general decline of culture in the world. These topics are on agenda nowadays, too. It is now that they are starting to talk about the revival of nationalism, the emergence of radical movements and the election victory in different countries of the populists with their policies of protectionism. However, culture plays a key role in all this. If it is developed, many horrors and catastrophes can be avoided. Saying so one does not understand the essence of culture itself. If once own culture is high, other cultures will seem low, therefore, the latter should be enriched by their own culture, which seems ideal and perfect on its own. Many European countries were led by this idea during the period of geographical discoveries and colonial expansion.

Culture proved to be extremely diverse and cannot be simulated with other high cultures. Today, this can be observed in economics and politics. For example, S. Huntington wrote, comparing the economic indicators of several countries, the following: "looking at the economic statistics of Ghana and South Korea thirty years ago, in the early 1990s, I was struck by the similarity of the indicators of these countries. ... Three decades later, South Korea has become an industrial giant. ... In Ghana, where per capita income was only one-fifteenth of that of South Korea, nothing similar was observed. How can such sharp changes in development be explained? Undoubtedly, many factors played a role here, but, it seems that the matter was primarily due to cultural differences. South Koreans valued frugality, skillful investment, education, organization, and discipline. The people of Ghana had different values. In other words, cultures are serious" [1, p. 9]. Huntington offers an interesting way of development, which implies the following: "is it possible with the help of political or other tools to transform the culture or remove the barriers that arise on the way to progress?" [1, p. 12]. In this case, in our opinion, attempts to impose culture are doomed to failure, as it will in any case have different levels for the population. What options can be found to solve this problem?

First of all, one should understand what are the constitutes of a political culture and what are its opportunities to influence culture in general? Political culture can be analyzed as a part of culture in general, but with its own characteristics, which just create a mechanism for the dissemination of culture itself. So what does the term political culture mean? "In the broadest sense, it is a way of life of the people." However, political scientists "use this term in a narrower sense: here it refers to the psychological orientation of people and denotes a certain" psychological matrix "that defines people's attitude to such phenomena as a party, government, constitution, as all this is expressed in beliefs, values and symbols" [2, p. 252]. In this case, it is highly important to pay attention to the problem of symbols in political culture, what are they and what is their semantic meaning? We will not go into the details of symbolism [3] and its psychological characteristics, but simply dwell on the traditional scheme of political symbols.

So, for any person, symbolism is first of all a coat of arms, a flag and an anthem. However, they cannot always reflect the full content of political culture and culture as a whole. We can give examples of a change in symbolism after revolutions and referenda, when they were changed depending on the political realities of a group of people who came to power. A case in point is the return of historical symbols on the territory of the former USSR or the CMEA countries with their modifications, retouching and withdrawal of some attributes of

these symbols themselves. An example is the emblem of People's Republic of Poland. In Belarus, however, historical symbols were replaced with new ones through a referendum or former USSR symbols were transformed. Therefore, today in Belarus one can observe the presence of two symbols representing the coats of arms of Belarus: the official coat of arms and historical symbols recognized at the state level and used by the opposition. On the one hand, this is a problem that shows the complexity of political symbolism and its impact on society as a whole. Moreover, in other countries with a stronger culture, similar situations or even more radical changes occurred. For example, the coats of arms of France, Italy, and Ireland have appeared recently, but at the same time they are not the main political symbols of these countries: the shamrock is a more significant symbol of Ireland, in France it is a royal lily or Lorraine cross which were used at the time of the resistance movement during World War II. In Belarus, unfortunately, the cross of Euphrosyne of Polotsk is treated more like a religious symbol, although its historical and political burden is very significant in society. Confirmation of the importance of these symbols for a citizen is an understanding of his identity, which S. Huntington spoke about. He wrote about the US flag, concluding that "since the Civil War, Americans are accustomed to paying tribute to the national flag. "Stars and Stripes" gradually acquired a religious status, turned into an icon, became a symbol of national identity for Americans ... However, this flag has never had the meaning it acquired after September 11, 2001" [4, p. 22-23]. The personification of the flag and coat of arms as symbols of the nation is of great importance. These symbols may change depending on the political course and power, but at the same time, the identity itself is preserved. But there is a more significant symbolic environment, which is not limited to only one or a small group of symbols of political culture. At the same time, it is important to understand what identity is, because there one finds an important feature. So, S. Huntington wrote that "identity is the identity of an individual or group. It is a product of self-identification, the understanding that you or I have special qualities that distinguish me from you and us from them. Identity is inherent even by a newborn, in whom it is determined by such attributes as gender, name, parents, citizenship. ... Identity, as a group of researchers formulated, "correlates with the images of individuality and distinctiveness ("self") reproduced by the actor, and is formed (and also changes over time) due to the relationship of a person with significant characters from his environment". As long as people interact with their environment they have no choice but to define themselves through relations with others and to identify the revealed similarities and differences" [4, p. 50-51]. In this case, the formation of identity, especially at an early age, is influenced by a cultural landscape that defines and socializes a person living in a certain territory. It can be nature itself, the physical features of the territory - mountains, deserts, forests, swamps or objects created by man, namely: architecture. Its importance in the formation of identity is huge, it is a significant part, if not the basis, of culture itself and political culture as a whole. For a political culture, architecture is a symbolic landscape, a space that forms the human environment, filling it with meaning. It should be emphasized that most architectural monuments that have symbolic significance, for example, various palaces, tombs or religious buildings, carry a touch of power relations, that is, they make up the space of the political life of the population. The essence of this can be imagined and shown through the capital of the state and major cities of the country. Most often this is the quintessence of the ideas of the authorities or the ruler. The most important historical and architectural monuments are concentrated in this city. Capitals are moving or building in a new place. In certain cases, they capture and transfer their residences there. Moreover, they can be destroyed to the ground in order to erase the entire identity and historical past of former greatness. The main thing is that architecture becomes a marker and a symbol of power. An example of this is the imperial capitals, which throughout their existence created a cultural and political space that contains and conveys symbols of the political culture of an entire state, even if the capital was later destroyed. Two cities can be recalled, that influenced the main architectural styles existing in Europe - Athens and Rome. Their model was a certain standard for subsequent architects and their powerful customers. In other words, the architectural environment of the city affects the political culture and is one of the main elements of the constitution of the individual. The layout of streets and the scope of construction are aimed at ensuring that a person identifies himself with this architecture, monuments and is proud of them. In this vein, Paris, London, Berlin and Moscow are built. The task of these cities and their architecture is to transfer its repressive culture and power to future generations through the city spirit. It should also be understood that the core of the architectural style will be represented by a local design, however, the exchange with other styles enriches and fills it in with new content. For example, the Moscow Kremlin, where one can find the influence of architects from Italy. But over time, the features are leveled and one's own style and its cultural content are created. This illustrates another variable representing a civilizational characteristic that is transmitted through architecture to political culture. In other words, the emergence of civilizations with all their attributes is observed. More over according to S. Huntington: "it is impossible to imagine the development of the mankind in isolation from civilizations" [5, p. 22-23]. The understanding of civilization is a separate issue, but

it should be kept in mind that it can also manifest itself in architecture. An example is Belarus, which is on a civilizational break. In Belarus the influence of two civilizations is vivid and this can be found both in political culture and in architecture as a whole. However, this confrontation created a distinctive culture with its own architectural school, the examples of which are various churches, cathedrals and city planning. It is one's own, unique culture that develops in the breaking period that helps the ethnic group or nation survive in the conditions of global cataclysms. Unfortunately, political culture underlines the current situation in Belarus. In fact, Belarus was not lucky in this regard – it suffered greatly from numerous wars and the most terrible social constructs and political regimes were realized here. To understand this, one should compare the restoration plans of Minsk and Warsaw, where completely different ways in the cultural and architectural direction were chosen. These cities suffered almost equally - more than 80 percent of the cities was destroyed, but the symbolism and, apparently, political culture are significantly different. In Warsaw, an ideal replica of the old city was restored from ruins to show its identity and political culture. In Minsk, it was decided to build an ideal new city - the "city of the sun" [6] - to transmit and reproduce the totalitarian ideology and its culture. A classical antique architecture called the "Stalin Empire", rather than constructivism or modernity, was used. What is characteristic, after the construction of the central part of the city, a similar situation continued, for example, the demolition of the old Nemiga. Thus the power makes space through architecture and reproduce political culture within the framework of the system created by it. As far as political culture is concerned, even today, analyzing the architecture of Minsk, one should admit that it is still visible how the authoritarian culture is reproduced, although there are pointed elements of historical monuments restoration works, however, these are only certain examples. It can be said with no doubt that Minsk is the bearer of a political culture that does not exist anymore; it has lost its originality in Jewish quarters and in the district royal city. Reproduction in Minsk of a "patrial political culture" is expressed through the construction of buildings that are not suitable for the city and the destruction of historical buildings in the city center. At the moment, a similar situation is observed not only in the capital: for example, in the ancient city of Polotsk [7]. Today, near the main architectural symbol of the city - "Polotsk Sofia", the construction of a cadet corps building is being held on site of the upper castle. Archaeological excavations and a museum could have been much more appropriate at this place. This would underline the urgent problem of the nation wants to survival of the nation in the era when culture has finally begun playing an important role in the world again. The government should pay more attention to the historical heritage and its restoration. In other words, the creation and return of symbols that will help raise the level of culture in general and political culture in particular. An example is the neighboring Republic of Lithuania, which restored the Lower Castle as a symbol of the state and nation. Now the Castle of Batoria in Grodno is being restored in Belarus, but this is only a little fragment of what can be restored as a symbolic space of the nation. In other words, the people of Belarus should strive to change the architectural appearance and political culture of the state.

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UDC 698.7

DEVICE FOR ADAPTING PEOPLE WITH DISTURBANCES OF HEARING AND VISION IN AREA

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The article discusses the main devices used to create a barrier-free environment in both public and residential buildings. The advantages are highlighted and directions for the use of each device are noted.

Every day, a person with a disability is faced with difficulties associated with the lack of a barrier-free environment in buildings and in the territories adjacent to them. The absence or disturbance of the sensory organs, allowing orientation in area, play an important role in interaction with the environment. Often they have to intuitively adapt to the environment in which they are located.

At the moment, modern technology allows us to adapt the environment for visually impaired or blind people, as well as for people with hearing impairment. For them, the main reference point in area are sensory (tactile) and sound devices.

Equipment and materials designed to ensure accessibility for blind and hard of hearing people can be divided into the following categories:

1. Tactile pointers. These are elements in a barrier-free environment that allow a blind person to determine their location using tactile sensations. On such devices, the basic information is duplicated in Braille.

2. Tactile-sound devices. Such tactile devices transmit information with sound. The information on this index can be used by people who do not know the technique of reading in Braille.

3. Visual and sound devices. These are emergency warning systems that provide information to all visitors to a public building.

4. Tactile-visual marking. It acts as a designation of a bladed-less direction of movement for blind and visually impaired people in area.

Complete navigation in area for blind and visually impaired people can be done using tactile tablets and mnemonic diagrams, which relate to tactile pointers.

Tactile tablets can be located both inside and outside the building, approximately near the doorway on the handle side. Information on pointers is applied using flat-convex fonts, and can also be supplemented with Braille (Fig. 1, a). This is a point-to-point tactile font designed for writing and reading by blind and poorly seeing people. Designed in 1824 by the Frenchman Louis Braille. For the image of letters in Braille, six points are used, which are located in two columns [1].

The tactile tablets indicate the names of educational, medical and other public institutions, as well as the numbers and names of rooms and rooms. To inform a completely blind person, the indicators are placed at a height of 1100 mm, for the visually impaired - at a height of 1400 to 1600 mm. To ensure high performance, tactile products should be made on the basis of PVC plastic with a thickness of at least 3 mm. To ensure a contrasting effect, as well as to ensure optimal conditions for color perception by a visually impaired person, the tactile plate should have a yellow body color (RAL 2021) [2,3].

Unlike tactile tablets, tactile mnemonic diagrams, with the help of their relief, convey the entire floor plan, the main landmarks of movement in area, designed specifically for blind or visually impaired people (Fig. 1, b). Information is presented in a tactile way using the Braille system. On the mnemonic diagrams, a plan of the room, an evacuation plan, a plan of bathrooms, etc. are applied. Tactile mimics are mainly located in the lobby of the building, not far from the entrance at an altitude of 1100 mm from the floor. Due to the fact that tactile pointers made in a layer-by-polymer manner are the most easily perceived by blind people, a tactile surface is a relief consisting of a set of polymer layers, where each subsequent layer is polymerized on the surface of the previous one using UV radiation. The number of polymerized layers determines the height of the tactile image of at least 0.8 mm [4].

For the manufacture of each of the listed pointers, qualified specialists are required for the correct compilation of information, as well as time for the production of the device. For quick adaptation of objects and premises, tactile stickers are used (Fig. 1, c). They can be applied to the buttons of intercoms and elevators, on keyboards, handrails, household appliances, vehicles, etc.

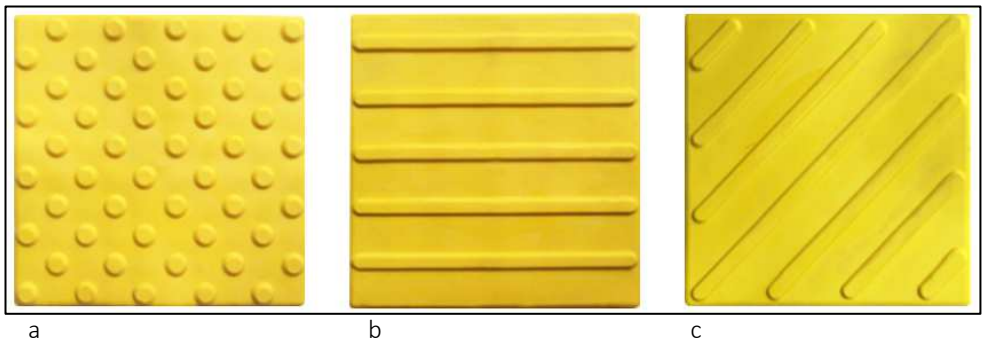
a b c

a - tactile braille label; b - tactile mnemonic diagram; c - tactile sticker on the handrail

Figure 1. – Tactile pointers

Tactile-sound devices include tactile tablets and tactile mnemonic circuits equipped with special sound panels. Such elements transmit tactile information with sound. These stands are widespread at socially significant objects: museums, exhibition halls, libraries, park areas, metro, city center. Each device is equipped with a clear-relief image, basic information duplicated using the Braille system, as well as sound buttons with professional voice acting [5].

Visual-audible warning systems, sound beacons are the most common devices for voice informing visually impaired and blind people. They are located in the lobby of the building with pre-recorded sound tracks, to ensure comfortable movement of people with limited mobility in area. Also, these systems additionally alert people with general information about this institution.



a b c

a - warning (conical); b - guide (longitudinal); c - rotary (diagonal)

Figure 2. – Tactile tiles

You can also coordinate movements using tactile-visual markings. Contrast marking, tactile indicators, tactile tape, etc. belong to it. Nowadays, the most important and widespread device for navigating people with visual impairment is tactile tile (Fig. 2). It allows you to navigate in area and follow the correct and safe direction

of movement [6]. The most common are three types: conical, longitudinal and diagonal. The cone tile serves to inform the obstacles to the movement of people with disabilities. To direct the path of movement and to inform about the turn, longitudinal and diagonal tactile tiles are used respectively.

Tactile PVC and TPU eco-tile Designed for laying both outdoors and indoors. It is made using raw materials after recycling. To ensure long-term performance, the tile must be made of high-quality thermoplastic elastomer with a hardness on the Shore scale of not more than 85 units on the scale A. To ensure high performance on abrasion, the product must be painted in the total weight of the material. Product color RAL 2021 [7].

In public areas with low maneuverability, a self-adhesive tactile tile and tactile tape are used for navigation. Also, carpet and rubber coverings, as well as materials contrasting in color and texture with the main coating, can be used as tactile guides.

The proper use of devices for the adaptation of people with visual and hearing impairments in area will help to properly coordinate the movement of the mobility impaired population. Creating a barrier-free environment allows people with disabilities to fully function in area and society.

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UDC 539.374

COMPARATIVE ANALYSIS OF ELASTIC-PLASTIC PROCESSES AT COMPLEX ACTIVE LOADING AND LOADING WITH UNLOADING

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In the article, there are the results of comparative analysis of phenomenon of delay of vector and scalar properties for paths of active loading and paths with unloading during elastic-plastic deformation. An attempt has been made to classify broken paths of active loading by extracting from them those in which fractures do not significantly affect the appearance of the process image and can be equated to simple loading and those where such simplification is unacceptable.

The simplest type of complex loading is two-link paths with fracture angle in the ranges: (0-90 °) - active loading and (90-180 °) - paths with unloading [1], [2], [6], [8]. The researched broken paths can be considered as a set of several two-link paths [3], [4]. The results of comparative analysis of experimental studies of two-link and polygonal paths are presented below.

Trajectories with unloadings. Experimental study of loading process for deformation paths in the form of two-link broken ones with change of angle at fracture point from 90 to 180 ° is considered. On tubular stainless steel samples, the lag of vector and scalar properties was investigated. The path fan is shown in Figure 1.

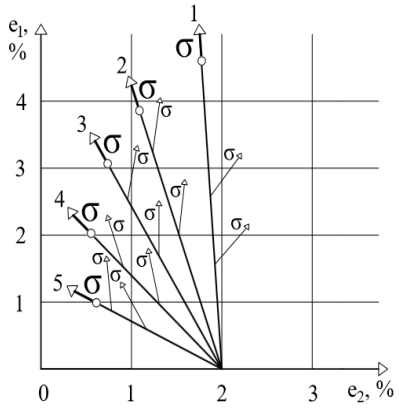

Figure 1. – Beep of paths with unloading

Graphs are obtained for dependence of approach angles on increment of trajectory length counted from a break point [3]. It has been found that as the fracture angle increases, the length of the delay trace of the vector properties decreases and the length of the delay trace of the scalar properties increases (Fig.2).

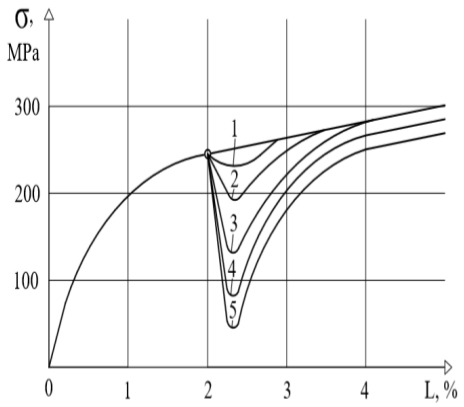

Figure 2. – Response functions for offloaded paths

Quantitative changes in the length of the lag trace of the vector and scalar properties are shown in the Table 1.

Table 1

Break corner	$\lambda_в$, %	λ_c, %
90°	1,8	0,2
110°	1,6	0,4
125°	1,3	0,8
145°	1,0	∞
160°	0,45	∞

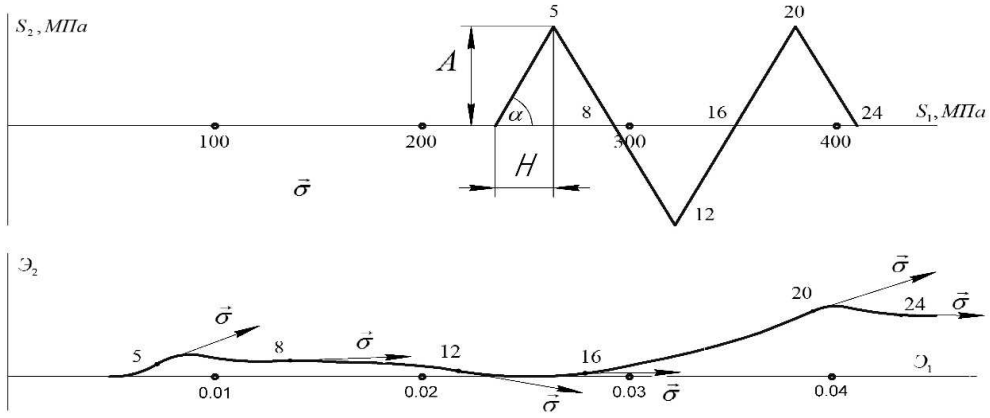

Figure 3. - Loading and deformation paths at torsion reversal

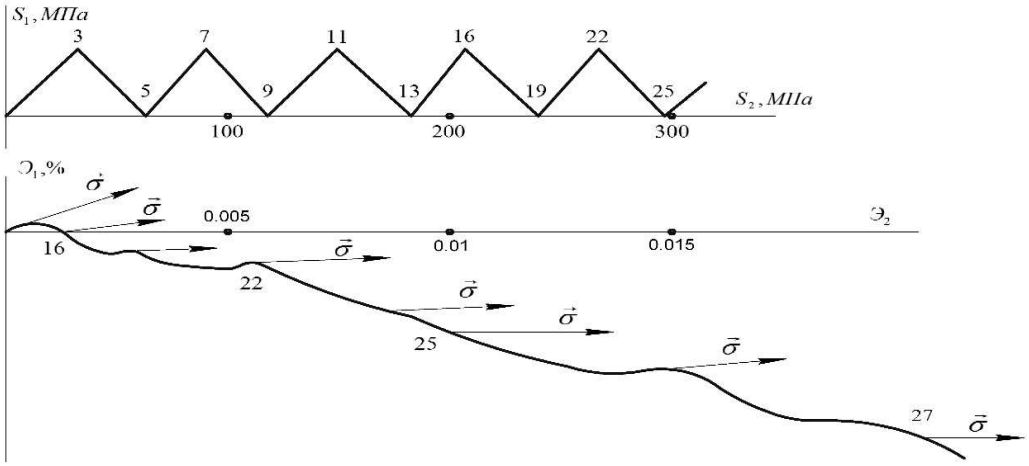

Figure 4. - Loading and deformation paths without torsion reversal

Polygonal trajectories. An alternative set of paths are polygonal loading paths, examples of which are shown in Figures 3 and 4. Here we have A/H- parameter difficulties. Two types of paths are considered: reversed and without torsion reversal [7]. The figures show the respective strain paths. It can be seen from the figures that on the paths having a reverse, the delay trace of vector properties is exhausted (the voltage vector passes the path), which is not observed on the zero paths. Therefore, deformation along these paths is complex, and along track ways reversed - close to simple. Changing the complexity parameter does not violate this trend. Thus, reversed paths with a sufficient degree of accuracy can be classified as simple. This conclusion is confirmed by the analysis of scalar properties: the points of the response function curve [5] of reversed paths lie near the simple loading curve, and the same curves of zero paths are located further. In addition, these curves show notable failures which are characteristic of offloading paths, discussed above. This fact allows us to classify them as "quasi-loading" paths.

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UDC 691.322.7

RATIONAL WAYS TO USE FIBER CONCRETE

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During the analysis, the most rational areas of application of fiber-reinforced concrete and the influence of various fibers on the physico-mechanical characteristics of concrete were identified. The positive effect of dispersed concrete reinforcement on their performance is described.

Nowadays, the use of a new generation of reinforced concrete is developing. Fiber concrete is a new type of concrete with interspersed fibers throughout the volume. Depending on the origin, the fibers are divided into three types: fiberglass, steel and synthetic fibers.

In the course of studying the material in [1], the most rational areas of application of fiber-reinforced concrete were revealed, such as prefabricated elements and structures: pipelines, beams, railway sleepers, floating dock modules, explosion-proof structures, piles, heating elements, street fittings, etc. and also monolithic structures, floors of industrial buildings, defense structures, roads, water dams, irrigation canals, etc. These designs are widely used abroad and have proven their effectiveness. Fiber reinforcement increases the ratio of tensile strengths during compression and tension, which leads to increased concrete efficiency.

In the work of Sofienko N.V., Pelyarchuk N.N. and Popova O.N. [2] the use of fiber-reinforced concrete as a promising material in construction was examined. According to its characteristics, fiber-reinforced concrete is suitable for the construction of structures subject to dynamic loads and thin-walled structures with great durability. The achievement of the economic effect is due to a change in the technology of obtaining and erecting structures from fiber-reinforced concrete and its new properties. The use of fiber-reinforced concrete increases the service life of structures, which leads to a reduction in the cost of their operation during the life of the structure.

In the article Durachenko A.V. [3] examined the use of fiber-reinforced concrete in the construction of Russia. Steel fiber concrete has been widely used in the construction of runways and roads, their difference in increased resistance to pulsating loads, abrasion and atmospheric influences. Fiber concrete is also used in industrial and civil engineering. Enclosing elements, floors, walls, partitions, coatings, pipes, channels and many others are made from it. The economic effect is achieved due to greater wear resistance, durability, serviceability and increased safety during seismic activity.

In [4], the effect of basalt fiber on the physico-mechanical characteristics of self-compacting concrete is studied. After 28 days, self-compacting fiber-reinforced concrete gains strength of 104.5 MPa, Poisson's ratio of 0.17, elastic modulus of 63.9 GPa, and water absorption of 2.2%. The indicators of these characteristics make it possible to use them in high-level resource-saving construction, the construction of nuclear power plants, reservoirs, bridges, tunnels, offshore structures, runways, aerodrome coatings, launch complexes for space ships and other special structures.

The work [5] describes the use of fiberglass concrete for building decoration. Technological properties make it possible to give fiberglass concrete almost any shape, geometry, texture and relief. Its plasticity and lightness allow architects to embody any ideas. When using concrete with the addition of glass fiber for decorative finishes, you can not worry about the increased load on the foundation, due to the lightness of the thin-walled composite material. The disadvantage of this building material is its cost, but, here we have the reduction in the cost of strengthening the bearing walls and foundations, so the high cost is unproven.

Lesovik V.S. in article [6] examines the use of fiber-reinforced concrete in seismically active areas. Most of all in the world Arabic countries are affected by seismic activity, for them, along with the effectiveness of construction, is its cost. The use of fiber-reinforced concrete increases plasticity during compression and tension, shear resistance increases, without special detailing of seismic resistance, adequate resistance to deformation of the potential and damage to tolerance can be achieved. In this case, it is possible not to accept special details for the earthquake resistance of structures and buildings, which is an economic factor. It also makes it possible to reconstruct buildings that were built without seismic adaptability.

Gafarova in the article [7] describes the use of various types of fiber. The physico-mechanical characteristics of fiber-reinforced concrete depend on the type of fiber. Polypropylene and nylon fibers have a low modulus of elasticity, which does not provide a qualitative increase in the strength of concrete. Due to the fact, that poly-

propylene fiber is not subjected to corrosion, it has found application in the construction of hydraulic structures, bulk floors, offshore structures. Environmental friendliness, heat resistance, durability are characteristic for basalt fiber. Concrete with basalt fiber has high physical and mechanical characteristics: tensile strength, heat resistance, durability, low creep, high crack resistance, etc. Also for fiber-reinforced concrete, fiberglass is common. It reduces the cost of concrete and improves operational and technical characteristics. Steel fiber is the most effective. Concrete with the addition of steel fibers increases the compressive and bending strength, has high impact resistance, crack resistance and low brittleness, which is a consequence of increasing the resistance of concrete in all directions.

In [8], the study is devoted to the influence of various fibers on the characteristics of fiber concrete. In industrial construction, steel fiber reinforced concrete is more often used, since when it is used, the coating thickness is reduced by 40-50% without loss of strength and performance characteristics in comparison with ordinary concrete. The use of steel fiber leads to an increase in ductility, frost resistance and bearing capacity. Fiberglass concrete has been widely used, since glass fibers are not subjected to corrosion. The disadvantage of glass fibers is low alkali resistance, which leads to the possibility of using glass fiber only in chemically inert environments. Seclofibroconcrete is very plastic and does not lose its strength characteristics when stained. Basalt fiber has high physico-mechanical properties, chemical resistance and weather resistance, which is also environmentally friendly. The use of basalt fiber reduces shrinkage cracks and increases the technical and economic indicators of the structure as a whole.

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UDC 621.785

THE STUDY OF THE ELECTRIC STRENGTH OF COMPOSITE MATERIALS BASED ON A POLYMER MATRIX

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The results of studies of polymer-based composite materials are presented. The characteristics of electrical resistivity and strength are measured. Recommendations on the practical application of the investigated materials are given.

The development of modern technology has led to the emergence of materials that have exceptional performance. Polymeric materials can have a molecular weight of from several thousand to several million.[1]

Distinctive properties of polymers are :

– Low rate of thermal conductivity. That is why some polymers can be used as insulation during some work;

– A high coefficient of LTEC is caused by a relatively high mobility of the bonds and a constant change in the strain coefficient;

– Despite the high rate of thermal expansion coefficient, polymer materials are ideal for spraying. Recently, it is often possible to meet a situation where the polymer is applied to the surface in the form of a thin layer to give the metal and other materials anti-corrosion properties. Modern application technologies make it possible to obtain a thin protective film;

– The specific gravity can vary in a rather wide range depending on the specific composition;

– A fairly high tensile strength from a part is caused by increased ductility. The resistivity can vary over a fairly wide range. An example of such polymers is hard PVC, which has 10^{17} Ohm × cm;

– The coefficient of linear expansion is from 70 to 200 × 10^{-6} per degree Celsius;

– To enhance the rigidity and strength of polymeric materials, various reinforcing fillers are introduced into their composition: fiberglass, carbon fibers, carbon -containing nanoparticles, metal - carbon nanocomposites, etc.

– Good dielectric properties allow the use of polymeric material without fear of electric shock. That is why polymers are often used to create tools and equipment designed to work with electricity.

The interest in polymeric materials is caused by the fact that every year the share of polymers accounts for an increasing number of products. Products from composite materials are used in everyday life, electronics, agriculture, construction. Today, polymeric materials are found in various states of aggregation such as glue, grease, sealant, paint, some solid polymeric materials. Solid composites are widely used in the production of a wide variety of equipment. As previously noted, composites based on a polymer matrix have high elasticity, due to which silicone, rubber, foam rubber and other similar polymeric materials were obtained .[2]

Of particular interest is the material that is used to seal the housings of devices, electronic components. An important characteristic for such materials is the electrical resistance .

It is known, that there are two paths of current flow of solid dielectrics: through the insulator and on its surface. Therefore, to assess the ability of a dielectric to conduct electric current in these directions, the concepts of volume and surface resistances are used. [3]

By volumetric (ρ_v) is meant the resistance that a dielectric possesses when direct current flows through its volume. The bulk resistance depends, besides other things, on the structure and composition of the material.

Surface (ρ_s) is the resistance that a dielectric possesses when direct current flows over its surface. Surface resistance depends on the state of the surface of the material through which current flows.

The article presents the results of studies of composite materials based on polymer matrix. Silicone and acrylic were chosen as matrix materials .

The methodology for determining the specific volume and surface electrical resistance was carried out according to GOST 6433.2-71 [4]

The results of the studies are presented in table 1.

Table 1. - Specific surface and volume resistance

Material	ρ_s Ohm * m	ρ_v Ohm * m
Acrylic Sealant		
Clean	$13.5 * 10^8$	$5 * 10^9$
Fiberglass (Fiber)	$1.6 * 10^6$	$11.4 * 10^7$
Fiberglass (Canvas)	$1.0 * 10^6$	$8.4 * 10^9$
Coal 10%	$1.0 * 10^6$	$1.7 * 10^9$
Coal 20%	$1.2 * 10^6$	$2.1 * 10^9$
Soot 10%	$1.2 * 10^6$	$11.1 * 10^7$
Soot 20%	$1.0 * 10^6$	$10.2 * 10^8$
PC10%	$3.09 * 10^8$	$4 * 10^8$
PC20%	$1.3 * 10^6$	$24 * 10^9$
Material	ρ_s Ohm * m	ρ_v Ohm * m
Siliconesealant		
Clean	$13.5 * 10^8$	∞
Fiberglass (Fiber)	$2.3 * 10^{10}$	∞
Fiberglass (Canvas)	$2.3 * 10^{10}$	∞
Coal 10%	$1.0 * 10^6$	∞
Coal 20%	$0.9 * 10^6$	∞
Soot 10%	$0.8 * 10^6$	∞
Soot 20%	$0.8 * 10^6 (34 * 10^6)$	∞
PC10%	$0.9 * 10^6$	∞
PC20%	$0.8 * 10^6$	∞

From the analysis of the results shown in table 1, the material based on silicone matrix with filler in the form of fiberglass has the highest surface electrical resistivity. Materials with silicone matrix with filler in the form of 20 % RS-5402 have the smallest surface electrical resistivity, and the material with filler in the form of 20 % carbon black has the same resistance.

Since the test material can be used for sealing the enclosure, a very important characteristic is electric strength. Strength in the broad sense is understood as the ability of the body to withstand the destruction that occurs as a result of external forces. The destruction of the polymer material takes place under the influence of electrical forces that determine the electrical resistance.

$$E_{пр} = \frac{U_{пр}}{d},$$

where U_{CR} - breakdown voltage between conductors, V; d is the thickness of the dielectric layer, microns.

Having determined the value of EPr, it is possible to choose the optimal thickness of electrical insulating coatings with a margin of electrical strength.

It is known, that the electrical strength of the material depends on the composition, structure, concentration and type of filler material, thickness. This allowed us to determine the parameters of the study of the dielectric strength. [2]

Table 2 shows the results of tests of silicone and acrylic samples for electrical strength.

Table 2. - The results of the test for the electric strength of silicone sealants

Filler	VoltagekV	The thickness of the material, microns	Breakdown	E_{ol}, V / cm V / cm
Silicone sealant				
Clean	25.5	1.735	not	$1.4 * 10^8$
Fiberglass (Fiber)	27.3	1.713	not	$1.6 * 10^8$
Fiberglass (Canvas)	26.5	1.395	thereis	$1.89 * 10^8$
Coal 10%	26.5	1.705	not	$1.55 * 10^8$
Coal20%	26.5	1.842	not	$1.43 * 10^8$
Soot 10%	26.8	1.751	not	$1.53 * 10^8$
Soot 20%	26.8	1.893	not	$1.41 * 10^8$
PC10%	26.5	1.802	not	$1.47 * 10^8$
PC20%	26.5	1.827	not	$1.45 * 10^8$

Filler	VoltagekV	The thickness of the material, microns	Breakdown	E_{ol}, V / cm
Acrylic sealant				
Clean	10.4	0.867	thereis	$1.19 * 10^8$
Fiberglass (Fiber)	21.5	1.313	not	$1.63 * 10^8$
Fiberglass (Canvas)	8.7	0.988	thereis	$8.8 * 10^7$
Coal 10%	9.3	1.015	thereis	$9.16 * 10^7$
Coal 20%	10.4	1.010	thereis	$1.02 * 10^8$
Soot 10%	11.4	0.942	thereis	$1.2 * 10^8$
Soot 20%	9.8	0.856	thereis	$1.14 * 10^8$
PC10%	11.5	1.066	thereis	$1.07 * 10^8$
PC20%	7.8	1.332	thereis	$5.8 * 10^7$

From the analysis of table 2, we can conclude: silicone sealants have greater electrical strength than acrylic.

Composites based on a silicone matrix had the greatest electric strength .

Our research allows us to establish the dependence of E_{pr} composites on the type and amount of filler. The highest dielectric strength was found in materials based on a silicone matrix filled with fiberglass (in fiber). The conducted studies will allow us to propose composite materials as sealants for electronic components.

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UDC 691

THE INFLUENCE OF THE MICROSTRUCTURE ON THE ACOUSTIC PROPERTIES OF BUILDING MATERIALS

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The analysis of the structure of single-layer and two-layer samples, as well as a physical explanation of the propagation of sound waves in building materials of various structures. A comparative analysis of the soundproofing and sound absorbing properties of the applied samples is given. Determining the sound transmission of building materials and their combinations.

Introduction. Acoustics (from the Greek. Acustikos - listening) is the science of sound. Building acoustics solves the problem of ensuring a normal sound mode in rooms for various purposes. The main task of modern building acoustics is to reduce the level of noise pollution in rooms. Noises are called sounds caused by various reasons, but not carrying useful information. Noise has a negative effect on the mental and physical health of a person. Reducing the level of noise pollution of the environment in which a person is located is an important biomedical and social task [1]. Noise arising in the room can be divided into external and internal. The main source of external noise in residential development are vehicles. Noise is usually characterized from a physical and physiological point of view. The physical characteristic of noise includes the magnitude of sound pressure and the distribution of this pressure over frequencies — the noise spectrum. The physiological characteristic of noise is determined by its effect on the human body; medium- and especially high-frequency noise is the most harmful [2].

One of the key parameters that affects labor productivity, creativity and health is acoustic comfort. Acoustic factors such as sound insulation and sound absorption play an important role in the design of work and living spaces. Electronics, heating, ventilation and air conditioning, mechanical appliances and other noise-producing equipment in the office, as well as the people themselves, are the main sources of noise in the room. Leisure places such as restaurants, cafes, cinemas and theaters require a separate approach to acoustic design.

Task formulation. In the research, we consider the main properties of acoustic materials in order to obtain information about the principle of propagation of sound waves in them, as well as their practical application, and we study the macro and micro structures of each sample using an Axiovert-10 microscope. The basic elements of the designed and manufactured training acoustic camera, which is further used to study the acoustic characteristics of building materials are described. As building materials, samples from drywall, wood concrete, foam plastic, foam rubber, ecotherm, armstrong were studied both individually and in combination.

Methods of research. The measurements were carried out in one-third octave bands with geometric mean frequencies of 100-8000 Hz, in accordance with TKP 45-2.04-154-2009 [3]. Prepared samples of the studied materials with dimensions of 40x45 with different thicknesses are placed in an acoustic chamber. Measurement of sound pressure level in the sound camera and sound waves, followed by the output of the output data.

Working process. The study used a training acoustic camera [4] and samples of the studied materials. First, sound transmission was measured in an empty chamber, then with the test materials being placed in the chamber, and sound transmission, sound absorption, and sound reflection coefficients were calculated. Sound absorption depends on the frequency and in practice is expressed by the sound absorption coefficient:

$$\alpha_1 = \frac{E_1}{E_2} \quad (1)$$

where α_1 - sound absorption coefficient;

E_1 - energy of the absorbed sound wave;

E_2 - energy of the incident sound wave.

Similarly, the reflection coefficient can be determined by the formula:

$$\alpha_2 = \frac{E_3}{E_2} \quad (2)$$

where α_2 - sound reflection coefficient;

E_3 - energy of the reflected sound wave.

And the sound transmission coefficient is then defined as:

$$\alpha_3 = \frac{E_4}{E_2} \quad (3)$$

E_4 - energy of the transmitted sound wave.

Also considering that:

$$\alpha_1 + \alpha_2 + \alpha_3 = 1 \quad (4)$$

We have studied single-layer samples: drywall, arbolite [5], armstrong, as well as combined two-layer samples: drywall and ecotherm, drywall and plastic foam.

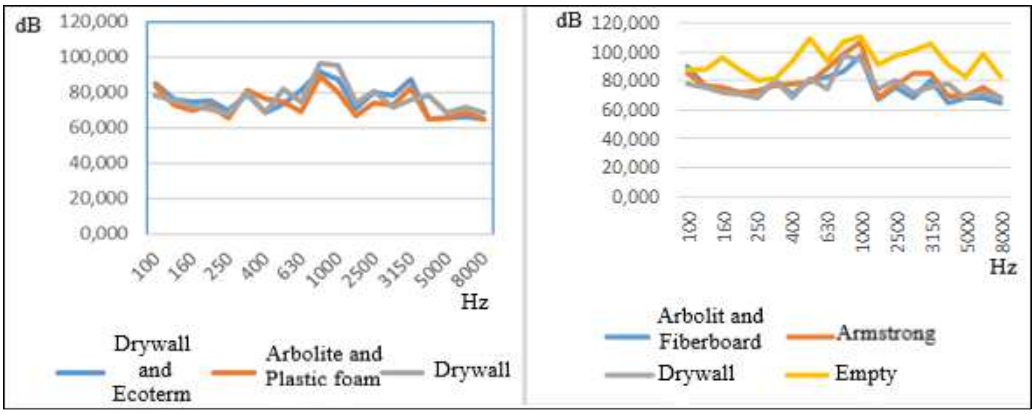


Figure 1. – Comparison chart materials for sound transmission

An analysis of the above graphs showed a decrease in noise level by an average of 18.34 dB for wood concrete with fiberboard, by 14.61 dB for armstrong, by 17.63 dB for drywall, by 18.14 for drywall and ecotherm, by 20.38 dB for drywall and plastic foam in comparison with the initial data.

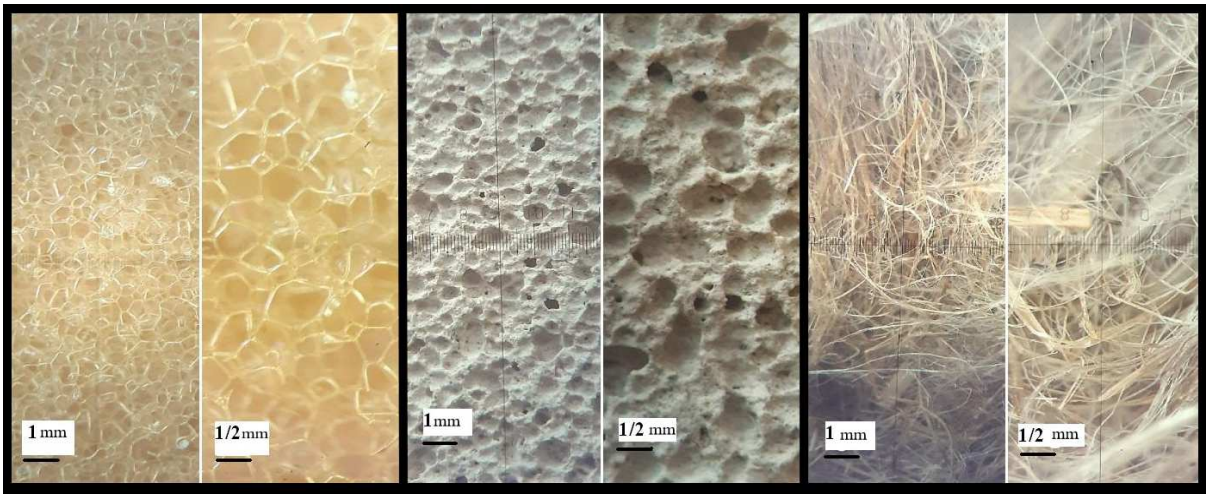
Table 1. - The results of measurements of the acoustic properties of materials.

acoustic odds / material	Armstrong	Arbolite	Drywall	Drywall + ecotherm	Drywall + plastic foam
Sound Absorption Average, %	12.0	15.0	15.4	15.9	19.1
Sound reflection Averеage,%	3.990	4.202	3.763	3.1	2.746
The average value of sound transmission,%	84.6	80.8	81.5	81	78.7

The ability of materials to absorb sounds is mainly due to their porous structure and the presence of a large number of communicating open pores from the side of the sound. The maximum pore diameter should not exceed 2 mm, and the total porosity should be at least 75% [6]. This is due to the fact that when a sound wave passes through the thickness of the material, it brings the air enclosed in its pores into oscillatory motion. In this case, small pores create greater resistance to air flow than large ones. The movement of air in them is inhibited, and as a result of friction, part of the mechanical energy is converted into heat. The higher the open porosity of the insulating surface, the higher the sound absorption.

Acoustic materials are similar in structure to heat-insulating materials. Both materials require high porosity (Fig. 2). However, due to the fact that the nature of the influence of heat and sound flow is different, the nature of the optimal structure is different for them. Hence, the most effective heat-insulating materials are those that have closed finely porous structure that excludes air convection. Acoustic, in particular, sound-absorbing materials should have an open porous structure capable of absorbing sound energy [6].

Sound-absorbing materials can have a fibrous, granular or cellular structure and have varying degrees of stiffness (soft, semi-rigid, hard). The sound-absorbing properties of materials are also affected by their elasticity. In products with a flexible deformable framework, there are additional losses of sound energy due to the active resistance of the material to forced vibrations under the influence of incident sound waves [7].



(left side- Foam rubber, middle side- Gas silicate block, right side- Ecotherm)

Figure 2. – Images of the structure of materials

Nowadays, the most versatile soundproofing materials are materials based on natural raw materials, for example, products based on stone (basalt) wool. Due to their specific structure, they have very good sound-proofing abilities. When sound waves fall on the material, its finest chaotically directed fibers transform the energy of sound vibrations into thermal energy by friction with each other. Figure 2 shows the microstructure of the ecotherm, which is made of flax and has both excellent thermal insulation and soundproofing characteristics.

Conclusion. According to the results of the experiments, a comparative analysis of the sound-insulating and sound-absorbing abilities of the partitions showed that the combined two-layer sample (drywall and plastic foam) has the best acoustic properties. Thus, this combination can be used for wall decoration, where good acoustics such as a movie theater and the like are very important.

The surfaces of acoustic materials examined under a microscope demonstrate the potential for sound absorption and sound insulation. Porous and fibrous materials are more likely to absorb sound than closed cell structures. When materials with closed cell structures are more suitable for sound insulation purposes.

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UDC 624.072

CONCERNING THE QUESTION OF CALCULATING A BEAM WITH A HINGE-ROD CHAIN

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We consider the calculation of a statically indeterminate combined system consisting of a beam and a hinge-rod chain of a general form for the action of an arbitrary vertical load. The qualitative regularities of the internal forces in the rods of the hinge-rod chain are established. Depending on the scheme of interaction of the chain with the beam, the calculation of combined systems with and without a horizontal reaction support is considered. Finite formulas are obtained for determining the internal forces in such systems.

Among the rod structures encountered in construction practice, a very wide class is formed by combined systems consisting of a stiffener beam and a hinge-rod chain (Fig.1). By static properties, such systems can be either statically determinate or statically indeterminate. Particular examples of the calculation of such systems are given in [1], [2].

There are two options of the design of the hinge-rod chain - arched and suspension types. Depending on the scheme of interaction of the chain with the beam, there are combined systems that have a horizontal reaction support (spread) (Fig. 1.a) and ones that do not (non-spread) (Fig.1.b).

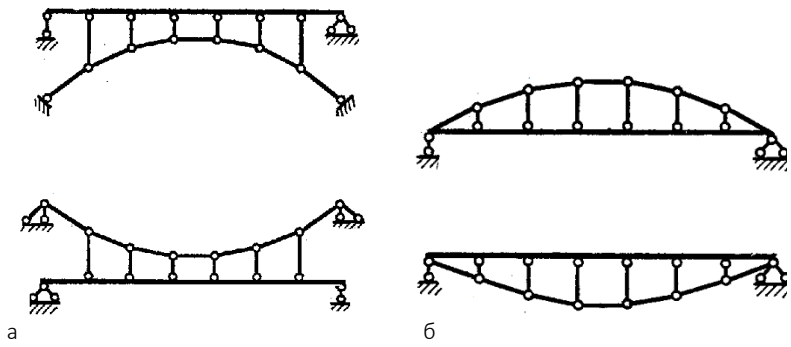

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Figure 1. – Combined systems

With respect to the difference in the interaction schemes of the chain with the beam, it is of interest to consider the qualitative laws of the internal forces arising in the elements of the chain. We assume that the chain has an arbitrary finite number of nodes.

Since the elements of the chain act as truss rods, only longitudinal forces arise in them. Let us consider the longitudinal force diagram in an arbitrary node of the chain of number n (Fig.2).

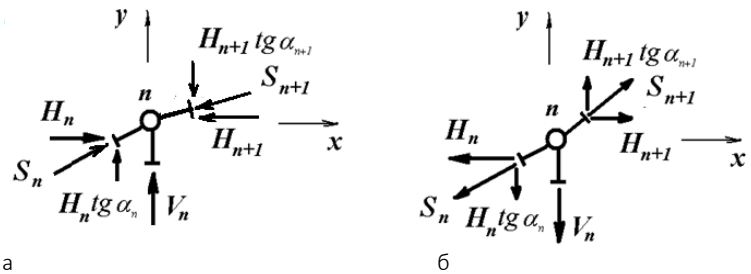

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Figure 2. – Scheme of longitudinal forces in an arbitrary node of the chain

In the case of the arched version, all elements will be compressed (Fig.2.a), and in the case of the suspension version, they will be tensioned (Fig.2.b). For the forces acting on an arbitrary node of the chain, we compose the projection equations on the x and y axes.

From the equation of projections onto the x axis it follows that

$$H_n = H_{n+1} = H = const \quad (n = 1, 2, ...) \tag{1}$$

The resulting relation (1) characterizes the first property of the chain. The horizontal components of the longitudinal forces in all inclined chain rods are the same. This same horizontal component is a chain spread. Then the longitudinal forces in the inclined rods of the chain are related to its spread by the ratio

$$S_n = \frac{H}{\cos\alpha_n} \tag{2}$$

From the equation of projections onto the y axis, it follows that the longitudinal forces in the vertical rods are related to the chain spread by the following relation

$$\left|V_n\right| = H\left(tg\alpha_{n+1} - tg\alpha_n\right) \tag{3}$$

The obtained relations (2), (3) are characterized by the second property of the chain. The internal forces in all chain rods are expressed through the chain spread.

We consider the chain case, that is most common in construction practice, when the distance between the chain posts is the same

$$a_{n-1} = a_n = a_{n+1} = a \tag{4}$$

and the chain nodes are outlined according to the law of a quadratic parabola

$$y = kx^2 \tag{5}$$

In this case, the position of arbitrary three adjacent nodes of the срфшт, taking into account (4), (5), is described by the following relations:

- nodes' abscissas

$$\begin{aligned} &x_{n-1} \\ &x_n = x_{n-1} + a \\ &x_{n+1} = x_{n-1} + 2a \end{aligned} \tag{6}$$

- nodes' ordinates

$$\begin{aligned} &y_{n-1} = kx_{n-1}^2 \\ &y_n = k\left(x_{n-1} + a\right)^2 \\ &y_{n+1} = k\left(x_{n-1} + 2a\right)^2 \end{aligned} \tag{7}$$

Hence, the tangents of the slope angles of the chain rods adjacent to an arbitrary node of the chain of number n, taking into account (6), (7), are related to the corresponding ordinates by the relations

$$\begin{aligned} tg\alpha_n &= \frac{y_n - y_{n-1}}{a} \\ tg\alpha_{n+1} &= \frac{y_{n+1} - y_n}{a} \end{aligned} \tag{8}$$

Substituting (7), (8) into (3), after the corresponding transformations, we obtain that the force in an arbitrary chain's vertical element is described by the expression

$$\left|V_n\right| = 2akH \tag{9}$$

From the resulting expression (9), it follows that the longitudinal forces in all the vertical elements of the chain are the same in magnitude.

Taking into consideration the established properties of the hinge-rod chain, we consider the calculation by the Force Method of the stiffener beam and the hinge-rod chain of a general form for the action of an arbitrary vertical load (Fig.1).

The initial set parameters of combined systems in all cases considered are:

- type of the system: *t* = 1 – suspension; *t* = 2 – arch;
- span value- *l* и chain rise – *f*;

– number of panels - p;

– load parameters - places of application and direction of concentrated and distributed loads, values of their modules and intensities;

– stiffness beam parameters — elastic modulus of the material - E_b, area - A_b and moment of inertia - I_b of the cross section;

– chain elements parameters - elastic modulus of the material of the belt rods - E_s, the elastic modulus of the material of the struts (vertical elements) - E_v, the cross-sectional area of the rods of the belt - A_s, the cross-sectional area of the struts - A_v.

The derived parameters of combined systems in all cases considered are:

– belt panel length - $a = \frac{l}{p}$;

– number of nodes in the chain - $k_y = p + 1$;

– number of rods in the belt of the chain - $k_s = p$;

– number of struts in the chian - $k_v = p - 1$.

– The geometry of the hinge-rod chain of the calculated combined systems is characterized by;

– outline law of the chain's axis – $y(x)$;

– coordinates of the chains nodes - $y_k \quad \left(k = 1, ..., k_y\right)$;

– length of the belt's rods - $l_{s_k} = \sqrt{\left(y_{k+1} - y_k\right)^2 + a^2} \quad \left(k = 1, ..., p\right)$;

– angle of the chain rods - $tg\alpha_k = \frac{y_k - y_{k+1}}{a} \quad \left(k = 1, ..., p\right)$;

– length of the struts - $l_{v_k} \quad \left(k = 1, ..., k_v\right)$.

The considered spreader and non-spreader combined systems for both options of the structural design of the hinge-rod chain are once statically indeterminate systems. In all cases, to remove the only excess connection, the hinge cuts the middle section of the beam and, therefore, the main system of the force method is a statically determinate combined system (Fig.3).

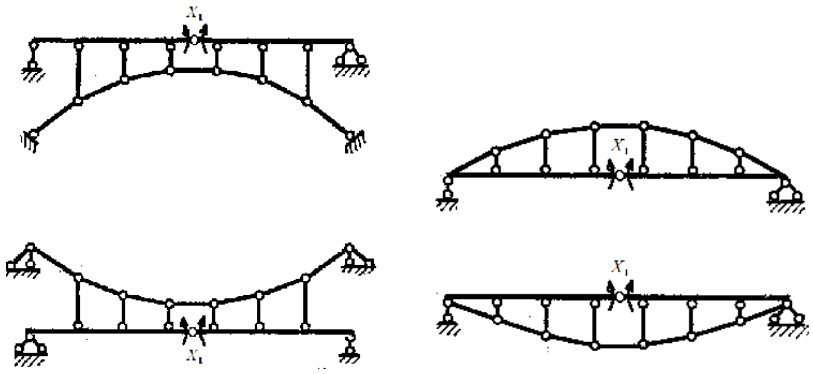

Figure 3. – Main system of the Force Method

The canonical equation of the force method for all considered combined systems has the same form

$$\delta_{11} X_1 + \Delta_{1P} = 0$$

and the main unknown in all cases is the bending moment in the most dangerous section of the stiffener. The final formulas are obtained that relate the internal forces of the combined systems under consideration with the beam internal forces, with the chain spread and the main unknown.

The formulas for determining the internal forces in the hinge-rod chain are:

– chain spread - $H = \frac{M_{Cb} - X_1}{f}$

– longitudinal force in the belt's rods - $S_k = \frac{M_{Cb} - X_1}{f \cos \alpha_k} \quad (k=1,...,p)$

– longitudinal force in the struts - $V_k = \frac{M_{Cb} - X_1}{f} (tg\alpha_{k+1} - tg\alpha_k) \quad (k=1,...,k_v)$

The formulas for determining the internal forces in the stiffener beam are:

– non-spread combined systems of any type

$$M(x) = M_b(x) + \frac{X_1 - M_{Cb}}{f} y(x)$$

$$Q(x) = Q_b + \frac{X_1 - M_{Cb}}{f} tg\alpha(x)$$

$$N = \frac{X_1 - M_{Cb}}{f}$$

– spread combined systems of any type

$$M(x) = M_b(x) + \frac{X_1 - M_{Cb}}{f} y(x)$$

$$Q(x) = Q_b + \frac{X_1 - M_{Cb}}{f} tg\alpha(x)$$

$$N = 0$$

The established properties of the hinge-rod chain and the resulting final formulas for determining the internal forces in the considered combined systems are of practical importance and can be used both when designing new and when strengthening existing combined systems consisting of a beam and a hinge-rod chain.

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TRANSFORMATION OF MOGILEV'S PUBLIC SPACES

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The article discusses the concept and feasibility of urban public spaces. The conversion methods are given on the example of the central historical part of the city of Mogilev. Brief characteristics of the selected objects are given. Conceptual proposals for improving the urban environment have been made.

Keywords: *public space, square, historical status, complex, pedestrian space.*

Introduction. On a city-wide scale public spaces can be represented by a combination of elements such as pedestrian streets, squares, parks, squares, boulevards, territories in front of public buildings adjacent to houses of the territory, etc. Spaces of this type are designed to facilitate the content of trade, the organization of leisure, cultural the development of citizens, the development of their social skills, regardless of their financial situation, ethnicity or gender. Consequently urban public spaces should be accessible, safe and comfortable in the first place.

The image of large European cities is often collected in the minds of people on the basis of the real appearance of historically developed public spaces. An example of this is Red Square in Moscow, concluded between the Moscow Kremlin and China-City, or the Triumphal Route in Paris, which originates from the Louvre and ends in the defense quarter [1].

Main part. The historical center of Mogilev was formed on the right high bank of the Dnieper. The old city was a commercial and religious center. As part of the Grand Duchy of Lithuania, the city had the right to hold two fairs a year, and Magdeburg law allowed the city to acquire the town hall and accordingly the square in front of it. All of the above facts testify to the high social activity of the townspeople and the organization of various open public spaces, which now have historical significance.

The public spaces of Mogilev, discussed further in the article, namely squares, squares and boulevards, are adjacent to the main streets of the city - Pervomaiskaya Street and the pedestrian Leninskaya Street. In figure 1 is a situation scheme showing the main objects under consideration and the elements surrounding them. Therefore the fragment under study consists of an invitation site in front of the building of the cultural institution "Mogilev Regional Philharmonic", an avenue of heroes of the Mogilev region, the theater square, Herzen Square, the square of the Episcopal Palace, as well as the Slava Square and the Maxim Gorky Park. The common problem of these components of the urban environment is not rational functional use, not developed infrastructure and service system, and many territories are simply empty. The reason for this may be planning decisions of these territories that do not meet modern requirements, outdated equipment, inappropriate small architectural forms and the absence of a barrier-free environment. In an ideal situation, each of these spaces should fulfill several functions and have many scenarios for using them by the townspeople or guests of the regional center. However, it is worth noting that there is no single universal solution, therefore, each of the objects should be considered separately, taking into account its historical status and in combination with the surrounding buildings.

Compositionally the Slava Square is a node to which extended axial elements lead. A steep relief determined the completion of Pervomaiskaya Street with a dead end adjacent to the square. Located on the right bank of the Dnieper, it has become a natural, viewing platform. A huge territory is occupied by the Memorial complex "Fighters for Soviet power." The complex includes a twenty-meter stela symbolizing victory, eternal flame, the mass grave of the Red Army soldiers who died in 1920. The bronze bas-reliefs on the mass grave depict the themes: «Collectivization», «October Revolution», «Defense of Mogilev in 1941», «Partisan movement» and «Post-war time» [2]. The attitude of citizens towards the memorial complex is ambiguous. Large monumental forms cause a lot of controversy among the modern generation. However, it should be recognized that almost all excursions and city tours include visits to this square and neighboring attractions. In order to preserve the memory of the bloody events that befell residents of Mogilev the history of Belarusians in general, zoning of the territory should be carried out delicately.

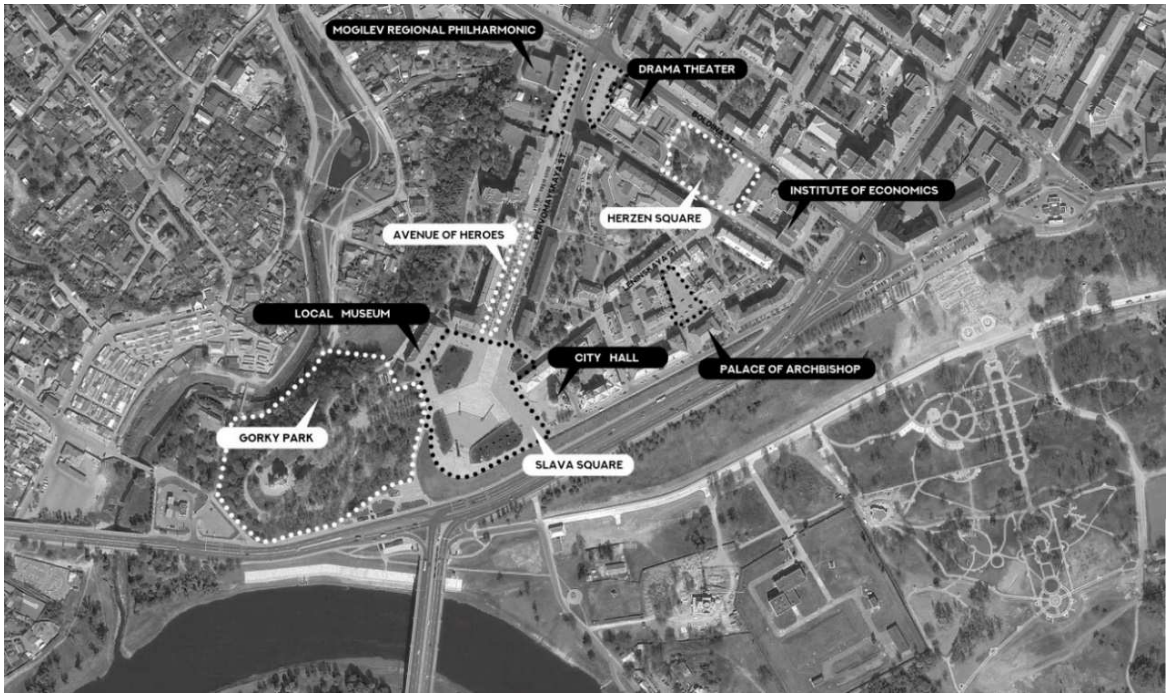

Figure 1. – Situation scheme

As part of the conceptual proposal, it is possible to develop an entrance group to the square from the Leninskaya street, to organize the square in front of the entrance to the museum of local lore that adjoins the Square of Glory by working with landscaping and paving. The section of Pervomaiskaya Street from the intersection with Boldina Street, which runs along the Heroes Alley, has great potential to become another pedestrian space completely free from cars, or a shared street. Public service facilities located on the first and ground floors of the adjacent residential development have courtyard driveways that can be used for loading and other needs, as an option. After necessary research, a decision can be made about using the underground space. The number of storeys (4-5 floors) of buildings is already man-scaled, and the transformation of the current roadway, crushing it into zones, new lighting design, will make the new space more cozy and friendly (Figure 2).

Figure 2. – New pedestrian zone

The area of the Bishop's Palace (second half of the 18th-19th centuries) has a more closed character in contrast to the Slava Square. This is a space deepened by several steps, bounded on three sides by outbuildings and having a fence with a front gate. The composition of the square is almost symmetrical about the axis of symmetry of the palace of Konissky's Archbishop. Several authentic buildings have survived on the territory of the old city, which survived numerous fires, perestroika time and WWII. The palace complex is one of such objects. Paving stones are still used as a covering material for sidewalks and driveways, the enclosing elements are

made of forged metal, and the color scheme of the facades is designed in calm pastel shades (Figure 3). The status of the objects, the general spirit of the place suggest that the most organic solution in this case will be the preservation and maintenance of the existing state of the palace complex. In this case, one should not introduce new functions into the sacred object, as, for example, this was done to St. Sophia Cathedral, a museum was created on the site of the church.

Figure 3. – Front gate of the palace complex

People's habits of attending cultural institutions have changed with an increase in the pace of life of the population. The storage area in front of the building is no longer used for meetings as before, information stands have already been replaced by advertising on the Internet. Herzen Square which is located near the courtyard facade of the Mogilev Drama Theater does not attract visitors it simply does not lie on the shortest path from one point of attraction of people to another. The summer stage of the theater which is a continuation of the courtyard facade is not used. The fountain established at the end of the 20th century, does not function, which is why it also ceased to be a place of attraction for citizens. As a conceptual solution to these problems, the creation of a dry fountain (without an open bowl with water) or a thematic installation can be proposed. In addition, a venue for outdoor events in the warm season can be thought out, with the possibility of using mobile and stationary equipment (spectator seats, screens, podiums, etc.). Interaction with an interesting object such as a musical or light fountain will help revitalize the square (Figure 4).

Figure 4. – Herzen Square

Invitation venues in front of the theater and philharmonic are surrounded by main streets. Near the above-mentioned objects (on bends), in the triangles of visibility, it is forbidden to install any large street equipment that interferes with a full-fledged visual view from the roadway. The creation of large installations, information boards is impossible. Therefore it is possible to solve the existing situation by means of not high elements

of improvement of the environment: landscaping (lawn, flower beds, flower beds, undersized shrubs), the arrangement of seats.

Conclusion. The proposals for transforming Mogilev's public territories are based on the idea of creating individual, unique and modern urban spaces meeting current modern living standards. Which could adapt to the needs of citizens depending on the time of day or the time of year.

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TECHNOLOGY, MACHINE-BUILDING

UDC 621.715.2

AUTOMATION OF PRODUCTION PREPARATION BASED ON 3D LAYOUT OF TECHNOLOGICAL EQUIPMENT

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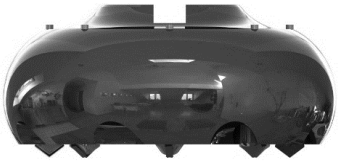
Introduction. The automation of production based on the prototyping of technological equipment based on the results of 3D modeling when creating block-modular face mills are presented.

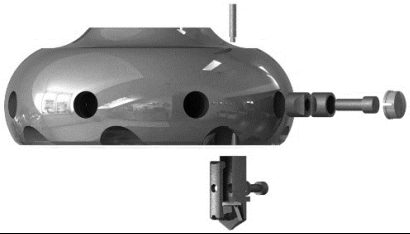
Research results. The results of work on the automation of production based on the prototyping of technological equipment based on the results of 3D modeling when creating block-modular face mills are presented.

Basic. Preparation of machine-building production, as known, includes the development of product designs and manufacturing techniques. Automation of procedures and development of the proposed designs and technologies on mock-ups obtained using layer-by-layer synthesis contribute to reducing time costs at this stage of production.

A technique that has been developed for 3D designing and printing on 3D printers of technological equipment models, in particular block-modular cutting tools (BMRI) [1-3]. The methodology includes the calculation and design of 3D structures using the software such as Ansys, Compass Vertical, Solid Works and the technologies for their machining on turning and milling three-axis machines of the Emko and Robodrill model, printing on a 3D printer type "Mojo" and "hybrid" method, combining traditional and additive technologies (table 1).

Table 1 – The Method of manufacturing a block-modular cutting tool

Tradicional

Metal tool construction
Additive

Plastic tool construction
"Hybrid" (unconventional)

Metal cutting units and assembly elements + plastic case

Distinctive features of the obtained BMRI mock-ups are the "streamlining" of the shell shapes and efficient of structural elements from the point of view of the laws of hydro and aerodynamics or chip and heat removal, as well as the use of special balancing devices (elements).

Mathematical and physical modeling of various options for shapes (cylindrical, spherical, torus) and the location of structural elements (orthogonal and at an angle) during the flow around liquids and air flows of BMRI has been conducted.

The optimal design options have been established. It is provide minimal energy consumption, losses, matching chip, and heat-conducting flows from the working area at the static and dynamic BMRI positions.

Rationing of work and cost estimation were carried out during the implementation of various production technologies of BMRI (Ficture 1).

Method for manufacturing block-modular cutting tool:

Tradicional	Additive	«Hybrid»
≈1000 bel. rubles	≈ 350 bel. rubles	≈ 720 bel. rubles

Figure 1. – Estimation of manufacturing costs

As can be seen from Figure 1, even the use of the "hybrid" method of producing a BMRI prototype from polymeric materials allows one to save money in comparison with the development of BMRI designs on experimental metal samples.

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UDC 621.715.2

MODERN 3D PRINTING TECHNOLOGIES OF PRODUCTS AND PARTS

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Introduction. Active development of 3D printing technologies is currently observed. The aim of this research project is learning existing methods of 3D printing for following analysis and use in modern mechanical engineering. 3D printing is a promising area for research because appeared relatively recently [1].

Research results. At the moment, you can divide all existing methods of 3D printing into three categories:

1. LS (Laser Sintering), based on laser technologies;
2. HP (Heating Printing), based on material heating;
3. Basic, based on glued powder printing;

Basic. 3DP (three-dimensional printing). Glue is applied to the material in powder form, which binds the granules, then a fresh layer of powder is applied over the glued layer, etc. In the end, as a rule, it turns out material sandstone (similar in properties to gypsum).

LS - Laser Sintering (

Figure 1. – Laser sinteringОшибка! Источник ссылки не найден.)

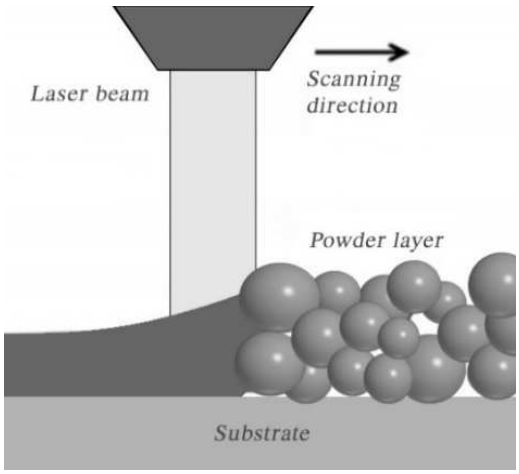

Figure 1. – Laser sintering

SLS – selective laser sintering.

The basic principle of operation is to spray a multi-colored hardener onto a thin layer of fine powder in predetermined areas. This procedure is repeated many times, and as a result, the necessary element is formed. It should be noted that the layers are so thin that they are visible under the previous ones. As a result of the increase in the number of layers, the bottom of the tank gradually drops down. The time of receipt of the finished product directly depends on the complexity of the execution of the object itself.

SLA - **laser stereolithography**

The principle of the operation of this technology is the action of a laser, UV (ultraviolet) or IR (Infrared) on a photopolymer (liquid). As a result, the liquid is converted to a fairly hard plastic.

Platform deepens in liquid polymer, then the beam passes through the liquid layer under the platform, that leads to hardening and sticking it to the platform, thus, a single layer is created. As a result of repeating such a procedure many times the necessary layout is formed.

LOM - laminated object manufacturing

Thin laminated sheets of material are cut with a knife or laser, and then sintered or glued into a three-dimensional object. That is, a thin sheet of material is laid, which is cut out along the contour of the object, thus one layer is obtained, the next sheet is laid on it, and so on. After that, all sheets are pressed or sintered.

SL – stereolithography

There is a small bath with liquid polymer. The laser beam passes over the surface, and in this place the polymer polymerizes under the influence of UV (ultraviolet). After one layer is ready, the platform with the part is lowered, the liquid polymer fills the void, the next layer is baked, and so on. Sometimes the opposite happens: platform with the part rises up, the laser is respectively located below ...

After printing by this method, the object requires post-processing - removal of excess material and support, sometimes the surface is ground. Depending on the required properties of the final object, the model is baked in the so-called ultraviolet ovens.

Photopolymer is often toxic therefore, when working with him, you need to use protective equipment and respirators.

Polyjet

Photopolymer shoots in small doses from thin nozzles, as in inkjet printing, and immediately polymerizes on the surface of the manufactured device under the influence of ultraviolet radiation. An important feature that distinguishes PolyJet from stereolithography, is the ability to print various materials.

LENS - laser engineered net shaping

Material in powder form is blown from the nozzle and arrives at the focused laser beam. Part of the powder flies past, and the part that falls into the laser focus instantly sinter and layer by layer forms a three-dimensional part.

DMLS - direct metal laser sintering

Powdered metal consumable enters the working chamber in a volume necessary to printing one layer. A special roller smoothes the powder equally over the entire surface, while removing excess from the chamber. The laser sinteres the fresh material with the existing layer according to the original model (picture 1). This process continues until the printing of the part is complete.

HP - Heating Printing (Ошибка! Источник ссылки не найден.)

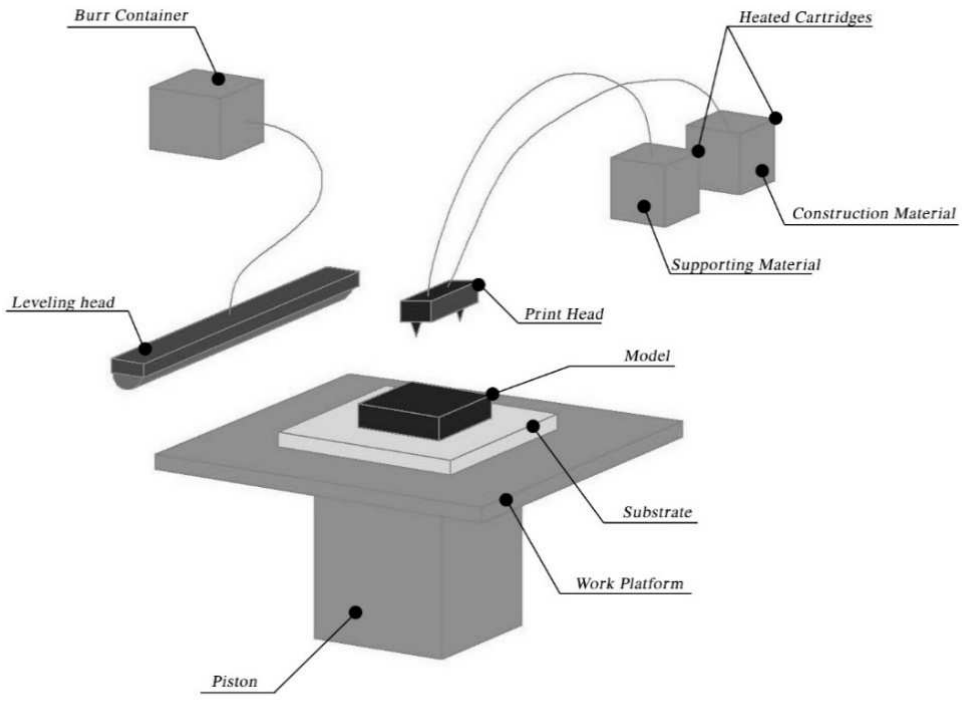

Figure 2. – Heating Printing

MJM - multi jet modeling

In this method, the light curing of the polymer is carried out through the influence of UV (ultraviolet) flash. The molten acrylic photopolymer (plastic) is applied to the printing platform using the head. On this platform, the plastic lends itself to being illuminated by a halogen lamp, resulting in hardening of the material. The procedure is repeated many times to achieve the desired result. An important detail is the supporting of protruding or overhanging parts, which is carried out using household wax.

DLP - digital light processing

DLP is quite similar in its technological process to MJM (multi jet modeling). A clear difference is the effect of the projector on the model with the usual light flux to obtain polymer cure. The photopolymer is added to the cell as it is consumed. During the printing process, the machine closes to prevent the model from flashing.

The protruding parts are also supported by the use of wax. Which removal technology is the same.

FDM - fused deposition modeling

FDM is the creation of inkjet technology. Using this technology, the printer operates directly from plastic coils tucked into the extruder. The main principle of work is the melting of a plastic rod, the formation of a drop from it and applying it to a moving platform in a given place.

EBM - electron beam melting

Additive manufacturing method similar to selective laser sintering (SLS), but using a high-energy electron beam in vacuum instead of a laser. As with SLS (selective laser sintering), the consumable for EBM (electron beam melting) is typically a powder pulverized to a powder consistency using ball mills. As a material, titanium, alloys based on it and some steel grades are usually used.

DIW - direct ink writing

Robocasting is an additive technology that implements layer-by-layer 3D printing of an object by extrusion of "ink" through the forming hole of the head of a 3D printer. "Ink" comes out of the nozzle in a liquid state, but immediately takes the desired shape due to its plasticity. This distinguishes robocasting from fusion modeling, since it does not require hardening or drying of the "ink", they immediately take the desired shape.

EBF - electron beam freeform fabrication

The manufacture of electronic forms in vacuum by electron beam melting, where a wire of one or another metal is used as a consumable material. It is carried out by analogy with EBM (electron beam melting), and the difference is that the metal is fed into the electron beam melting zone, as was said, in the form of a wire, not a powder.

SHS - selective heating sintering

Melting layers of thermoplastic or metal powder by thermal radiation. The peculiarity of the method is that all layers are baked immediately, since the radiation enters through a special mask, which directs heat to those points where it is necessary to fix the layer.

DED - directed energy deposition

One of the additive processes, according to which building material and energy for its fusion are supplied simultaneously to the place of construction of the product.

Powder material using a special device is spread out in a thin layer of the order of several tens of microns on the installation desktop in accordance with the obtained 3D model. And this happens almost simultaneously with sintering. In other words, a layer of building material is not formed here, but the material is fed to a specific place where energy is currently being supplied and where the process of forming the part is going on. Just as the welder introduces the material (electrode) to the place where the melt zone is formed due to the electric arc.

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ON THE POSSIBLE APPLICATION OF TUBERCLES ON PUMPING IMPELLER TO DECREASE HYDRAULIC RESISTANCE

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This article is devoted to the biomimicry engineering approaches. The main idea of a tubercle technology and its advantage are presented. The conveniences of the usage of pumping impellers with tubercles in the main pipeline transport were formulated. It was also suggested to make profound learning of application of the tubercle technology in rotating devices.

Life has existed on earth for billions of years and during that time life has learnt what works, what is appropriate here, and what lasts here. The idea is that we should be looking at living organisms, at these mentors, at these biological elders that have figured out how to create a sustainable world. Rather than inventing it from scratch we should take our cues from them. These organisms are the consummate engineers, they are consummate chemists and technologists. They have learned how to do it in the context. The core idea behind biomimicry is that the best ideas might not be ours, they might already have been invented.

Biomimicry is a practice that learns from and mimics the strategies found in nature to solve human design challenges. Biomimicry offers an empathetic, interconnected understanding of how life works and ultimately where we fit in. Biomimicry is an innovation inspired by the nature. It is a new discipline in which the people that make our world: chemists, architects, material scientists and product designers, draw engineering ideas from evolution.

Solutions to global challenges are all around us. Here can be shown some biomimicry examples [1].

The first instance is the shopping Eastgate centre located in Harare, Zimbabwe. Rather than using a traditional fuel-based air-conditioning system to regulate temperature within the building, the Eastgate Centre is designed to exploit more passive and energy-efficient mechanisms of climate control. This building saved 10% on costs up-front by not purchasing an air-conditioning system. Architect Mick Pearce worked with the construction company Arup to design the Eastgate Centre. Pearce was inspired by models of internal temperature regulation in termite mounds.

The more streamlined Shinkansen train not only travels more quietly, it now travels 10% faster and uses 15% less electricity. Eiji Nakatsu, an engineer with JR West and a birdwatcher, used his knowledge of the splashless water entry of kingfishers and silent flight of owls to decrease the sound generated by the trains. Kingfishers move quickly from air, a low-resistance (low drag) medium, to water, a high-resistance medium. The kingfisher's beak provides an almost ideal shape for such an impact.

EvoLogic developed and patented their Sweep Spread Carrier technology to manage the challenging conditions presented by ocean waters. They developed underwater sensors that can transmit frequencies similar to those emitted by dolphins. These sensors can be used to detect underwater earthquakes and therefore aid in tsunami warning systems. They can also be used for guiding ships. The device is based on eight years of research on the physics of dolphin communication. According to the website [2], dolphins and whales have adapted to the situation under water very well, communicating over long distances. They chirp and sing across a broad frequency bandwidth. This continuous change of frequencies not only serves to transmit information, but also to compensate for sources of interference such as echoes and noise.

As we can see biomechanics is able to be used in engineering industry and the main pipeline transport is not an exception as a complex of industrial dangerous objects which have to comply with the regulative requirements. The applications of pipelines span domestic, commercial and industrial purposes. Pipelines can be used to carry natural gas to homes, jet fuel to airports, and crude oil to refineries. The efficient transport of oil from production wells to oil refineries would be impossible without the use of an elaborate network of pipelines. This important midstream oil and gas component is also critical to the transfer of finished petroleum products to end-users or dependent industries. The use of expansive networks of pipelines ensures that domestic and industrial users have access to an uninterrupted flow of vital, energy generating gases and liquids. At the same time the industry is quite energy intensive. The main pipeline transport accounted for more than 4% of total world transportation energy consumption [3].

The facilities of pipeline transport can be divided into site and linear objects. The ideas of engineering bionics, in their turn, can be applied to both of them. As to the linear part of an oil transport the ideas of the Austrian inventor Viktor Schauberger [4,5], who was inspired by nature, are extremely important for the designers of modern gas pipelines, oil pipelines, water lines of hydro stations and all other types of pipeline transport. The thing is about using the phenomenon of swirling flow in pipelines, which is still not used as a positive effect. This approach can be used to reduce the dynamic resistance of main pipelines and water lines of hydroelectric power plants. Swirling the flow along the central axis with usage of elementary butterfly inserts or placing a curled spring inside the pipe can significantly reduce the energy costs of moving the contents of any transport pipe. The cost of upgrading the transport pipe with such inserts are minimal. At the moment, a huge part of the energy produced in the world is used precisely for pumping oil and gas products. Reducing these energy costs through trunk transportation, even if only by a few percent, can be of immense importance.

As to the site facilities they are presented by a reservoir park, an oil metering unit with filters, the main pumping and booster pumping stations, a pressure control unit and nodes with safety devices, the units for starting and receiving treatment devices, the technological pipelines with shutoff valves. Among them the most important and responsible part is the main pumps which require a lot of electrical energy in order to transform the rotation energy into the kinetic energy. In this case, the observation of nature can help to solve the engineering problem of improving the operating parameters of a pump.

Humpback whales are the only whales that have bumpy leading edges on their flippers and that can have some important engineering consequences. Scientists ran some fluid dynamic simulations of wings with tubercles and wings without tubercles. It turned out that the tubercles increased the lift and simultaneously reduced the drag. For a specialist who works on wing performance, that is a spectacular achievement to be able to increase the lift and reduce the drag at the same time. Further investigations followed with several researchers involved. Soon it became clear that these bumps give benefits. Tubercles focus the flow between the bumps. That focused flow helps to keep the flow attached to the wing and it also helps to isolate the lift in-between the tubercles on the reason of existence of a high-lift region [6].

Moreover, something that improved the performance in the water could also bring big benefits in the air. WhalePower Corporation is a Canadian company established in Toronto. It creates energy efficient rotating devices for different applications. The WhalePower team developed prototypes and tested them. As a result, there were 20 percent energy savings, improved efficiency, greater stability and greater durability. The tests have shown that blades with tubercles are more energy-efficient and quieter than standard blades [7].They literally revolutionize low speed performance far beyond any conventional blades. Scientific studies have established that the addition of tubercles to the leading edges of airfoils directly addresses the fundamental limitations of conventional aerodynamic performance:

- tubercle airfoils display enhanced stable lift;
- tubercles keep drag low even at high pitch angles;
- tubercles dramatically improve stall angle (pitch) performance;
- tubercle airfoils deliver stable operation over an unmatched range of pitch angles and better still, when they do stall, they stall gradually.

This technology can be used for such equipment as wind turbines, fans, compressors and pumps. We propose to apply this technology to the main oil pumps, which will lead not only to a quieter and more stable operation of the equipment, but also to a decrease in hydraulic resistance and a more rational use of energy. In pumps, tubercles can be made by cutting spades of pumping impeller with notches. It is difficult to talk about the exact numbers of hydraulic resistance at the moment. To do this, it is necessary to conduct research with special software programs and, possibly, in a wind tunnel, which demand many scientific resources.

The tubercle effect is a phenomenon where tubercles or large 'bumps' on the leading edge of an airfoil can improve its aerodynamics. Tubercle technology is both sustainable and unique. The technology is not very widespread in the world yet. However, it is proved that this technology has certain advantages in the operation of various kinds of equipment in different industries compared to blades with straight leading edge. Tubercles are a technology for the future.

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THE INFLUENCE OF OFFICE ENVIRONMENT ON THE HEALTH OF WORKERS

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The article analyzes a complex of indoor factors of office environment, which influence the health status of personnel, and the main measures to reduce the adverse impact of this factors.

In modern society office workers include the majority of professions and jobs combined with a set of features of the office environment. Nowadays, office work can range from secretarial, clerical, accounting, commercial, economic, informative, technological, research, legal to administrative, coordinating, management. In developed countries the number of office workers is constantly increasing, in the U.S. it is about 60% of the working population.

In the office environment many factors are harmful for the health of office workers. Among such factors are air environment factors, external physical factors, ergonomics, work intensity and tension, psychosocial factors.

Microclimate. Microclimatic discomfort is the most common problem in the office environment. To determine the necessary parameters of microclimate in offices the civilized world uses two major international standards ANSI/ASHRAE 55-2010 [3] and ISO 7730:2005 [9], which are based on mathematical models of Fanger, one of which was developed for general temperature comfort (PMV model) [6], and the model of "draughts" [7]. The PMV model considers the combined effects of four physical factors (temperature, air velocity, average radiation temperature, relative humidity) and two "human" factors (clothes and movement). Standard ISO 7730:2005 introduces 3 categories of micro climatic room conditions and allows (for category C) the presence in a room of up to 15% of people experiencing general temperature discomfort. Graphical representation of Fanger's "comfort zone" has become a part of the international standards, which are now complemented by a computer-based computation algorithm. The general micro climatic comfort is closely connected with local factors ("draughts", floor surface temperature, radiation temperature asymmetry, vertical temperature difference) which determine the local temperature comfort of dwelling houses, which is also taken into account in the standards.

Air dryness is one of the main factors affecting the overall well-being, eye and mucous membrane condition, upper respiratory tract and skin of office workers. Low humidity increases the survival rate of rhino-viruses and influenza viruses as well as increases the "hanging" period of dust in the room air preventing the aggregation of fine aerosols in the large aerosol. High air humidity promotes the growth of fungi, bacteria and some respiratory viruses. Both low and very high humidity are incompatible with the use of artificial ionization - heavy ions will form in dry air and charged hydro-aerosols in humid air.

Air mobility is one of the key factors determining micro climatic comfort as it affects skin temperature and humidity, convective and evaporate heat loss and generally thermal perception.

Aerosol pollution. In the air of office buildings there are aerosols (solid, liquid, colloidal; organic and non-organic composition; biological and non-biological nature) of varying degrees of dispersion. These are organic, mineral and synthetic fibres (furniture, carpets, clothes, fabrics, building materials), including paper and book dust, suspensions of household chemicals, copying and multiplying equipment, tobacco smoke, down and pollen of plants, microorganisms of bacterial, viral, fungal and other nature - living and in the form of spores; epidermis and hair of people, detritus and insect faeces, etc. One cubic centimeter of office air contains up to 5 million different particles.

Office dust is the most powerful sensitizer. Small particles of biological nature have the highest allergenicity. Exposure to paper dust of office workers in Finland has been shown to be associated with symptoms of eye irritation, upper respiratory tract, shortness of breath, skin inflammation, tonsils, middle ear infection and chronic bronchitis [10].

Chemical pollution (gases). Office gaseous toxicants can be divided into 2 main groups:

1) external genesis (entering the premises from the outside);

2) internal genesis (produced by construction and finishing materials, paints, furniture, equipment, cleaning, detergents, deodorizing agents, plants, etc.); in this group special attention should be paid to anthropotoxins (gases of human metabolism - carbon dioxide, nitrogen dioxide, hydrogen sulfide, acetone, ammonia, amines, phenols, etc.).

The first group includes primarily the combustion products of automotive fuels and industrial emissions from the street into buildings. These are many substances and compounds, both inorganic and organic, many of which are carcinogens. Radon and its decomposition products should be considered separately. Radon is a radioactive gas, a potential carcinogen; it stands alone because it has strictly specific features of penetration from the ground and accumulation in the lower floors of buildings, and requires special ventilation measures to reduce the dose load on people who come into contact with it.

The second group consists of volatile organic compounds represented by almost all classes of organic chemistry (aliphatic limit and unsaturated hydrocarbons, aromatic, terpene, halogen-containing, aldehydes, phenols, alcohols, acids, ketones, amines and other compounds), carbon dioxide and nitrogen oxides, tobacco smouldering gases, ozone emitted during the work of office equipment.

It should be taken into account that the majority of gases in office premises can usually be of "external" or "internal" origin, but at a sufficient distance from major highways and industrial objects, and with the proper organization of air intake for ventilation needs, the contribution of external sources to the overall air pollution of offices is not so significant.

Is also important to bear in mind that the perceived quality of air is not a universal measure of its harmful effects on health, the sensory reactions of the body to many toxicants are not quantitatively related to their toxicity. Some dangerous gases are not at all felt even at high concentrations (for example, radon, carbon dioxide, carbon monoxide have no odor), while the gases of human metabolism (for example, hydrogen sulfide or nitrogen dioxide), extremely unpleasant in the sensations, almost never reach in the real conditions of office premises of concentrations dangerous to health, which does not eliminate the need to purify the air from such gases in order to eliminate physiological and psychological discomfort in people.

Carbon dioxide (CO_2) is the main pollutant of office space; it is the main anthropotoxin and is often used as an indicator of total air pollution connected with the presence of people in enclosed spaces. Carbon dioxide in very low concentrations (from 0.2%) already causes a feeling of breathing discomfort, drowsiness, rapid fatigue, headaches.

Volatile Organic Compounds (VOCs) is a set of groups of organic compounds that differ in many aspects. The biological effect of many VOCs is additive, and often potentiated. Hundreds of organic compounds are present in office air, with concentrations of most substances relatively low (tens of μg/m3). The levels of many VOCs can increase dramatically, many times exceeding MPC, during commissioning of the building, repair of premises, replacement of coatings, installation of new furniture and equipment, cleaning and washing, and in other cases of household chemicals. High levels of some VOCs in office air can persist for months (and even years), for example, after repairs or new furniture.

Biological pollution. Among all the variety of organic particles present in the air of office premises, the greatest impact on human health are microorganisms - fungi, bacteria, viruses. A close link has been established between the presence of microorganisms in the air and various allergic reactions (allergic dermatitis, rhinitis, asthma, non-specific allergic alveolitis). Many types of allergies, respiratory diseases, "chronic fatigue syndrome" are associated with the presence of spores of fungi and mycotoxins in the air, which weaken the immune system and suppress the function of the alveolus.

Aerionization. Among the factors that have an adverse effect on the well-being and health of people staying indoors for a long time, the lack of aeroions is of particular importance. Availability of sufficient concentration of ions in the air is one of the most important aspects of air quality, comfortable and "healthy" environment in general. Practice shows that concentration traces of aeroions in offices are close to zero, artificial ionization of office premises is almost nowhere.

External physical factors. Among the physical factors of an office space, electromagnetic fields (EMF) and lighting should be evaluated first. The main sources of EMFs in office premises are electrical wiring inside buildings, distribution boards, elevator equipment, cell phone broadcast antennas on roofs or near buildings, fixed and mobile phones, computers, computer networks, office equipment, household appliances. The number of EMF sources is very high, as a result of which the personnel of a modern office is exposed to a multitude of electromagnetic radiation of different frequency ranges at the same time. Scientific data confirming unfavorable influence of EMFs on hemopoiesis, endocrine, central nervous system, anti-tumor protection are gradually accumulating.

Ergonomics, intensity and tension of work. The main ergonomic unfavorable factors in the office are the forced sitting work position, physical inactivity, many hours of visual tension in front of the monitor, static-dynamic hand tension working on the keyboard, etc.

The widespread usage of computers in offices has created the problem of monotony of physical, visual and mental stress due to high repeatability and reduced workspace movements. According to the literature, the frequency of musculoskeletal disorders among office workers can reach 80%. The most frequent are tendons of the wrist (computer mouse syndrome), elbow and shoulder joints. The imperfect design of tables and chairs provokes osteochon-

drosis, venous blood stagnation in the lower limbs. Prolonged work on the computer causes vision overload, which provokes "dry eye syndrome", leads to asthenopia, increases the risk of myopia and glaucoma. Long-term computer work increases the risk of cardiovascular, gastrointestinal, immune, endocrine and mental disorders.

Psychosocial factors. Unlike traditional domestic hygienic approach to assessment of harmful working conditions from the point of view of priority of parameters of production environment and labor process (physical severity and tension), psychosocial and organizational factors of health risk take one of the leading places in the scale of harmful working conditions of office workers abroad.

Due to the unfavourable psychological climate in the team and shortcomings in the organization of work, approximately one third of office workers often or very often experience emotional stress and anxiety at work, suffer from sleep disorders and depressive states. The main factors of professional risk of cardiovascular diseases in office workers are organizational factors, personnel management policy, content of work process [13].

Working at the computer implies constant concentration of attention, which often leads to the development of mental fatigue. Processing large amounts of information (especially in conditions of zeitnot) becomes an additional stressful factor. Such stress on the background of a pronounced computer, Internet and gaming addiction (growing in modern society) forms a prolonged exhaustion, reduced work rate, loss of concentration and self-control, apathy.

Among the main measures to reduce the adverse impact of office environment factors can be referred to:

1. Use of modern air conditioning and ventilation systems, ionizers and humidifiers, airing the room.

2. Use of special screens and protective filters against electromagnetic radiation, laying electrical wiring in shielding boxes. Interior and exterior walls finishing with shielding paint. Use of modern LCD monitors. Disconnection of unused electromagnetic radiation sources.

3. In addition to windows, light pipes and lanterns can be used as sources of natural light in office premises. Artificial and natural light sources should provide general, local and area lighting.

4. Rationalization of work and rest regimes, optimization of work rate, proper organization of the work place, allocation of separate rest zones. Application of industrial gymnastics. Occasionally, a gymnastic ball may be used as an alternative to a sitting chair.

5. Activities to improve the aesthetic conditions of work include a rational painting of the premises. Colour can affect a person's psyche and aesthetic perception. It not only changes the state of the visual analyzer, but also affects the well-being and mood, and therefore on the performance of the person.

6. Conducting workplace assessments, occupational health and safety instructions, and medical examinations.

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TWO-DIMENSIONAL INTEGRAL TRANSFORM WITH THE MEIJER G-FUNCTION IN THE KERNEL IN THE SPACE OF SUMMABLE FUNCTIONS

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Two-dimensional integral transformation with the Meijer G-function in the kernel in the space of summable functions on a domain $R_+^2 = R_+^1 \times R_+^1$ was studied. $\mathfrak{L}_{\overline{\nu},\overline{2}}$ - theory of a considered integral transformation was constructed. Conditions for the boundedness and one-to-one operator of such a transformation from one $\mathfrak{L}_{\overline{\nu},\overline{2}}$ - space to another were given, an analogue of the integration formula in parts was proved, various integral representations for the transformation under consideration were established. The results generalize the well know findings for corresponding one-dimensional integral transformation.

Keywords: *two-dimensional integral G- transformation, Meijer G- function, two-dimensional Mellin transformation, the space of integrable functions, fractional integrals and derivatives.*

Introduction. Let us consider the following integral G-transformation

$$(\mathrm{G}\,f)(\mathrm{x}) = \int_0^\infty \mathrm{G}_{\mathrm{p,q}}^{\mathrm{m,n}}\left[\mathrm{xt}\left|\begin{matrix}(\mathbf{a}_i)_{1,\mathrm{p}}\\(\mathbf{b}_j)_{1,\mathrm{q}}\end{matrix}\right.\right] f(\mathrm{t})\,d\,\mathrm{t} \quad (\mathrm{x} > 0)\,, \tag{1.1}$$

where $\mathrm{x} = (x_1, x_2) \in R^2$; $\mathrm{t} = (t_1, t_2) \in R^2$ - vectors, R^2 - two-dimensional Euclidean space; $\mathrm{x}\cdot\mathrm{t} = \sum_{k=1}^{2} x_k t_k$ – their scalar product, particularly $\mathrm{x}\cdot 1 = \sum_{k=1}^{2} x_k$ for $1 = (1,1)$; $\mathrm{x} > \mathrm{t}$ means $x_1 > t_1, x_2 > t_2$ and similarly for signs $\geq$, $<$, $\leq$; $\int_0^\infty := \int_0^\infty \int_0^\infty$; $N = \{1, 2, \ldots\}$ - space of natural numbers, $N_0 = N \cup \{0\}$, $N_0^2 = N_0 \times N_0$, $R_+^2 = R_+^1 \times R_+^1 = \{\mathrm{x} \in R^2, \mathrm{x} > 0\}$ [1, §28.4];

$\mathrm{m} = (m_1, m_2) \in N_0^2$ и $m_1 = m_2$; $\mathrm{n} = (n_1, n_2) \in N_0^2$ и $n_1 = n_2$;

$\mathrm{p} = (p_1, p_2) \in N_0^2$ и $p_1 = p_2$; $\mathrm{q} = (q_1, q_2) \in N_0^2$ и $q_1 = q_2$; $(0 \leq \mathrm{m} \leq \mathrm{q}, 0 \leq \mathrm{n} \leq \mathrm{p})$;

$\mathbf{a}_i = (a_{i_1}, a_{i_2})$, $1 \leq i \leq \mathrm{p}$, $a_{i_1}, a_{i_2} \in C$ $(1 \leq i_1 \leq p_1, 1 \leq i_2 \leq p_2)$;

$\mathbf{b}_j = (b_{j_1}, b_{j_2})$, $1 \leq j \leq \mathrm{q}$, $b_{j_1}, b_{j_2} \in C$ $(1 \leq j_1 \leq q_1, 1 \leq j_2 \leq q_2)$;

$k = (k_1, k_2) \in N = N \times N$ $(k_1 \in N, k_2 \in N)$ – index with $k! = k_1! k_2!$ and $|k| = k_1 + k_2$;

$D^k = \dfrac{\partial^{|k|}}{(\partial x_1)^{k_1} (\partial x_2)^{k_2}}$; $d\,\mathrm{t} = d\,t_1 \cdot d\,t_2$; $f(\mathbf{t}) = (t_1, t_2)$; $\mathrm{G}_{\mathrm{p,q}}^{\mathrm{m,n}}\left[\mathrm{xt}\left|\begin{matrix}(\mathbf{a}_i)_{1,\mathrm{p}}\\(\mathbf{b}_j)_{1,\mathrm{q}}\end{matrix}\right.\right]$ - function such as:

$$\mathrm{G}_{\mathrm{p,q}}^{\mathrm{m,n}}\left[\mathrm{xt}\left|\begin{matrix}(\mathbf{a}_i)_{1,\mathrm{p}}\\(\mathbf{b}_j)_{1,\mathrm{q}}\end{matrix}\right.\right] = \prod_{k=1}^{2} \mathrm{G}_{p_k,q_k}^{m_k,n_k}\left[x_k t_k \left|\begin{matrix}(a_{i_k})_{1,p_k}\\(b_{j_k})_{1,q_k}\end{matrix}\right.\right], \tag{1.2}$$

which is a product of Meijer G- functions $G_{p,q}^{m,n}[z]$ [2, chapter 6].

This paper is devoted to the study of transformation (1.1) in weighted spaces $\mathfrak{L}_{\overline{\nu},\overline{2}}$, $\overline{\nu} = (\nu_1, \nu_2) \in R^2$ $(\nu_1 = \nu_2)$, $\overline{2} = (2,2)$, integrable functions $f(\mathbf{x}) = f(x_1, x_2)$ on R_+^2, for which $\|f\|_{\overline{\nu},\overline{2}} < \infty$, where

$$\|f\|_{\overline{\nu},\overline{2}} = \left\{\int_{R_+^1} x_2^{\nu_2 \cdot 2 - 1}\left[\int_{R_+^1} x_1^{\nu_1 \cdot 2 - 1} |f(x_1, x_2)|^2 dx_1\right] dx_2\right\}^{1/2} < \infty\,.$$

The conditions of boundedness and mutual uniqueness of the transformation operator (1.1) from one space $\mathfrak{L}_{\overline{\nu},\overline{2}}$ to another are given, an analogue of the integration formula by parts is proved, various integral representations for the transformation under consideration are established. The results obtained generalize those obtained earlier for the corresponding one-dimensional G – transformation [2, ch. 6].

Preliminary information. For integer non-negative m, n, p, q $(0 \le m \le q, 0 \le n \le p)$, for $a_i, b_j \in C$ with *C*, the set of complex numbers $(1 \le i \le p, 1 \le n \le q)$ Meijer *G- function is a function defined via the Mellin-Barnes type integral*:

$$G_{p,q}^{m,n}\left[z \left| \begin{matrix} (a)_p \\ (b)_q \end{matrix} \right. \right] = G_{p,q}^{m,n}\left[z \left| \begin{matrix} a_1,...,a_p \\ b_1,...,b_q \end{matrix} \right. \right] = G_{p,q}^{m,n}\left[z \left| \begin{matrix} (a_i)_{1,p} \\ (b_j)_{1,q} \end{matrix} \right. \right] = \frac{1}{2\pi i}\int_L \mathcal{G}_{p,q}^{m,n}(s) z^{-s} ds, z \ne 0, \quad (2.1)$$

where

$$\mathcal{G}_{p,q}^{m,n}\left[\begin{matrix} (a_i)_{1,p} \\ (b_j)_{1,q} \end{matrix} \middle| s \right] = \mathcal{G}_{p,q}^{m,n}\left[\begin{matrix} (a)_p \\ (b)_q \end{matrix} \middle| s \right] = \frac{\prod_{j=1}^{m}\Gamma(b_j+s)\prod_{i=1}^{n}\Gamma(1-a_i-s)}{\prod_{i=n+1}^{p}\Gamma(a_i+s)\prod_{j=m+1}^{q}\Gamma(1-b_j-s)}. \quad (2.2)$$

Here *L* is specially selected endless contour leaving the poles $s = -b_j - k$ $(j = 1,2,...,m; k = 0,1,2,...)$ on the left, and the poles $s = 1 - a_j + k$ $(j = 1,2,...,n;\ k = 0,1,2,...)$ – on the right, and the empty products, if they occur, are taken to be one. For more details on the theory of the *G*-function (2.1), see [2, ch. 6].

G - transformation is called the integral transformation [2, formula (6.1.1)]

$$(Gf)(x) = \int_0^\infty G_{p,q}^{m,n}\left[xt \left| \begin{matrix} (a_i)_{1,p} \\ (b_j)_{1,q} \end{matrix} \right. \right] f(t)dt, \quad (2.3)$$

containing Meijer G - function (2.1) in the kernel.

Introduce the space $\mathfrak{L}_{\nu,r}$ of Lebesgue measurable, generally speaking, complex-valued functions f in $\mathrm{R}_+ = (0,\infty)$, for which $\|f\|_{\nu,r} < \infty$, where

$$\|f\|_{\nu,r} = \left(\int_0^\infty \left| t^\nu f(t) \right|^r \frac{dt}{t} \right)^{\frac{1}{r}} \quad (1 \le r < \infty, \nu \in \mathrm{R}), \quad (2.4)$$

Notice that

$$\|f\|_{\mathfrak{L}_{\nu,r}} = \|f\|_{L_r(R_+^1, t^{\nu r-1})}, (1 \le r < \infty, \nu \in \mathrm{R}).$$

For the function $f \in \mathfrak{L}_{\nu,r}$ $(1 \le r \le 2)$ *Mellin* transformation $\mathfrak{M}f$ is determined by equality [2], [3]

$$(\mathfrak{M}f)(s) = \int_{-\infty}^{+\infty} f(e^\tau) e^{s\tau} d\tau \quad (s = \nu + it; \nu, t \in \mathrm{R}). \quad (2.5)$$

If $f \in \mathfrak{L}_{\nu,r} \bigcap \mathfrak{L}_{\nu,1}$, $\mathrm{Re}(s) = \nu$, then (2.5) coincides with the usual Mellin transformation:

$$(\mathfrak{M}f)(s) = f^*(s) = \int_0^{+\infty} f(t) t^{s-1} dt. \quad (2.6)$$

Two-dimensional Mellin transformation of the function $f(\mathrm{x}) = f(x_1, x_2)$, $x_1 > 0, x_2 > 0$, is defined by formula [3, formula1.4.42]:

$$(\mathfrak{M}f)(\mathbf{s}) = f^*(\mathbf{s}) = \int_{R_{++}^2} f(\mathrm{t})\, \mathrm{t}^{\mathbf{s}-1}\, d\,\mathrm{t}, \quad (2.7)$$

$R_{++}^2 = \left\{ \mathbf{t} = (t_1, t_2) \in R^2 : t_j > 0 (j = 1,2) \right\}$, $\mathbf{s} = (s_1, s_2), s_j \in C$ $(j = 1,2)$.

Inverse Mellin transformation for $\mathrm{x} = (x_1, x_2) \in R_{++}^2$ is given by formula [3, formula (1.4.43)]:

$$(\mathfrak{M}^{-1}g)(\mathrm{x}) = \mathfrak{M}^{-1}\left[g(\mathbf{s}) \right](\mathrm{x}) \frac{1}{(2\pi i)^2} \int_{\gamma_1 - i\infty}^{\gamma_1 + i\infty} \int_{\gamma_2 - i\infty}^{\gamma_2 + i\infty} \mathrm{x}^{-\mathbf{s}}\, g(\mathbf{s}) d\mathbf{s},\ \gamma_j = \mathrm{Re}(s_j)\ (j = 1, 2). \quad (2.8)$$

The formula of Mellin transformation from G - transformation (2.3) for "enough good" functions f has the form [1, (6.1.2)]

$$(\mathfrak{M}\ Gf)(s) = \mathcal{G}_{p,q}^{m,n}\left[\begin{matrix}(a_i)_{1,p}\\(b_j)_{1,q}\end{matrix}\middle| s\right](\mathfrak{M}f)(1-s)\,, \tag{2.9}$$

where $\mathcal{G}_{p,q}^{m,n}(s)$ are given (2.2).

We will need the following constants defined through the parameters of the G-function (2.1) [1, formulas (6.1.5) – (6.1.11)]:

$$\alpha = \begin{cases} -\min\limits_{1\le j\le m}[\mathrm{Re}(b_j)], & m>0,\\ -\infty, & m=0,\end{cases} \qquad \beta = \begin{cases} 1-\max\limits_{1\le i\le n}[\mathrm{Re}(a_i)], & n>0,\\ \infty, & n=0;\end{cases} \tag{2.10}$$

$$a^* = 2(m+n)-p-q\,; \tag{2.11}$$

$$\Delta = q-p\,; \tag{2.12}$$

$$a_1^* = m+n-p\,;\ a_2^* = m+n-q\,; \tag{2.13}$$

$$\mu = \sum_{j=1}^{q} b_j - \sum_{i=1}^{p} a_i + \frac{p-q}{2}\,. \tag{2.14}$$

We call the exceptional set of $\mathcal{E}_{\mathcal{G}}$ the set $\mathcal{G}(s)$, is defined in (2.2), of real numbers ν such that $\alpha<1-\nu<\beta$ and $\mathcal{G}(s)$ has a zero on the line $\mathrm{Re}(s)=1-\nu$.

$\mathfrak{L}_{\bar{\nu},\bar{2}}$ - теория *G*- преобразования

Introduce a two-dimensional analogue of the function (2.2):

$$\bar{\mathcal{G}}_{\mathrm{p,q}}^{\mathrm{m,n}}(\mathbf{s}) \equiv \bar{\mathcal{G}}_{\mathrm{p,q}}^{\mathrm{m,n}}\left[\begin{matrix}(\mathbf{a}_i)_{1,\mathrm{p}}\\(\mathbf{b}_j)_{1,\mathrm{q}}\end{matrix}\middle|\mathbf{s}\right] = \prod_{k=1}^{2}\mathcal{G}_{p_k,q_k}^{m_k,n_k}\left[\begin{matrix}(a_{i_k})_{1,p_k}\\(b_{j_k})_{1,q_k}\end{matrix}\middle| s_k\right]. \tag{3.1}$$

We call *the exceptional set* of $\mathcal{E}_{\bar{\mathcal{G}}}$ of the function $\bar{\mathcal{G}}_{\mathrm{p,q}}^{\mathrm{m,n}}(\mathbf{s})$ the set of vectors $\bar{\nu}=(\nu_1,\nu_2)\in R^2\ \ (\nu_1=\nu_2)$ such that $\alpha_1<1-\nu_1<\beta_1$, $\alpha_2<1-\nu_2<\beta_2$, and the functions type (2.2) $\mathcal{G}_{p_1,q_1}^{m_1,n_1}(s_1)$, $\mathcal{G}_{p_2,q_2}^{m_2,n_2}(s_2)$ have a zero on the line $\mathrm{Re}(s_1)=1-\nu_1$, $\mathrm{Re}(s_2)=1-\nu_2$, respectively.

Apply two-dimensional Mellin transformation (2.7) to G - transformation (1.1) and taking into account (2.9), we get the following formula for "enough good" functions f:

$$\left(\mathfrak{M}\,\mathrm{G}\,f\right)(\mathbf{s}) = \bar{\mathcal{G}}_{\mathrm{p,q}}^{\mathrm{m,n}}\left[\begin{matrix}(\mathbf{a}_i)_{1,\mathrm{p}}\\(\mathbf{b}_j)_{1,\mathrm{q}}\end{matrix}\middle|\mathbf{s}\right](\mathfrak{M}f)(1-\mathbf{s})\,, \tag{3.2}$$

where $\bar{\mathcal{G}}_{\mathrm{p,q}}^{\mathrm{m,n}}(\mathbf{s})$ is given (3.1).

To formulate statements representing the $\mathfrak{L}_{\bar{\nu},\bar{2}}$ theory of G-transformation (1.1) we need the following two-dimensional analogues of constants (2.10) – (2.14):

$$\alpha_1 = \begin{cases} -\min\limits_{1\le j_1\le m_1}\left[\mathrm{Re}(b_{j_1})\right], & m_1>0,\\ -\infty, & m_1=0,\end{cases},\ \beta_1 = \begin{cases} 1-\max\limits_{1\le i_1\le n_1}\left[\mathrm{Re}(a_{i_1})\right], & n_1>0,\\ \infty, & n_1=0,\end{cases} \tag{3.3}$$

$$\alpha_2 = \begin{cases} -\min\limits_{1\le j_2\le m_2}\left[\mathrm{Re}(b_{j_2})\right], & m_2>0,\\ -\infty, & m_2=0,\end{cases},\ \beta_2 = \begin{cases} 1-\max\limits_{1\le i_2\le n_2}\left[\mathrm{Re}(a_{i_2})\right], & n_2>0,\\ \infty, & n_2=0,\end{cases} \tag{3.4}$$

$$a_1^* = 2(m_1+n_1)-p_1-q_1,\ a_2^* = 2(m_2-n_2)-p_2-q_2\,; \tag{3.5}$$

$$\Delta_1 = q_1-p_1, \Delta_2 = q_2-p_2;\ (18) \tag{3.6}$$

$$\mu_1 = \sum_{j=1}^{q_1} b_{j_1} - \sum_{i=1}^{p_1} a_{i_1} + \frac{p_1-q_1}{2},\quad \mu_2 = \sum_{j=1}^{q_1} b_{j_2} - \sum_{i=1}^{p_1} a_{i_2} + \frac{p_2-q_2}{2},\ (21) \tag{3.7}$$

Denote by $[X,Y]$ the set of bounded linear operators acting from a Banach space X into a Banach space Y.

From [2, theorem 3.6 and 3.7, theorems 6.1 and 6.2, corollary 6.1.1 and 6.2.1], representation (3.2) and direct verification we get the $\mathfrak{L}_{\overline{\nu},\overline{2}}$ - theory of G- transformation (1.1).

Theorem 1. *We suppose that*

$$\alpha_1 < 1-\nu_1 < \beta_1,\ \alpha_2 < 1-\nu_2 < \beta_2,\ \nu_1 = \nu_2, \tag{3.8}$$

and either of the conditions:

$$a_1^* > 0, a_2^* > 0 \tag{3.9}$$

or

$$a_1^* = 0, a_2^* = 0, \quad \Delta_1[1-\nu_1] + \mathrm{Re}(\mu_1) \le 0, \quad \Delta_2[1-\nu_2] + \mathrm{Re}(\mu_2) \le 0. \tag{3.10}$$

holds.

Then we have the results:

a) There is a one-to-one transformation $\mathrm{G} \in [\mathfrak{L}_{\overline{\nu},\overline{2}}, \mathfrak{L}_{1-\overline{\nu},\overline{2}}]$ *such that (*3.2*) holds for* $f \in \mathfrak{L}_{\overline{\nu},\overline{2}}$ *and* $\mathrm{Re}(\mathbf{s}) = 1-\overline{\nu}$.

If $a_1^* = 0,\ a_2^* = 0, \quad \Delta_1[1-\nu_1] + \mathrm{Re}(\mu_1) = 0, \quad \Delta_2[1-\nu_2] + \mathrm{Re}(\mu_2) = 0$ *u* $\overline{\nu} \notin \mathcal{E}_{\overline{G}}$, *then the transformation* G *maps* $\mathfrak{L}_{\overline{\nu},\overline{2}}$ *onto* $\mathfrak{L}_{1-\overline{\nu},\overline{2}}$.

b) If $f \in \mathfrak{L}_{\overline{\nu},\overline{2}}$ *u* $g \in \mathfrak{L}_{\overline{\nu},\overline{2}}$, *then the relation holds*

$$\int_0^\infty f(\mathrm{x})(\mathrm{G}\,g)(\mathrm{x})d\,\mathrm{x} = \int_0^\infty (\mathrm{G}\,f)(\mathrm{x})g(\mathrm{x})d\,\mathrm{x}. \tag{3.11}$$

c) Let $\overline{\lambda} = (\lambda_1,\ \lambda_1) \in C^2$ *and* $f \in \mathfrak{L}_{\overline{\nu},\overline{2}}$. *If* $\mathrm{Re}(\overline{\lambda}) > -\overline{\nu}$, *then the transformation (1.1) is given by*

$$(\mathrm{G}\,f)(\mathrm{x}) = \mathrm{x}^{-\overline{\lambda}} \frac{d}{d\,\mathrm{x}} \mathrm{x}^{\overline{\lambda}+1} \int_0^\infty G^{\mathrm{m,n+1}}_{\mathrm{p+1,q+1}}\left[\mathrm{xt}\left|\begin{matrix}-\overline{\lambda}, (\mathbf{a}_i)_{1,\mathrm{p}} \\ (\mathbf{b}_j)_{1,\mathrm{q}}, -\overline{\lambda}-1\end{matrix}\right.\right] f(\mathrm{t})d\,\mathrm{t}, \tag{3.12}$$

(26)

when $\mathrm{Re}(\overline{\lambda}) < -\overline{\nu}$ *is given by*

$$(\mathrm{G}\,f)(\mathrm{x}) = -\mathrm{x}^{-\overline{\lambda}} \frac{d}{d\,\mathrm{x}} \mathrm{x}^{\overline{\lambda}+1} \int_0^\infty G^{\mathrm{m+1,n}}_{\mathrm{p+1,q+1}}\left[\mathrm{xt}\left|\begin{matrix}(\mathbf{a}_i)_{1,\mathrm{p}}, -\overline{\lambda} \\ -\overline{\lambda}-1, (\mathbf{b}_j)_{1,\mathrm{q}}\end{matrix}\right.\right] f(\mathrm{t})d\,\mathrm{t}. \tag{3.13}$$

d) The transformation $\mathrm{G}\,f$ *is independent of* $\overline{\nu}$ *in the sense that, if* $\overline{\nu}$ *and* $\tilde{\overline{\nu}}$ *satisfy* (3.8) *and either (3.9) or (3.10), and if the transformations* $\mathrm{G}\,f$ *and* $\tilde{\mathrm{G}}\,f$ *are defined in* $\mathfrak{L}_{\overline{\nu},\overline{2}}$ *and* $\mathfrak{L}_{\tilde{\overline{\nu}},\overline{2}}$, *respectively, by* (3.2), *then* $\mathrm{G}\,f = \tilde{\mathrm{G}}\,f$ *for* $f \in \mathfrak{L}_{\tilde{\overline{\nu}},\overline{2}} \cap \mathfrak{L}_{\overline{\nu},\overline{2}}$.

e) If $a_1^* > 0, a_2^* > 0$ *or if* $a_1^* = 0, a_2^* = 0, \ \Delta_1[1-\nu_1] + \mathrm{Re}(\mu_1) < 0, \ \Delta_2[1-\nu_2] + \mathrm{Re}(\mu_2) < 0$, *then* $\mathrm{G}\,f$ *is given in (1.1) for* $f \in \mathfrak{L}_{\overline{\nu},\overline{2}}$.

Corollary 1. Let $\alpha_1 < \beta_1, \alpha_2 < \beta_2$ *and let one of the following conditions hold:*

a) $a_1^* > 0, a_2^* > 0$;

b) $a_1^* = 0, a_2^* = 0, \Delta_1 > 0, \Delta_2 > 0$ *u* $\alpha_1 < -\dfrac{\mathrm{Re}(\mu_1)}{\Delta_1}, \alpha_2 < -\dfrac{\mathrm{Re}(\mu_2)}{\Delta_2}$;

c) $a_1^* = 0, a_2^* = 0, \Delta_1 < 0, \Delta_2 < 0$ *u* $\beta_1 > -\dfrac{\mathrm{Re}(\mu_1)}{\Delta_1}, \beta_2 > -\dfrac{\mathrm{Re}(\mu_2)}{\Delta_2}$;

d) $a_1^* = 0, a_2^* = 0, \Delta_1 = 0, \Delta_2 = 0$ *u* $\mathrm{Re}(\mu_1) \le 0, \mathrm{Re}(\mu_2) \le 0$.

Then the G-transformation can be defined on $\mathfrak{L}_{\overline{\nu},\overline{2}}$ *with* $\alpha_1 < \nu_1 < \beta_1, \alpha_1 < \nu_2 < \beta_1,\ \nu_1 = \nu_2$.

Theorem 2. *Let*

$$\alpha_1 < 1-\nu_1 < \beta_1,\ \alpha_2 < 1-\nu_2 < \beta_2,\ \nu_1 = \nu_2,$$

and either of the following conditions holds :

a) $a_1^* > 0, a_2^* > 0$;

b) $a_1^* = 0,\ a_2^* = 0,\quad \Delta_1(1-\nu_1)+\mathrm{Re}(\mu_1) < 0,\quad \Delta_2(1-\nu_2)+\mathrm{Re}(\mu_2) < 0$.

Then for $f \in \mathfrak{L}_{\overline{\nu},\overline{2}}$ *and* $\mathrm{x} > 0$ $\left(\mathrm{G}\, f\right)(\mathrm{x})$ *is given in (1.1)*

Corollary 2. *Let* $\alpha_1 < \beta_1, \alpha_2 < \beta_2$ *and let one of the following conditions hold:*

a) $a_1^* > 0, a_2^* > 0$;

b) $a_1^* = 0, a_2^* = 0, \Delta_1 > 0, \Delta_2 > 0$ *u* $\alpha_1 < -\dfrac{\mathrm{Re}(\mu_1)+1}{\Delta_1}, \alpha_2 < -\dfrac{\mathrm{Re}(\mu_2)+1}{\Delta_2}$;

c) $a_1^* = 0, a_2^* = 0, \Delta_1 < 0, \Delta_2 < 0$ *u* $\beta_1 > -\dfrac{\mathrm{Re}(\mu_1)+1}{\Delta_1}, \beta_2 > -\dfrac{\mathrm{Re}(\mu_2)+1}{\Delta_2}$;

d) $a_1^* = 0, a_2^* = 0, \Delta_1 = 0, \Delta_2 = 0$ *u* $\mathrm{Re}(\mu_1) \le 0, \mathrm{Re}(\mu_2) \le 0$.

Then G-transformation can be defined by (1.1) in $\mathfrak{L}_{\overline{\nu},\overline{2}}$ *with* $\alpha_1 < \nu_1 < \beta_1, \alpha_1 < \nu_2 < \beta_1,\ \nu_1 = \nu_2$.

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UDC 621.37/39(075.8)

CHARACTERISTICS OF FIBER-OPTIC COMMUNICATION SYSTEM RECEIVERS

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This article discusses fiber-optic receivers used in fiber-optic communication systems. Their characteristics are considered. The reasons for errors are analyzed.

The main task of the optical receiver is to convert the modulated light stream coming from the optical fiber into a copy of the original electrical signal sent to the transmitter. As a detector, the receiver usually uses a PIN or avalanche photodiode, which is mounted on an optical connector (similar to that used for light sources). Photodiodes usually have a fairly large sensor element (a few micrometers in diameter), so the requirements for positioning the optical fiber are not as strict as for transmitters. The intensity of the radiation coming out of the optical fiber is quite small, and high-gain internal amplifiers are installed in the optical receivers. Therefore, it is important to use receivers only with the fiber size for which they are intended, otherwise there may be an overload of the amplifier [1].

Recently, various new modulation formats have been intensively studied in scientific laboratories. Receivers for such systems have a more complex structure, but they are part of the receivers of binary amplitude-modulated signals.

The most important performance characteristic of the current information transmission system that determines the communication quality is the error rate. The error coefficient is determined by the formula:

$$K_{er} = N_{er}/N, \quad (1)$$

where N is the total number of characters transmitted over the measurement interval; N_{er} – the number of characters received incorrectly over the measurement interval.

The reason for errors is the presence of noise. Indeed, in real communication systems, the photocurrent values corresponding to both 1 and 0 fluctuate over time due to the presence of noise. Such temporary current fluctuations can lead to erroneous interpretation of the information symbol.

The nature of errors in binary digital communication systems with amplitude modulation is explained in Fig. 1.

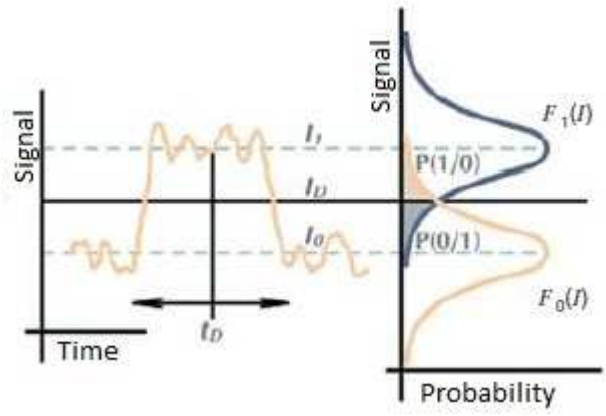

Figure 1. – Electrical information signal with noise at the input of the comparison circuit, zero level I_0, unit level I_1, comparison level I_D, clock duration t_D (left) and probability distributions of the measured signal current values for 1 and 0 (right). The shaded areas show error probabilities: P (1/0) – the probability of interpreting 0 as 1; P (0/1) – the probability of interpreting 1 as 0

Due to the presence of noise, the measured current value differs from its exact value. The spread of measured current values when transferring logical 1 and 0 is described by the corresponding functions F1(I) and F0(I) of the probability distribution. On the right (Fig.1) the graphs of functions F1(I) and F0(I) are shown as upper and lower curves, respectively. As you can see from the figure, the graphs of these functions intersect the line

corresponding to the I_D comparison voltage level. This means that there is some probability of an incorrect interpretation of the received signal. Such probability is usually very small, but different from 0. The probability P (1/0) of an erroneous interpretation of 0 as 1 is determined by the area under the part of the distribution function F0(I) cut off by the I_D comparison level. Similarly, the probability P (0/1) of an erroneous interpretation of 1 as 0 is determined by the area under the part of the distribution function F1(I) that is cut off by the I_D comparison level.

If the transmission probability is equal to 0 and 1, the error coefficient is determined by a simple expression:

$$K_{er} = 1 / 2 (P (1/0) + P (0/1)), \quad (2)$$

Under the assumption of a Gaussian noise distribution with zero average intensity values and standard deviations σ1, σ2 for 1 and 0, respectively, the error coefficient is determined by the expression:

$$K_{er}(Q) = \frac{1}{\sqrt{2\pi}} \int_{Q}^{\infty} dx \exp(-\frac{x^2}{2}) = \frac{1}{2} erfc(\frac{Q}{\sqrt{2}}), \quad (3)$$

Where $Q = \frac{I1 - I2}{\sigma 1 + \sigma 2}$ is an indicator of the quality of the received signal [2].

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UDC 621.01

CLASSIFICATION OF FUNDAMENTAL TECHNOLOGICAL MODULES

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The classification and coding of fundamental technological modules during their unification, which are the basis for modern methods of digital production preparation, are proposed.

Description of the product design with a variety of modules. Engineering products are distinguished by a huge, continuously growing variety. Therefore, in these conditions, it is important to build a single database of product designs and their parts. The existence of a single base allows you to manage the development of product designs, minimize duplication in the creation of new designs and effectively develop technologies for their manufacture [1, 2].

To solve these problems, first it is necessary to obtain information on the characteristics of product designs (PD). The traditional description of the PD includes an assembly drawing, detail drawings, an explanatory note and does not meet modern requirements. In the drawings, significant parts of the numerous characteristics are presented in an implicit, weakly formalized form. Therefore, in the part drawing the number of surfaces, their functional purpose and the connection between them are not indicated. To eliminate the noted deficiencies, a PD description with the help of set of modules is proposed [3].

Let's take a module of parts (MP) of a product as PD modules and a module of surfaces (MS) as module of part of surface. The process of joining together MP parts and MS detail surfaces is determined by the stage of the product's life cycle since at different stages MP and MS perform different roles and are represented by a different composition respectively of parts and surfaces.

Thus, the product can be represented by a set of MP, and if all details replace the sets of MS, then PD can be represented by a set of MS. The modular structure of PD can be described by a graph of a hierarchical structure, the top of which is the basic detail. For example, in a metal cutting machine, the base part is a bed.

PD graph is constructed in the following way. First, we determine the basic part of the product and take it as the top of the graph, then we establish the elements of the PD (MP or parts) installed on the base part, after that the elements installed on the elements of the previous level are specified. The graph is constructed in this way up to the last item.

As a result, we get a graph, an example of which is shown in Figure 1.

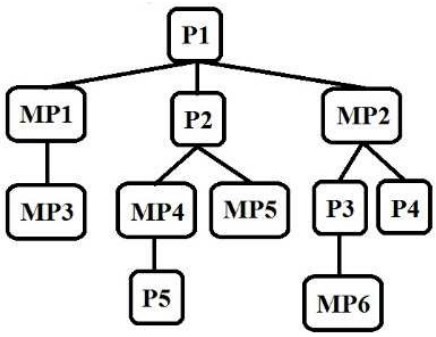

Figure 1. – Product graph

Now, to describe the PD, we'll use such characteristics of the graph as numbers of elements, levels, nodes, nodes at each level, and branches.

The edges of the graph indicate the coordinating dimensions connecting the sets of bases parts, which are the main auxiliary bases.

The main bearing surfaces are the surfaces by which the part is installed into the product, and the auxiliary based surfaces are the surfaces on which other parts are mounted on the part.

The graph node has information about the PD element characteristics. For example, if a node reflects a detail, then its mass, overall dimensions, material, etc. are indicated. It is advisable to show the characteristics of the nodes in tabular form.

Depending on the level of the PD detail description, graphs of three levels can be built. They are MP and parts not included in their composition (first level), details (second level), MS (third level).

Similarly, the surface of the part is intended to perform, respectively, some service functions. These modules are denoted as MPF and MSF.

According to the functional feature, MPF and MSF should be divided into functional technological modules (MFT, MST) and service functional modules (MFS, MSS).

MFT is a PD part with which the PD performs its official function;

MFS is a PD part which allows the MFT to fulfill its purpose.

MST is a combination of a part surfaces, with the help of which the part performs the corresponding service function;

MSS is a combination of surfaces with the help of which MST fulfills its purpose.

Combination of MPF parts and the MSF part surfaces on a functional basis ensures the unambiguity of their definitions.

For example, in the case of a lathe a spindle assembly with a chuck (MFT1) for setting the workpiece and a tool holder (MFT2) for installing the tool act as a MFT.

To ensure the law of relative motion of the MFT1 and MFT2, the gear box MFS1, the gear box MFS2, and the engine MFS3 serve as the MFS.

In the case of an MTF vehicle, a body for placing a load (MFT1) and a chassis (MFT2) to ensure the movement of the vehicle are used, and as an MFS are an engine (MFS1), a transmission (MFS2) and other devices that ensure that the MFT performs its functions.

As for the part, it is generally needed for the product to perform the workflow and is used for installing other parts on it. Therefore, the base modules and work surface modules act as MST for the part.

For example, in a gear wheel, a set of side surfaces of the teeth for transmitting torque and a second MST — a set of bases: an end, a hole, and a side surface of the key groove for mounting a gear in the product act as one MST.

To fulfill its official purpose, the listed MST are combined into a part with the help of connecting surfaces united in MSS.

Classification of functional technology modules. For the presentation of the details of the MSF set, the following classification is proposed.

By their service, all MSF can be divided into three classes: basing (MSB), working (MSW) and connecting (MSC). Such a division of the MSF gives them an unambiguous definition and is the main difference and advantage of this classification.

The next step in the development of the classification of the MSF is the division of each class into subclasses, groups and subgroups. Therefore, further each MSF class should be subdivided according to the constructive and geometrical features.

In Fig.2. a classification of MSF types is given, from which it follows that it contains 26 types of MSF, 14 of which are of MSBs type and 6 are of MSW and MSC types. Their examples are shown in Fig.3.

For the top of the graph we take the PSB, which acts as a set of main bases for the part. At the second level MSF are located, the design base of which is the first MSF level. At the next level, there are MSFs, the design base of which is the MPF of the previous level, and this continues to the last MSF details.

The graph of the MSF details shows its structure at the modular level, the MSF composition and the level of the design complexity. On the edges of the graph the MSF coordinating dimensions tolerances can be indicated.

Conclusion. The description of a product structure with the help of a hierarchical graph at the first level makes it possible to identify functional technological modules of the product and, on their basis, to construct a unified classification of products as exploitation objects. Representation of parts by a set of modules allows to identify modules of based, working and connecting surfaces and on their basis to build a single classification of parts, focused on different stages of the product life cycle.

The proposed unified methodological base allows you to manage the development of product designs, eliminate duplication in the creation of new designs and effectively develop technologies for their manufacture.

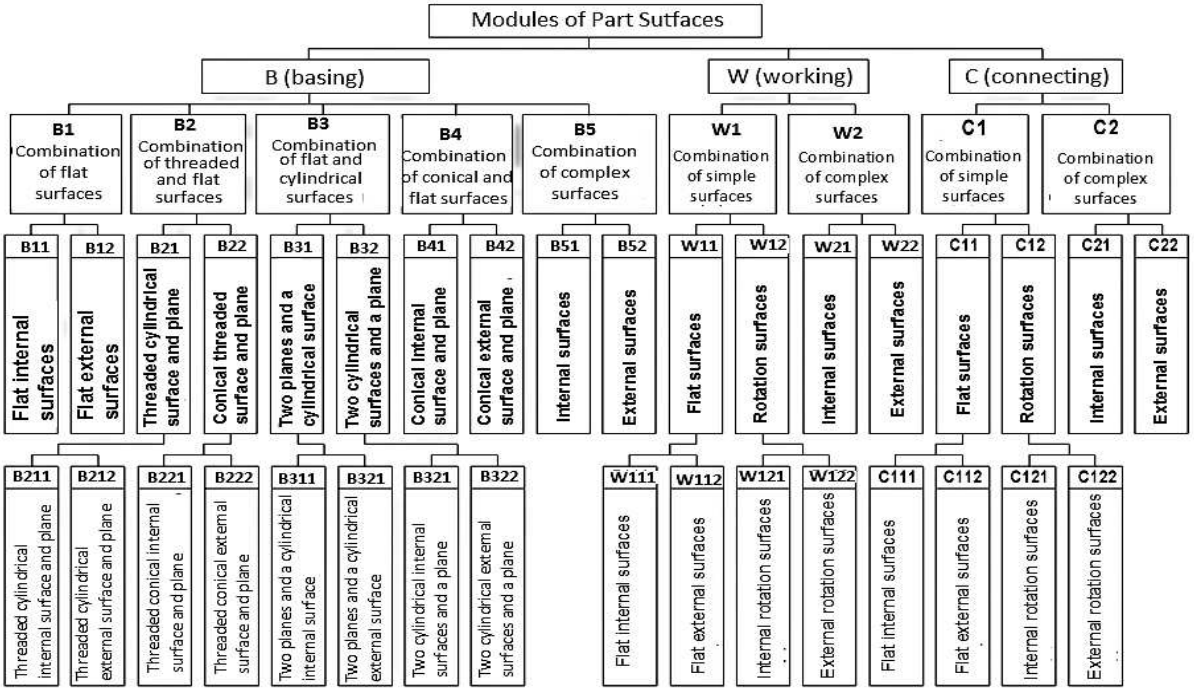

Figure 2. – Classification of MSP

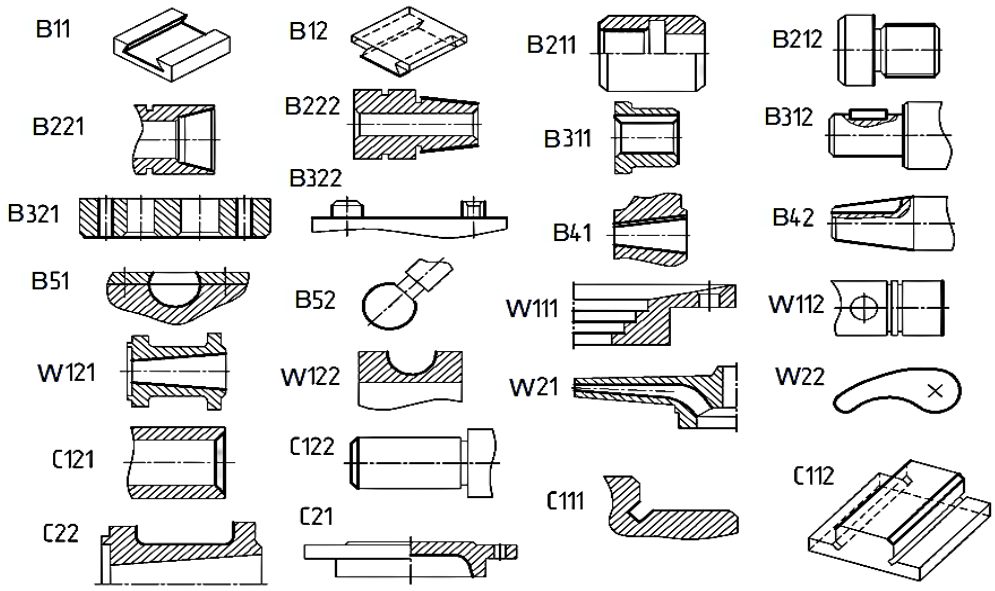

Figure 3. – Examples of constructive design types of MSF

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UDK 621.01

DEVELOPMENT OF BLOCK-MODULAR CUTTING TOOLS FOR CNC MACHINES

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Modular tool systems, including the types of tool modules, mechanisms for fastening of modules, tool systems for multi-purpose processing have been analysed, which has allowed us to determine current trends in the design and production of tool systems. The design schemes of various types of block-modular cutting tools are considered and the designs of a cutter and countersink for their application on CNC machines "Robodril" are proposed.

Introduction. A large reserve for improving the efficiency of mechanical engineering is put in creating a rational system of tool support for domestic enterprises based on the experience of leading foreign companies, such as Sandvik Coromant (Sweden), Mitsubishi (Japan), Iscar (Israel), Hertel (Germany), and others.[1] The systems proposed by the companies provide for the design of a wide range of cutting tools with unified design elements for each type of tool, the use of advanced technologies for their production, including the application of wear-resistant coatings on the blades, development of recommendations for the operation mode of cutting tools taking into account the properties of processed and tool materials, diagnostics and repair of tools during operation. This approach to the tool supply of enterprises allows to reduce the range of cutting tools, to increase their service life and, ultimately, to reduce material and financial costs for the design, production and operation of cutting tools. [2, 3]

Main part. Currently, the Department of Technology and Equipment of Machine-building Industry is working on the design and manufacture of block-modular cutting tools for CNC milling machines of the company Fanuc.[4, 5].

Distinctive features of the tools for these machines are the use of cone shanks of the Japanese standard JIS B6339 and limited overall dimensions of housing modules.

Figure 1 shows the design diagram of the end mill for a CNC milling machine. The tool blocks 1 are installed in the holes of the housing module 2. The blocks are attached to the housing module using a clamp consisting of a thrust pin 3 and a threaded pin 4. The housing module with attached tool blocks is mounted on a shank 5 and clamped with a screw 7. Face keys 6 prevent the housing module from turning and make it rigid. The cap fitting 8 is screwed into the shank to tighten the cutter into the machine spindle.

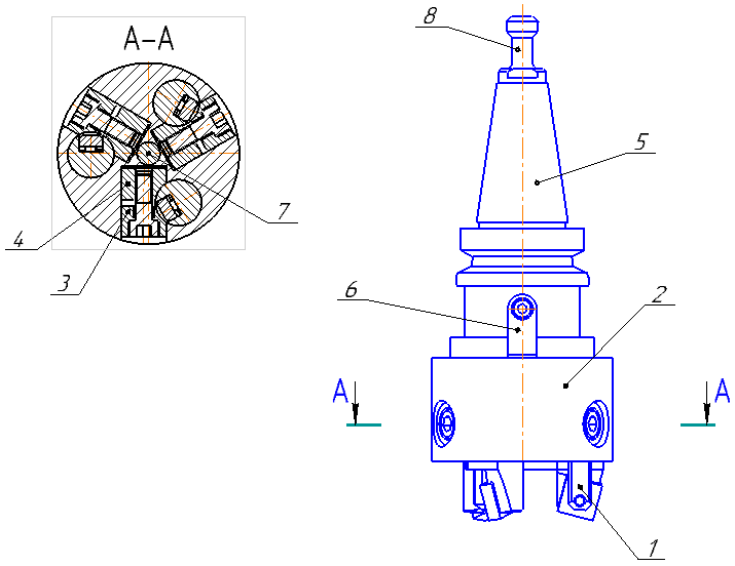

Figure 1. – Design diagram of the end mill

Fig. 2 shows a 3D model of the end mill design.

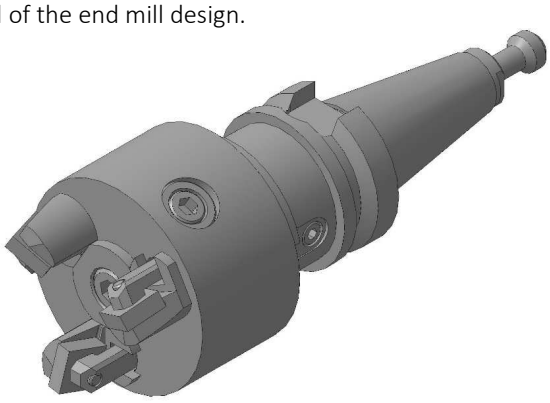

Figure 2. – -3D model of the end mill design

A design diagram of a countersink for a CNC milling machine (Fig. 3) includes tool blocks 1, which are installed in the holes of the housing module 2. The tool blocks are installed in the housing module at an angle of 15°, which allows you to process blind holes and get a groove with a 90 ° angle. The blocks are fixed in the housing module using a clamp consisting of a thrust pin 3 and a threaded pin 4. The housing module with fixed tool blocks is mounted on the shank 5 and clamped with a screw 7. Face keys 6 prevent the housing module from turning and make it rigid. The cap fitting 8 is screwed into the shank to tighten the countersink into the machine spindle.

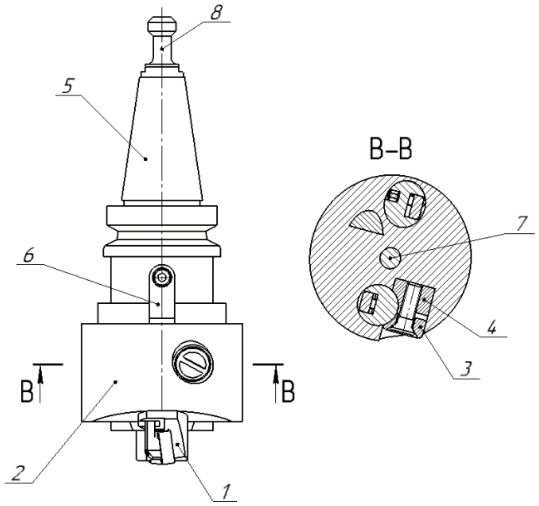

Figure 3. - structural diagram of the countersink

Fig. 4 shows a 3D model of the countersink design.

Figure 4. – 3D model of the countersink construction

Conclusion. The considered construction diagrams of various types of block-modular cutting tools and the proposed design of the cutter and countersink for their application on CNC machine tools "Robodril", the distinctive features of which are: shank B30, and the minimum possible size of the tool blocks, which made it possible to produce a face mill and countersink Ø63mm in diameter and the number of tool blocks equal to 2-3 pieces.

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PLASMA SOURCE OF CHARGED PARTICLES BASED ON A DISCHARGE IN CROSSED E×H FIELDS WITH AN INCREASED PERVEANCE

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This paper presents a design layout of the plasma source of charged particles in crossed E×H fields with high perveance. Its electrode structure is given, describes a source operation mechanism, the prospects for further development of a high-perveance source for industrial applications based on it are shown.

Introduction. The accumulated experience of using sources of charged particles [1-3] indicates the prospects of their use for the implementation of combined resource-saving technologies for processing surface layers, product engineering and the formation of composite coatings on materials. The creation of new constructions of sources with a plasma emitter for the implementation of combined resource-saving technologies for electron-ion-plasma processing of surface layers based on them will reduce energy costs, as well as improve the operational characteristics of products. To solve this problem, it seems promising to develop high-performance sources of low- and high-energy (depending on the field of application) beams of charged particles.

It should be noted that the perveance P is a measure of the intensity of the flow of charged particles and characterizes the effect of space charge on the beam of charged particles, it is equal to the ratio of the particle beam current to the equivalent accelerating voltage at this point to the extent of three second: $P = \frac{I}{U^{3/2}}$ [4].

The modern theory and experience of using plasma sources of ion and electron beams show that diode structures with plasma charge emitters automatically provide enhanced perveance at a given emission current density [5]. This is due to the impossibility of forming a Langmuir potential minimum near the plasma emitter due to the possibility of simultaneous emission of both electrons and ions from the plasma [6]. This possibility leads to an automatic movement of each element of the surface emitting plasma to implement zero potential gradient conditions on the entire surface. Thus, a diode with a plasma emitter operates in saturation mode when the emission current is equal to the current of the anode of the diode gap.

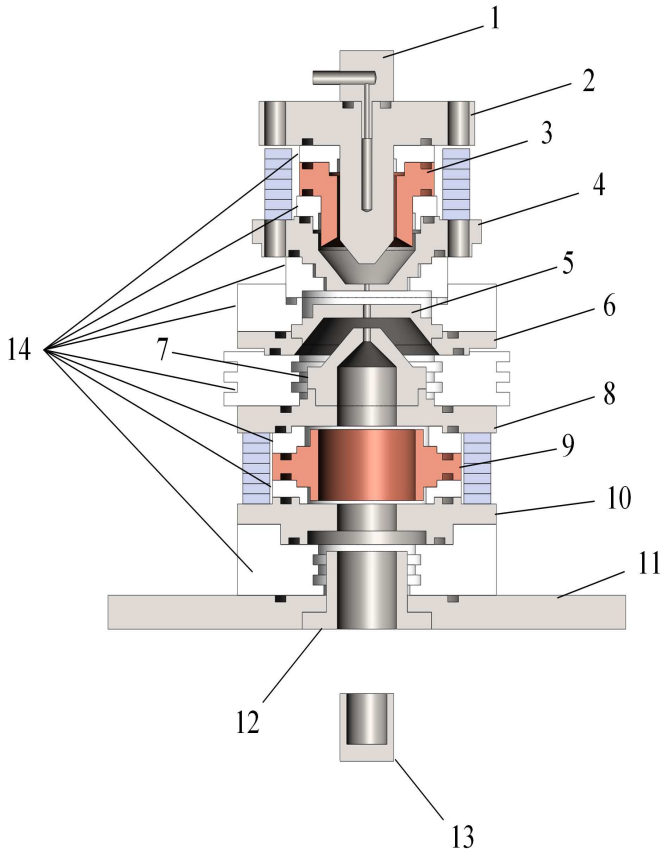
A further increase in perveance in a diode with a plasma emitter is possible due to compensation of the space current charge in the diode (electron or ion) by charges of a different type in the entire diode gap. Such a situation is realized, in particular, in double electric layers arising under certain conditions in a plasma. Such layers can be considered as diodes with a plasma emitter and a plasma anode. The perveance of double electric layers can be considered maximum for a given current density in the layer (diode).

Results and its discussion.

An analysis of the known designs of plasma sources of charged particles (electrons) and the basic physical processes in them shows that it is possible to modify these structures in order to create more effective conditions for the plasma formation and to obtain an emission current, without significantly complicating the design and changing the power supply systems. This paper presents a design layout of the plasma source of charged particles in crossed E × H fields with high perveance of the electrode structure of which is shown in Figure 1.

The mechanism of the proposed design is as follows. Plasma, through a part of the surface of which the electrons selection (emission) is carried out, is formed in a volume limited by the internal surfaces of the cathode 2, the reflective cathode 4, the main anode 3 and the emitter electrode 5. These electrodes are separated by insulators. Cathodes 2 and 4 are the tips of a permanent magnet, creating a magnetic field between them, which contributes to the oscillation of secondary electrons from the cathodes into the plasma formation space. Electrodes 5, 6, and 7 form an electron acceleration gap where a plasma surface that emits electrons is formed. Electrodes 8–10 form a gas-discharge structure that forms a plasma, which is a source of ions. This structure is a Penning type cell

[8]. At the same time, the magnetic field generated by the cathodes 8, 9 forms a certain magnetic focusing system for an accelerated electron beam propagating along the axis of this gas-discharge structure until it leaves the source in the process chamber.



1 – plasma gas inlet channel; 2 – cathode; 3 – main anode;
4 – reflective cathode; 5 – emitter electrode; 6 – auxiliary cathode; 7 – accelerating electrode; 8, 10 – cathodes; 9 – anode; 11 – flange for mounting the structure to the working chamber; 14 – insulators

Figure 1. – Appearance of the developed source layout with increased perveance

The electrodes of the developed model of the electron source are connected to the power supply system separately, each discharge structure has its own discharge power supply. It was assumed that the relationship of separately controlled discharges in the structure will contribute to an increase in the degree of gas ionization at reduced pressure. The mechanism of operation, which provides an increase in perveance, is as follows: the electron beam formed in the upper chamber (electrodes 2-5, Fig. 1) after acceleration enters the structure formed by the electrodes of the lower chamber (electrodes 8-10 Fig. 1), where a low-pressure discharge forms a plasma emitting ions. The generated electron beam, propagating along the axis in this structure, increases the degree of plasma ionization in this discharge. Ions propagate into the upper structure, increase gas ionization in the electron selection region and the emission current density, and partially compensate for the electron space charge in the accelerating gap, which generally leads to an increase in the source perveance.

The implementation of this mechanism is evidenced by a change in the slope of the current-voltage characteristics of extraction in the presence (Fig. 2, curves 4-6 and Fig. 3, curves 3-5) of discharge initiation in the lower discharge chamber (electrodes 8-10 of Fig. 1) in comparison with its absence (Fig. 2, curves 1-3 and Fig. 3, curves 1, 2). The type of characteristics indicates a weak effect on the source perveance of the discharge current and gas inlet (pressure in the discharge chamber) in the working range of the stable existence of the discharge. From the presented characteristics it is seen that the determining effect on the source perveance is exerted by the presence of an additional discharge in the lower discharge chamber (electrodes 8–10 of Fig. 1).

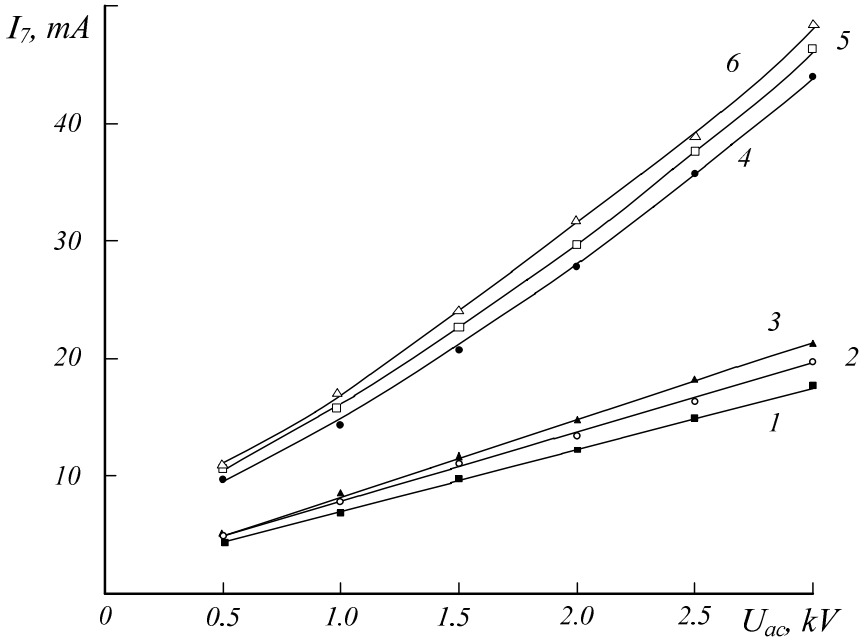


Figure 2. – Current I_7 (into Faraday cylinder) in the absence of (1-3) and the presence (4-6) discharge initiation in the lower discharge chamber (electrodes 8-10, Fig. 1) for various gas inlets *Q*:
I_d in the upper chamber (electrodes 2-5, Fig. 1) 200 mA, discharge voltage 420 V;
I_d in the upper chamber (electrodes 8-10, Fig. 1) 180 mA, discharge voltage 410 V.
Gas inlet *Q*: 1, 4 – $0{,}05 \cdot 10^{-4}$ l/sec; 2, 5 – $0{,}1 \cdot 10^{-4}$ l/sec; 3, 6 – $0{,}38 \cdot 10^{-4}$ l/sec

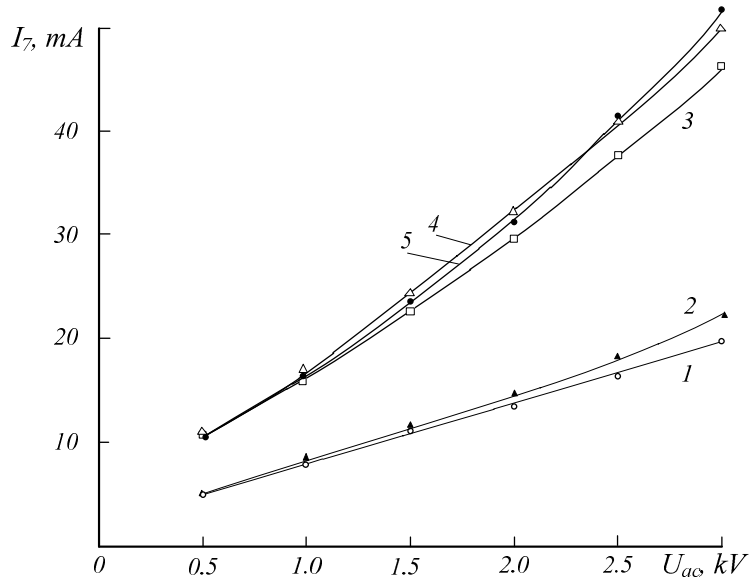


Figure 3. – Current I_7 (into Faraday cylinder) in the absence of (1-2) and the presence (3-5) discharge initiation in the lower discharge chamber (electrodes 8-10, Fig. 1) for various discharge currents in the upper and lower chambers:
1-5 – gas inlet Q – $0{,}1 \cdot 10^{-4}$ l/sec;
I_d in the upper chamber (electrodes 2-5, Fig. 1) 1, 3, 5 - 200 mA, discharge voltage 420 V; 2, 4 – 240 mA, discharge voltage 450 V;
3, 4 - I_d in the lower chamber (electrodes 8-10, Fig. 1) 180 mA, discharge voltage 410 V; 5 - I_d in the lower chamber (electrodes 8-10, Fig. 1) 210 mA, discharge voltage 430 V.
Gas inlet *Q*: 1, 4 – $0{,}05 \cdot 10^{-4}$ l/sec; 2, 5 – $0{,}1 \cdot 10^{-4}$ l/sec; 3, 6 – $0{,}38 \cdot 10^{-4}$ l/sec

Conclusion. Along with known methods that increase the switching of the electron current from plasma to the accelerating gap (emission current) in plasma sources of charged particles, a significant increase in the

perveance of plasma sources of both high-energy and low-energy beams is provided by filling the electron-accelerating gap with ions that compensate for the space charge of the electron beam. Moreover, to increase the perveance of plasma electron sources in a continuous mode, it is advisable to use an accelerating electrode in the form of a plasma surface that accelerates electrons and, at the same time, emits ions into the gap accelerating electrons. For this, the accelerating electrode must be an element of the electrode gas-discharge structure forming the plasma. Between the electron-emitting plasma and the plasma of the accelerating electrode, a double electric layer is formed with a high perveance for the accelerated electron beam.

The obtained results indicate the possibility and prospects of using the developed source for developing a high-perveance source for industrial applications.

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UDC 517.926+517.977

CRITERION OF UNIFORM FULL CONTROLLABILITY FOR LINEAR DISCRETE SYSTEMS WITH VARIABLE STRUCTURE

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Introduction. One of the actively developing sections of the theory of dynamical systems today is the theory of control of the asymptotic characteristics of linear dynamic (discrete and continuous) systems [1]. The main effective tools used in it and appearing initially in the theory of control of finite-dimensional linear dynamic systems [2] were the controllability matrix (Kalman matrix), as well as the property of uniform complete controllability of a linear controllable differential system. The aim of this work is to introduce the properties of uniform full controllability for linear controlled discrete systems with a varying structure and to obtain a coefficient criterion for the presence of such a property in these systems based on the controllability matrix. The results obtained are planned to be used in future in solving the problems of controlling the asymptotic characteristics of the above-mentioned discrete systems.

Materials and methods. In the present work, the object of study is linear controlled discrete systems with a changing structure, for which the property of their uniform complete controllability is introduced and studied. In the study, methods of the theory of matrices, the theory of discrete dynamic systems, and also the theory of control of linear dynamic systems are used.

Results and its discussion. In case $n_0, n_1, ..., n_t, ...$ and $r_0, r_1, ..., r_t, ...$ two sequences of positive integers, the linear discrete equation is considered to be

$$x_{t+1} = A_t x_t + B_t u_t, \quad t = 0, 1, 2, ..., \tag{1}$$

in which $A_t - (n_{t+1} \times n_t)$ - matrices, $B_t - (n_{t+1} \times r_t)$ - matrices, and sequence u_t at every moment of time takes values in space $\mathbb{R}^{r_t}$ (it plays the role of input). Equation (1) relates to the unknown sequence $x_t \in \mathbb{R}^{n_t}$ at points t and $t+1$.

Definition 1 [3]. The relation (1) for $u_t \equiv 0, \ t = 0, 1, 2, ...$, that is, a system of the form

$$x_{t+1} = A_t x_t, \quad t = 0, 1, 2, ...,$$

is called *a homogeneous system with a changing structure.*

The $(n_t \times n_\tau)$ - matrix (Cauchy matrix [3]) $X_{t,\tau}$ is defined in the following way:

$$X_{\tau,\tau} = I_\tau \ (I_\tau - \text{identity transformation into } \mathbb{R}^{n_\tau});$$

$$X_{t,\tau} = A_{t-1} A_{t-2} \cdot \ldots \cdot A_\tau \text{ at } t > \tau.$$

By analogy with [4], the concept of uniform complete controllability of system (1) is introduced.

Definition 2. System (1) is called σ - *uniformly and completely controllable system,* if such numbers as $\sigma \in \mathbb{N}$ and $\gamma > 0$, exist, which for any initial point in time $\tau \in \mathbb{N}$ and in any initial state $x_0 \in \mathbb{R}^{n_\tau}$ there is control $u = u(t), \ t = \tau, \tau+1, \ldots, \tau+\sigma-1$, satisfying inequality $\| u(t) \| \leqslant \gamma \| x_\tau \|$ for all $t = \tau, \tau+1, \ldots, \tau+\sigma-1$, and as such the solution of system (1) with this control and the initial condition $x_\tau = x_0$ satisfies equality $x_\sigma = 0 \in \mathbb{R}^{n_{\tau+\sigma}}$.

The controllability matrix is considered [3]

$$W_{\tau,\tau+\sigma} = \sum_{j=\tau}^{\tau+\sigma-1} X_{\tau+\sigma,\, j+1} B_j B_j^T X_{\tau+\sigma,\, j+1}^T$$

with sizes $n_{\tau+\sigma} \times n_{\tau+\sigma}$.

Theorem. *System (1) is uniformly and completely controllable if and only if such numbers as* $\sigma \in \mathbb{N}$ *and* $\alpha > 0,$ *exist, which for any number* $\tau \in \mathbb{N}$ *for every vector* $\xi \in \mathbb{R}^{n_{\tau+\sigma}}$ *inequality holds*

$$\xi^T W_{\tau,\tau+\sigma}\xi = \xi^T \cdot (\sum_{j=\tau}^{\tau+\sigma-1} X_{\tau+\sigma,j+1} B_j B_j^T X_{\tau+\sigma,j+1}^T) \cdot \xi \geqslant \alpha \| \xi \|^2 .$$

Conclusion. The results presented above will allow us to solve the problem of controlling the asymptotic characteristics of linear discrete systems with a varying structure.

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FORMATION OF BLOCK-MODULAR FACE MILLING CUTTERS WITH ADJUSTMENT OF GEOMETRIC BLADE PARAMETERS

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Design variants of adjustment models for adjusting cutting blocks in block-modular cutting tools and adjustment variants of face milling cutter in the radial and axial directions are considered. Possible variants for adjusting mechanisms and forming scheme of block modular face milling cutters with adjustment of the geometric blades parameters are proposed.

Currently, leading manufacturers of face milling cutters have a tendency to create cutting tools that consist of interchangeable structural elements. At the same time, in many such designs it is possible to adjust the accuracy and geometric parameters of the cutting tool due to additional interchangeable structural elements and modules.

But it is worth noting that in foreign instrumental systems the use of intertype modularity, which allows to use the same blocks and modules not only in milling cutters, but also in other types of tools, such as turning tools, countersinks, drills, etc., is difficult.

In this regard, the creation of modular cutting tools, in particular, face milling cutters, consisting of blocks and modules unified for different types of tools, and having a technological design for the conditions of any tool production, which, despite the lack of precision in the manufacture of individual elements, by adjusting the geometric parameters of the blocks and modules ensures, the achievement of the specified accuracy of the cutting tool and, therefore, specified parameters of manufactured products, is relevant.

Designs of block modular cutting tools have been developed [1-6] based on a unified cutting block. Experimental studies of the reliability and stiffness of fastening cutting inserts and cutting blocks have been conducted [7-8].

To reduce the nomenclature of block-modular face milling cutters, it is proposed to use a tool with adjustment of the geometric parameters of the blades in the end and radial directions.

For *n* directions of adjustment and m variants of precision execution, you can get:

$$K = n \cdot m$$

variants of adjustment mechanisms.

If the options for the face (F), radial (R) and face-radial (F–R) directions of adjustment and coarse (C), precise (P) and increased accuracy (IA) precision execution options are taken into consideration, various adjustment mechanisms can be attained depending on the direction and accuracy of adjustment. Such possible variants are presented in the diagram (Fig. 1):

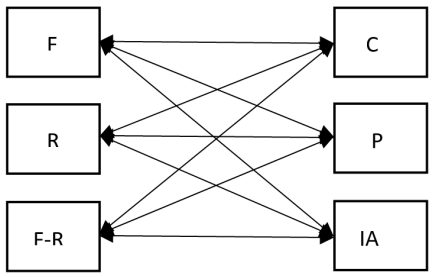

Figure 1. – Possible variants for adjusting mechanisms

Bearing the following notation:
CI – type (geometrical form) of cutting inserts,
CB – cutting block designs,
CM – clamping module designs,
AM – adjustment mechanism designs, which are divided into
AMER - (adjustment mechanism designs for runout adjustment),
AMRR - (adjustment mechanism designs for radial runout adjustment)

AMERR - (adjustment mechanism designs for end and radial runout adjustment),
HM – housing module designs,
BMFMC – block modular face milling cutter designs, were received:

1. Generalised code for forming adjustable block-modular face milling cutters:

$$CI \cup CB \cup CM \cup AM(AMER \cup AMRR \cup AMERR) \cup HM \rightarrow BMFMC$$

2. Scheme of forming adjustable block-modular face milling cutters in tabular form (Fig.2)/

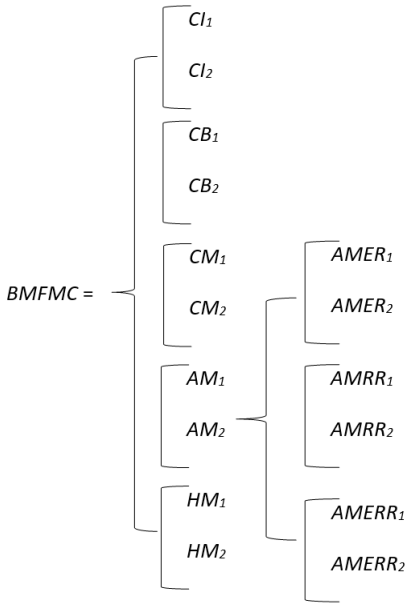

Figure 2. – Scheme of forming adjustable block-modular face milling cutters

Based on the proposed code and the scheme for forming block-modular face milling cutters, designs of block-modular face milling cutters with various variants for adjusting geometric parameters have been proposed. The proposed scheme for the formation of block-modular face milling cutters can simplify the work with a wide range of elements as it is easy to formalise and, therefore, to automate the design process of tools.

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DIGITAL TRANSFORMATION IN ENSURING OCCUPATIONAL SAFETY IN THE OIL AND GAS INDUSTRY

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The analysis of the used digital tools of integrated solutions for ensuring occupational safety has been carried out. It has been demonstrated that modern digital information and communication technologies have specific features and perform some of the functions of occupational safety specialists, which allow relevant services to switch to a new algorithm for ensuring occupational safety at work.

Keywords: occupational safety, digital tools.

Introduction. On the basis of the analysis of the global level of occupational injuries, experts of the International Labor Organisation have come to the conclusion that there are approximately 340 million registered work accidents each year of which 2.3 million are fatal, every minute 4 people die from work-related injuries and diseases. About 650 thousand deaths per year are registered in the working area from exposure to hazardous substances alone. The economic damage to society from adverse and hazardous working conditions is up to 4% of the world GDP. At the same time, it is well known that one dollar of the funds invested in the improvement of working conditions at a production site makes a profit of about $2.6 [1-8].

Results, their discussion and perspectives. According to official data of the National Statistical Committee of the Republic of Belarus, the total number of victims of industrial accidents has grown in the organisations of the Belneftekhim company over the last three years of observation. The dynamics of occupational injuries at the organisations of Belneftekhim obtained according to the data [9] is shown in figure 1. The main causes of accidents at work in the organisations of Belneftekhim are the same as elsewhere in the country, namely: violation of labour protection requirements by the injured; personal negligence; unsatisfactory organisation of hazardous work; violation of labour protection requirements by other workers.

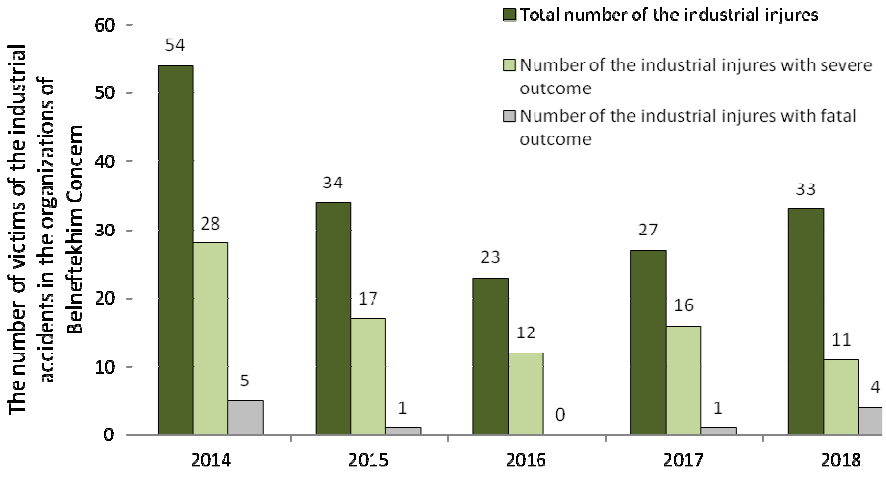

Figure 1. - The number of the injured in industrial accidents at the organisations of the Belneftekhim company

The unstable situation in the field of occupational safety and health at large industrial enterprises makes it necessary to reduce the risk of industrial injuries through the development and implementation of more efficient preventive measures [6-8]. The era of digital economy, "Industry 4.0", and the development of the Internet of things, dictate the need for growth of IT and Smart-development ("Smart Technology") in various enterprise management systems, including occupational health and safety management systems.

The development of preventive measures to reduce the number of industrial injures and occupational diseases requires of specialists in the field of labour protection to take into account and systematically study a large flow of information, to be able to analyse complex industrial situations, to predict events and provide timely information and balanced decisions on expediency of implementing certain preventive measures. This causes the necessity to use digital tools of integrated solutions for ensuring occupational safety and health. The analysis of the current state of this issue has determined the purpose of this study. We have analysed modern digital tools of integrated solutions used to ensure occupational safety at work, and they can be ranked by areas of activity [6-8]:

1) *Occupational health and safety training*: Olimpoks system (OOO A-P, Russia), OLIMPOKS training and controlling system and OLIMPOKS: Instruction system (OOO "TERMIKA", Russia), online training system LMS (Learning Management System) and VR (Virtual Reality) simulators (VRC CROC, Russia); VR-training, employee training system using virtual reality (Cerevrum Inc., jointly elaborated in Russia and the United States of America) and others.

2) *Control over compliance with occupational health and safety requirements:* "Production Control" integrated system of work safety (ISWS) ("Vizitech" company, Russia), mobile phone application "I am an inspector" (Rostrud, Russia).

3) *Organisation of work on occupational safety (automated working station (AWS) for occupational safety specialists):* "Occupational safety" for 1 C: Enterprises 8 (Inform Service Group, Russia), "1C. Production safety. Occupational safety" (INTERS, Russia), online service ("Abie System", Russia), information management system "Industrial safety and labour protection" (OOO "BREALIT", Russia), cloud service "MyObject" (Living core, Russia), AWS Occupational safety (ODO "Expertcentre", Belarus), system Q4 Safety (Engica, USA).) It should be noted that on the Russian market alone there are more than a hundred specialised AWS products which allow to reduce time for planning and organisation of work, to process large amount of information faster and to simplify labour-consuming monotonous work.

4) *Prevention of accidents:* "Smart" video analytics (Russian CROC, DSSL and other companies), "Electronic medical examination system" (EDISON, Russia)

5) *Personal protective equipment (PPE):* "Smart" hardhat (several companies: Human, ROSOMZ, Softline), other wearable devices (MTS and Megafon, Russia)

Digital simulators and equipment simulators, 3D virtual reality technology for skills training implemented in the process of training for occupational safety specialists can significantly improve the efficiency of staff training by creating an interactive learning environment as close to the real as possible. Replacing the traditional form of instruction by Smart-Technology is feasible due to the higher capacity of the visual sensory system compared to the auditory one. The visual perception of information activates the right hemisphere of the brain, which forms figurative thinking that promotes the transfer of information into the subconscious memory. The use of mobile applications allows users, regardless of the location of an employee, to properly prepare for the test of knowledge on occupational safety, passing trial tests, even staying offline.

Conclusion. The analysis of the used digital tools of integrated solutions for the purpose of ensuring occupational health and safety at work has shown that these technologies are already mandatory and necessary tools for occupational health services, especially at facilities in the oil and gas industry, characterised by increased explosion and fire hazards. Digital innovations are characterised by extensive functionality and are applied in various areas of work in the field of occupational safety.

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ANALYSIS OF EQUIPMENT OPERATION TIME AT THE REFINERY

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The results of the analysis of the service life of equipment operating under excess pressure at the Belarusian oil refineries are presented, directions for improving industrial safety when working with this type of equipment are proposed in this study. The average service life of equipment operating under excessive pressure at the studied enterprise has been identified.

Keywords: oil refinery, industrial safety, accident rate, equipment

Introduction. The enterprises of the oil refining industry are some of the most explosive objects. The high fire and explosive level of these enterprises is explained by the presence of a large amount of hydrocarbons that circulate in the process [1-13]. Emergency depressurisation of the technological equipment at a refinery plant can cause a major accident with concomitant emissions of toxic substances, destruction and damage of expensive equipment, breakdown of the technological processes, fires and explosions [14-16]. Every year approximately 20,000 major accidents occur in the oil and gas industry in the world, and in recent years there has been an increase of the accident rate in the oil refining industry [17-21]. Several examples of such accidents are:

– An accident in March 2005 at the isomerisation unit of one of the largest US refineries owned by British Petroleum in Texas City. There was a powerful explosion, followed by a strong fire. 15 people were killed and over 70 were injured;

– On May 29, in 2008, a hydrogen-containing mixture exploded in a hydrogen compressor unit for the secondary processing of oil at the Kirishi Refinery, and then a fire occurred. One person died on the spot, four died in hospital. The damage from the accident amounted to 107 million Rubles;

– On August 7, 2011 there was a fire at the Khabarovsk refinery. Spilled fuel and pumping station burned on a total area of 50 m^2 3 people were injured and 2 died;

– On June 15, 2014 at the gas fractionation unit of the Achinsk refinery there was a leak of hydrocarbon gas, which led to a major explosion and fire. 8 people died, 7 were hospitalised, the total number of the injured was 24 people. The damage amounted to approximately $ 800 million.

In the CIS countries there is a targeted state policy in the field of industrial safety. However, the state of accidents at work place continues to be a complex socio-economic problem.

Statistics show that the major accidents at oil refineries in most cases are due to leaks of flammable liquids and vapours or hydrocarbon gas. The reasons of their occurrence are as follows:

– violation of the rules of operation, technological regulations (27% of cases);

– defects in construction and installation works, low quality of installation and repairing of equipment (21%);

– defects in the manufacture of equipment and materials (16%);

– deviation from the requirements of the design and technical documentation (12%);

– equipment deterioration, product leaks through gaskets, mechanical seals, oil seals, equipment corrosion, furnace burnout in furnaces (11%);

– constructive imperfection of equipment (5%);

– external natural and man-made impacts (5%);

– imperfection of design solutions, etc. (less than % 3).

Improving the resiliency and trouble-free operation of equipment under excessive pressure at oil refineries, are now particularly relevant directions to improve the level of industrial safety for the industry. This fact has determined the purpose of this study.

Research methods. Equipment operating under excessive pressure at a Belarusian full-cycle oil refinery has been taken as a research object; equipment such as columns, vessels and reactors has been studied; heat exchangers (including crystallisers), separators and filters. The expert-statistical and analytical methods have been applied on the basis of a comprehensive analysis of repairing documentation for the period of 2008-2018 as well as the terms of operation of equipment functioning under excessive pressure at the Belarusian oil refineries.

Results and discussion. With the purpose of determination of the current state of equipment during shutdown repairs, as well as during technical diagnostics, and determination of the suitability for further operation and extension of the life cycle of equipment that has worked out a standard period the following combination of non-destructive testing methods is usually used: visual inspection in accessible places; ultrasonic thickness measurement of housing elements and nozzles; ultrasonic defectoscopy of welds, as well as control of the continuity of the base metal; penetration test; hydrostatic test.

Columns at a research plant accounts for 6% of the total number of equipment. According to GOST 31838-2012, this type includes cylindrical vertical vessels of constant or variable cross-sections, equipped with internal heat and mass transfer devices (plates or packing), as well as assistant units (liquid inlets, devices for set-up packed elements, etc.). providing a process (for example, rectification or direct heat exchange between steam (gas) and liquid, etc.). The analysis of repair documentation for the period of 2008-2018 has shown that the highest frequency of work is achieved by replaced nozzles with conditional passage up to DN100 (37% of the scope of work), replacing internal devices (23%), replacing nozzles with conditional passage DN100 and more (21%), while less frequently repairs take place on the base metal and metal of the body welds (about 19% of the work).

For the columns the replacement of internal devices usually means the replacement of the supporting elements of the plates welded to the vessel body, which have become unusable in the result of corrosive wear under the influence of the working medium. It is controlled visually and with the help of measuring devices. An effective way to increase safety is to widely use the technology of welding support elements through shims welded directly to the body of the vessels. If it is necessary to repair this unit, the support element is cut out and a new one is welded to the shim plate without touching the body of the vessel.

At the same time, there is no possibility of mechanical damage to the body when re-disassembling the support element. It also excludes its local overheating and changes in the metal structure as a result of overheating. It favorably affects to the period of further operation of this equipment. This method can also be applied to elements welded outside vessels, such as service platforms, booms, supporting elements of level gauge columns, etc.

Separators make up 6% of the total number of the examined equipment, belong to the settling items. Separators are similar in design to columns, but have smaller size and are equipped with fewer plates or an overflow plate for separating liquids by density. According to the maximum frequency of the types of repairs carried out by separators the work is performed on replaced nozzles with conditional passage of up to DN 100 (76% of the work); a small percentage falls on other types of repairs (repair of base metal and metal of body welds - 11% conditional passage of DN 100 or more - 9%, replacement of internal devices - 4%).

Filters make up 7% of the total number of the examined equipment, belong to the apparatus for the implementation of the filtering process. The most frequent repairs on filters are made for replacing nozzles with conditional passage of up to DN100 (71% of works), a small percentage are for other types of repairs (repairing base metal and metal of body welds - 19% and replacing fittings with conditional passage DN100 and more - 10%). The reason for this is that this type of equipment has low average life.

Reactors make up 2% of the total number of the examined equipment, belong to vessels in which chemical reactions take place including those with the use of a catalyst. As a rule, the presence of high pressure and temperature is observed. According to the maximum frequency of conducted repairs of reactors, repairs are made on the base metal and metal of the protective casing welds that were repaired (75% of the scope of work), 13% of the repairs mean replacing the internal devices of the reactors.

The small number of repairs of this type of equipment is explained by the large margin of safety used in manufacturing, due to the high operating pressures and temperatures, and the difficulty of carrying out repair on thick buildings. When defects are detected, this type of equipment is changed entirely to ensure trouble-free operation during the overhaul period.

Almost a single type of repair that is applied to the equipment of this type is repairing of the protective case, which is designed to protect the sprayed concrete lining from the corrosive effects of the working medium in the old types of reactors. From the point of view of improving reliability it is advisable to switch to modern bimetallic reactors.

Vessels make up to 41% of the total number of the examined equipment. According to TR CU 032/2013 vessels are hermetically closed containers (divided into fixed and mobile). This type of equipment is designed for conducting chemical, thermal and other technological processes, and also for the storage and transportation of gases, liquids, and other substances. The replacement of nozzles with conditional passage of up to DN100 (70% of the scope of work) has the highest frequency of repairs of vessels, 15% of the amount of work involved re-

placing nozzles with conditional passage of up to DN100 and more and repair of the base metal and metal of the body welds.

Heat exchangers make up 37% of the total number of examined equipment. According to GOST 31842-2012 heat exchangers are the equipment designed to transfer heat under non-isothermal operating conditions. According to the maximum frequency of the types of heat-exchange equipment repairs carried out, work on repairing the base metal and metal of the welds (31% of the work), work on replacing nozzles with conditional passage up to DN 100 (30% of the work) and replacing and repairing, are allocated partition walls of distribution chambers (24% of the scope of work).

The main defects detected in tube bundles of heat exchangers include:

– corrosive wear-out of pipe bundle pipes. It is controlled by hydraulic tests in the annular space;
– corrosive wear-out and thinning of the metal in the area of rolling tubes in tube plates.
– corrosive wear-out and thinning of the metal in the area of rolling tubes in tube plates. It is controlled by hydraulic testing in the annular space.

Reducing the number of operational defects and extending the time for maintenance-free operation of heat exchange equipment can be achieved by introducing strict control over the operation of this equipment. Often, the gaps in the places of rolling of the pipes are caused by the deformation of the pipes by the excessive pressure in the annular space during the filling of the apparatus. The filling of the apparatus must be made starting with the tube bundle for the purpose of balance the pressure and reduce the probability of deformation of the tube.

Similar in construction are rigid tube-shell heat exchangers. Detected defects are the same as in shell-and-tube heat exchangers with removable tubular system. At the same time, there is no possibility of visual control of the inner surface of the case. To increase the level of control and detect defects at earlier stages, maps of wall thickness measurements with an increased number of control points are compiled for heat exchangers of these types compared to heat exchangers with a movable pipe system. In addition, rigid tube heat exchangers are supplied with bellows expansion joints to compensate for temperature expansions. Compensators are made of thin-walled stainless steel. At the same time, based on the practical experience of operating devices with a lens compensator, there was often a situation in which the wall thickness of the case had sufficient margin to the screening thickness and the lens compensator became unusable due to corrosive erosion wear. Repair of heat exchangers of this type is impractical because of a non-dismountable design. So disassembly, replacement of worn-out sections of the shell or tube bundle pipes, replacement of a compensator, and the following assembly, are comparable in cost to new heat exchangers.

A specific type of heat exchange equipment is scraper chillers, that are additionally equipped with a scraper axle inside the internal tubes of heat exchangers. At the enterprise under study such equipment makes only 1% of the total number of equipment items, but the average lifetime of the chillers is significant - 49.2 years. The analysis of the repair documentation for repairs carried out on chillers showed that the only type of repair is the replacement of internal or less often external pipes, as the main wear parts of this type of equipment. In addition to the corrosive effects of the environment, the wear of the inner tubes is influenced by the friction of the scrapers. At axial displacement of the axle during assembly, or uneven wear of the bearings, there is increased wear-out of the composite gaskets of the shaft scrapers, and then friction of the metal scraper on the inner surface of the pipes. At the same time, there is no possibility to control the condition of the scraper gaskets and the internal pipes of the chiller because the pipes are inaccessible for full visual inspection, it is impossible to conduct ultrasonic thickness gauging. Ultrasonic thickness gauging of external pipes, visual inspection of internal pipes in accessible places using a flashlight along the pipe axis, as well as a hydraulic test for tightness and density of internal pipes, are used to assess the state of these technical devices. If a defect is suspected or traces of mechanical wear-out are detected, the inner tube is replaced. At the same time, in such devices it is advisable to use pipes made of solid steel grades to reduce mechanical wear-out of the internal surface of the pipes.

Table 1 shows the average service life of equipment operating under excessive pressure at the Belarusian refineries.

Table 1. – Lifetime of equipment operating under excessive pressure at the refinery.

Type of equipment operating under overpressure	Average life at the refinery, years
Columns	38,6
Vessels	34,8
Reactors	32,8
Heat exchangers	31,2
Separators	28,3
Filters	25,0

The table shows that the columns, vessels, and reactors are operated the longest. At the same time, the service life of the vessels working under excessive pressure declared by the developer is usually 20 years.

The comprehensive analysis of the life cycle of equipment operating under excessive pressure at the Belarusian oil refineries showed that nozzles with conditional passage of up to DN100, base metal and metal of the body welds of various equipment are subject to a high risk of increased wear-out during operation.

The reason for the frequent replacement of nozzles with a small conditional passage is associated with a small margin between the executive and rejecting thicknesses of nozzles.

For example, a pipe with a nominal thickness of 4 mm is most often used for the nozzle of DN50 by strength calculation. In accordance with the instructions for revision, repair and rejection which are applied at the enterprise under study, the rejection thickness for the DN50 connection pipe is 2.0 mm, unless otherwise greater value is indicated in the strength calculation. The executive wall thickness as a result of an error in the manufacture is often about 3.8-3.9 mm. At the same time, in practice such nozzles are rejected with a thickness of 2.5-2.7 mm, as an approaching rejection to improve the reliability and infallibility of work during the overhaul period and to prevent the process installation from stopping due to the omission of the product. In this case, even with a corrosion rate of up to 0.1 mm / year the thickness of the nozzle is not enough even for the declared service life of the vessel (usually 20 years). From practical experience, the replacement of such nozzles during the repair with heavy walled ones of about 6-8 mm leads to trouble-free operation of these units throughout the life cycle of the equipment until they are replaced.

Thus, as a way to increase the industrial safety of the equipment operating under excessive pressure, it is proposed that the new equipment is coordinated with the developers to reach an increase in the thickness of the fittings with conditional passage of up to DN100. At the same time, despite the slight increase in the cost of such equipment, it is possible to achieve maintenance-free operation of the equipment even after the end of the designated service life. The reasons for repairing the base metal and weld metal are hidden metallurgical defects and weld defects that were not detected during the manufacture of the vessel (apparatus), as well as the aggressive influence of the working medium of the vessel (apparatus), the formation of stagnant zones, the accumulation of solid particles from the working medium (scale, contamination, etc.), which are monitored visually and using ultrasonic thickness gauging. Ultrasonic and penetrant tests can be additionally performed in places suspicious of defects. In our opinion, in order to minimise the number of repairs of this type, it is necessary to strengthen the incoming control for the newly installed equipment. Also it is necessary to strengthen control over the selection of material for a specific working medium and operating parameters such as temperature and pressure and to ensure strict adherence to operation regulations. In the newly designed equipment modern technical solutions are applied to minimise the number of stagnant zones.

Conclusion. The results of the research on the comprehensive life cycle analysis of equipment operating under excessive pressure can be effectively used to increase the level of industrial safety, reduce the risk of accidents at oil refineries and petrochemical plants.

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REDUCED DUST POLLUTION IN THE PROCESSES OF PRODUCTION AND TRANSPORTATION OF PETROLEUM COKE

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A preventive agent based on residual products of Naftan Open Joint Stock Company has been developed. This agent is effective for dust suppression and reducing losses from blowing loose carbon-containing materials, in particular petroleum coke, as well as against freezing and sticking during their transportation at low temperatures. The resulting agent is not inferior in operational properties and more than three times lower in cost of industrial analogues.

Keywords: Oil refining, petroleum coke, dust, dust factor, dust suppression-antifreezing agent.

Introduction. Actual problem for refiners is to reduce the exposure of workers to dust factor in obtaining and transporting the petroleum coke and coke decrease freezing at low air temperatures [1, 2]. Air pollution can cause accidents and incidents. Working in a dusty environment for a long time causes occupational lung disease. The dust of petroleum coke smolders, spontaneously ignites and spontaneously ignites.

Task formulation – reducing the impact of the dust factor on workers in the process of obtaining and transporting petroleum coke by treating it with a specially developed dust suppression agent [3-8].

Methods of research. The input analysis of raw materials was performed in the laboratory of the Department of Technology and Equipment of Oil and Gas Processing. Compounding of light vacuum gas oil with high-molecular oil residues was performed on a laboratory setup. For the obtained prophylactic agents assumed viscosity at 50°C (GOST 6258), pour point (GOST 20287), flash point (GOST 6356), determination of water content (GOST 2477), determination mechanical admixtures (GOST 6370) and copper strip test (GOST 6321) were determined.

Results, their discussion and perspectives. To simulate the process of pulverization of petroleum coke, a sample was obtained from Visbreaking diesel fuel with 5% wt. fuel oil from the AVT-6 installation, manufactured by OJSC Naftan. The task was to determine the ability of the sample to prevent dust extraction and blowing during transportation of petroleum coke. A dry and processed sample of petroleum coke dust was placed in a wind tunnel for 30 minutes at a wind speed of about 30 km / h. The test simulation process is presented in figure 1. Coke pyleunos without treatment is 58% wt., and after treatment with agents - less than 12% wt., blowing losses are reduced by 4.8 times.

Figure 1. - Modeling the dust extraction process during transportation of petroleum coke

The efficiency of dust suppression of coke dust was determined by the mass method. The concentration of dust in the air was determined by subtracting the mass of the filter before and after drawing air through it with coke dust, related to its volume. The dust chamber is made of profile aluminum and has transparent walls (figure 2). It was found that dust suppressants with the addition of 5% wt. fuel oil reduces air pollution by 7.4 times.

Figure 2. - Dust chamber

Technical and economic indicators of the proposed sample were compared with industrial analogues and are shown in table 1.

Table 1. – Technical and economic indicators of prophylactic agents

Inducators	Niogrin PS-35S	Universin-S	Severin-2	Sample
Assumed viscosity at 50°C, GOST 6258, °AV	1,0 – 3,0	1,1 - 3,5	1,1 - 1,5	1,12
Pour point, GOST 20287, °C	- 35	- 40	- 50	< -65
Flash point, GOST 6356, °C	40	80	80	70
Determination of water content, GOST 2477, % of the mass	2,0	0,5	0,5	0,01
Copper strip test, GOST 6321	stands	-	-	stands
Cost $ / ton	180-200	180-200	210-1100	55

Conclusion. The proposed dust-suppressing and anti-freezing agent for preventing air dust does not cause corrosiveness of the cars surfaces made of metal, has a high flash point that meets fire safety requirements, a negative pour point that allows the tool to be used at an air temperature below 40 ° C, so it shows high dust suppression ability.

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ON THE POSSIBILITY OF FORMING COMBINED BEAMS OF CHARGED PARTICLES IN A PLASMA SOURCE BASED ON A DISCHARGE IN CROSSED E×H FIELDS

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In this work, the experimental electrode structure of a plasma electron-ion source for the joint formation of electron and ion beams is proposed, a number of characteristics are given, and the prospects for further development of an electron-ion source for industrial application on its basis are shown

Keywords: *plasma source of charged particles, electron-ion influence, electron beams, compensated ion beams.*

Introduction. Sources of ion and electron beams make it possible to realize an extensive cluster of modern innovative technologies for processing, modifying, and creating new materials. In some cases of such technologies, a significant increase in their quality and equipment performance is possible when implementing simultaneous exposure to electron and ion beams. Currently, this technology is usually provided using separate electron and ion sources. In this case, gas-discharge electrode structures, in which magnetron discharges are excited, [1, 2] are the most widely used for the formation of plasma surfaces emitting ion or electron beams, or discharges with oscillations of Penning type electrons (PIG) [3] or with a hollow cathode [4, 5]. Under technologically necessary conditions of low gas pressure, thermal cathodes are used to reduce the discharge voltage and the density of the emitting plasma in gas-discharge structures [6]. However, this is a drawback of sources, due to the low durability of thermal cathodes in gas discharges.

In these discharges, the emitting plasma is separated from the electrodes of the gas-discharge structure by near-wall electric layers, the parameters of which are determined by the potential difference between the plasma and each electrode, as well as the plasma density, as is accepted (at present) by the condition that the electric field strength at the plasma boundary is equal to zero [7] . The emitting plasma surface, as is customary, also obeys this condition [8]; therefore, the electron (ion) optical conditions in the interval of electron (ion) acceleration and beam formation depend on the position and shape of the emitting plasma boundary, i.e. on accelerating voltage and electrode geometry and their potential. This creates certain difficulties in the formation of large section beams [9].

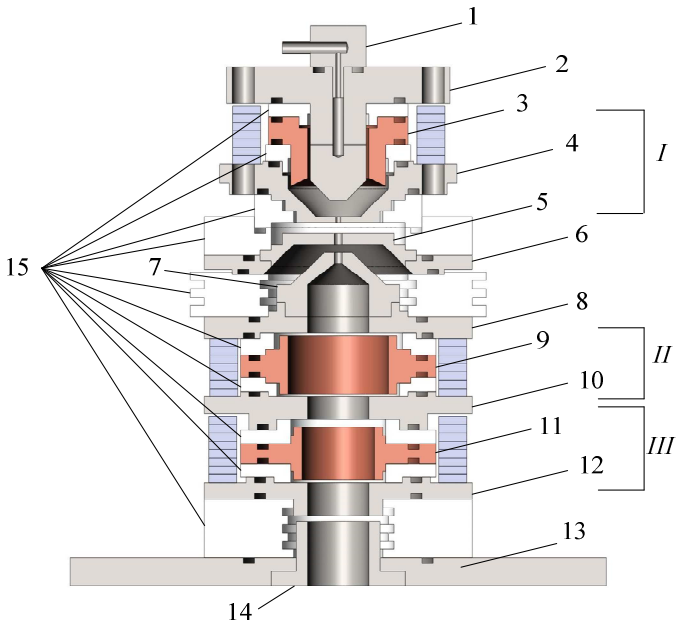
However, the well-known [10] effect of the possible formation of a secondary plasma in the accelerating gap can provide a significant improvement in the emission-optical properties of a source with a plasma emitter: a decrease in the beam divergence due to a decrease in the radial potential gradient in the accelerating gap; increase in emission current due to the reverse flow of charges from the secondary plasma into the emitting plasma [11]; as well as increasing the perveance of the accelerating system due to the partial compensation of the space charge of the beam.

The foregoing suggests the following. First, the possibility of creating a plasma object with electrostatic layers in it, capable of ensuring the formation of ion and electron beams combined in a single space. Secondly, the multifactorial nature of such a structure and the lack of necessary algorithms currently complicate the numerical simulation of such structures. Thirdly, the experimental study of such structures at this stage seems to be most effective for creating technological sources of combined ion-electron beams.

In this paper, we propose a concept and a design developed on its basis for a single multi-discharge structure that is capable of forming combined or alternating ion-electron beams, as well as some experimental results of the formation of such beams.

Physical concept and electrode structure of the experimental source . A sketch of the electrode structure of the developed model of the electron-ion source is shown in Fig. 1. The model is an emitting plasma generator formed in a volume limited by the inner surfaces of cathodes 2 and 4, anode 3, and emitter electrode 5 (discharge chamber I). Electrodes 6 and 7 form an electron acceleration gap where a plasma surface is formed that emits electrons. Electrodes 8-12 form a gas-discharge structure forming a plasma, which is a source of atomizing ions. This structure consists of two "Penning" type discharge cells (II and III) connected in series (along the axis) [3]. Elements of this structure 9 and 11 are the anodes of the discharge cells; elements 8, 10 and 12 - cathodes, which are simultaneously pole tips of permanent magnets. It can be assumed that in these cells, both the elec-

tron oscillation between the cathodes and the similarity of their cycloidal motion, realized in magnetron-type discharges, are provided [12, 13].



1 – fitting for plasma gas inlet; 2 – internal cathode; 3 – the main anode; 4 – external cathode; 5 – emitter electrode; 6 – auxiliary anode; 7 – accelerating electrode; 8, 10, 12 – cathodes; 9, 11 – anodes; 13 - flange for mounting the structure on the working chamber; 14 – matching electrode; 15 – insulators; I, II, III – areas of discharge chambers

Figure 1. - Appearance and internal structure of the developed layout electron-ion source with crossed E × H fields

At the same time, the magnetic field generated by the cathodes 8, 10 and 12 forms a magnetic focusing system for an accelerated electron beam propagating along the axis of this (second) gas-discharge structure until the ion-electron beam exits the source into the process chamber. A voltage is applied between the electrodes 12 and 14 that accelerates the ions to the ion energy required by the technology. At the same time, in this gap (between the electrodes 12 and 14), the beam of electrons accelerated in the gap between the electrodes 6 and 7 is decelerated. The ion emitting plasma surface formed between the electrodes 12 and 14 determines the paths of both ions and electrons in space drift of the electron-ion beam to the sputtered target, and therefore determines the distribution of the density of ion and electron currents on the surface of the target.

Each discharge chamber of a single structure has an independent power supply and acceleration system, which allows the formation of various operating modes of the entire source as a whole.

Figure 2 shows the current-voltage characteristics of extraction during the simultaneous formation of an electron beam (discharge chamber I, Fig. 1) and ions (discharge chambers II and III, Fig. 1) for two modes: a fixed voltage of the unit accelerating ions at the level of 1.5 kV and variation the electron accelerating voltage and the second mode of operation, when the electron accelerating voltage was recorded, and the ion accelerating voltage was varied.

In the case of a fixed ion accelerating voltage in section I (curve 1, Fig. 2), almost complete compensation of the electron beam is realized in the range from 0 to 1.5 kV and the current into the Faraday cup is close to zero. When the electron accelerating voltage exceeds +1.5 kV (a fixed value of the ion accelerating voltage -1.5 kV), the current in the Faraday cup rises, but it (region II on curve 1, Fig. 2) is lower than the value of the emission current obtained in this structure when initiating a discharge in the discharge chambers I and II and the supply of accelerating electrons voltage.

When the electron acceleration voltage is fixed at +1.5 kV and the ion acceleration voltage is varied (region I, curve 2 in Fig. 2), the current into the Faraday cylinder undergoes an abrupt change in polarity in the voltage region of 1.5 kV (Fig. 2, curve 2), which indicates the mutual compensation of the electron and ion beams to this value and the prevailing emission from the ion source at voltages above 1.5 kV. The ion emission current at a

voltage of 3 kV is 45 mA, and the ion emission current density is about 10 mA/sm^2, which indicates the prospects of developing an electron-ion source based on this design for the industrial implementation of various processing technologies and surface modification of materials.

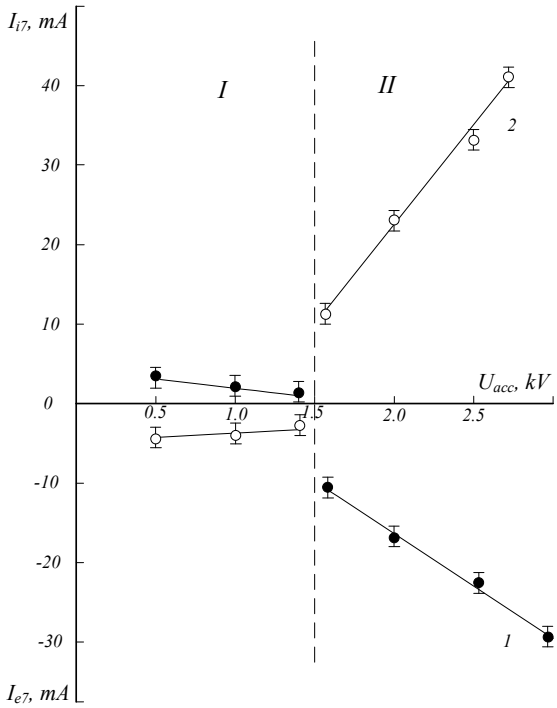


Figure 2. - Current I_7 (into the Faraday cylinder). I_{e7} is the electron current in the Faraday cylinder. I_{i7} is the ion current in the Faraday cylinder.

(1) fixed ion acceleration voltage of 1.5 kV.

(2) fixed electron acceleration voltage of 1.5 kV.

The discharge current in chamber I (Fig. 1) is 200 mA, and the burning voltage of the discharge is 420 V. The discharge current in chamber II (Fig. 1) is 180 mA, and the discharge voltage of the discharge is 410 V

It should be noted that in Figure 2, in region I, there is an area of uncertainty in the polarity of the emission current, which is apparently caused by the presence of double electric layers in the discharge structures II and III (Fig. 2). At accelerating voltages of more than 1.5 kV in region II (Fig. 2), the field of double electric layers already has a weak effect on the movement of charges in gas-discharge structures II and III (Fig. 2), and the currents of electrons I_{e7} and ions I_{i7} (Fig. 2). 2) have certain values.

The experiments were carried out in a wide range of gas inlets (1.1-3.5) mPa·m^3/sec and discharge currents (0.18-0.24) A. The characteristics were similar to those presented and are not shown in the figures. The linear form of current-voltage characteristics provides high controllability of the technological characteristics of the source. The presence of additional discharge structures and corresponding power supply systems, of course, complicates the design of the source, however, the uniqueness of the influence of voltage in additional power supplies on the extraction characteristics of the source as a whole allows you to create a common coordinated automated control system. The above characteristics indicate the possibility of developing a technological source of charged particles for the implementation of technologies that require combined exposure to electron and ion beams.

Conclusion. The presented design of a plasma source of charged particles are far from exhausting the whole spectrum of possible technological and constructive solutions, but only shows the potential possibilities of this type of sources for solving urgent problems of forming technological combined electron and ion beams for implementing electron-beam assisting by plasma-chemical processes or combined exposure to electron and ion beams. Although the tests performed showed the promise of the developed design for implementing the regimes of electron beam formation with an increased perveance and the formation of joint electron-ion beams, the capabilities of the developed structure are not limited to these operating modes. The proposed design can serve as a prototype for the creation of technological sources for the formation of compensated ion beams,

beams of neutral atoms, or for the implementation of alternating or simultaneous exposure to beams of both types of charged particles. Such sources can become a unique universal tool for applying film coatings for various purposes [11-13]. Such systems may be of interest as individual sources, as well as cells of a multi-bit source for forming an effect on large areas.

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ELECTROMECHANICAL MEASURING UNIT OF ELECTRON BEAM DIAGNOSTICS APPARATUS

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In this paper, we formulate a list of the main characteristics of the electron beam responsible for its technological properties and to be diagnosed, and propose the design of the electromechanical unit of the developed system that diagnoses the parameters of electron beams formed in electron-optical systems based on plasma emitters.

Introduction. Expanding the possibilities of industrial application of plasma emitter-based beam devices requires solving a number of theoretical and practical problems. In particular, scientific and practical interest is the development of electron-optical systems (EOS) of such a design that would provide maximum efficiency by reducing the beam divergence in the region of its primary formation, i.e. a search is required for the optimal geometry of the electrodes of the gas-discharge structure and the accelerating gap [1].

To optimize the EOS, it is advisable to use the parameters of the electron beams responsible for its quality: the beam divergence, its brightness, and generalizing these characteristics are emittance [2]. In turn, for their measurement, it is necessary to develop diagnostic equipment. Moreover, for the automatic processing of information (construction of three-dimensional surfaces, determination of the phase portrait of the beam, calculation of emittance and brightness), it is necessary to develop appropriate software. A similar complex, including an electromechanical device, a control system and a software package, can be used not only to optimize the designs of plasma sources under development, but also other beam devices in order to increase their technological efficiency and beam quality.

In this paper, a list of the main characteristics of the electron beam, responsible for its technological properties and subject to diagnosis, is formulated and the design of the electromechanical unit of the developed diagnostic system is proposed.

Physicotechnical parameters for evaluating the technological capabilities of electron beams. Plasma electron sources should provide the parameters that are necessary for the implementation of certain modes of electron beam exposure. These parameters include the following:

– emission current density;

– energy efficiency associated with the efficiency of switching the electronic component of the discharge current forming the emitting plasma into the beam;

– the value of the flow (pressure) of the plasma-forming gas.

Emission current density – j_e depends on the plasma density (value of the discharge current) and the result of the superposition of the field of the parietal layer with the length of the layer l_l in the emission channel of radius r_0 and the field of the accelerating electrode. In the near-wall layer, a negative (potential inhibiting for electrons) drop in potential is usually realized, and for $l_l > r_0$ the electrons leave the plasma in the accelerating gap through the potential barrier. The accelerating field penetrating the emission channel(s) reduces the potential barrier for electrons and, accordingly, increases the density of the emission current. In this case, the emission of electrons is carried out from the open plasma boundary, and then the emission current density becomes equal to the density of the thermal current of the electrons in the plasma, significantly exceeding the current density to the electrodes of the discharge chamber (discharge current). When the field of the accelerating electrode penetrates the discharge chamber through the emission channel, the emitting plasma surface may exceed the area of the emission channel. In this case, a beam crossover is formed in the channel, in which the current density is higher than the density in the plasma.

Extraction efficiency – $\alpha = i_e/i_d$ characterizes the degree of electron switching into the emission channel(s). There i_e emission current (in PES coinciding with the beam current), i_d – discharge current.

Energy efficiency (energy price of an electron in a beam). The parameter characterizes the efficiency of the plasma emitter and is determined by the ratio $H_э = \frac{i_e}{P} = \frac{\alpha}{U_d}$, where P – power spent on plasma formation (discharge power); U_d – discharge voltage.

For plasma emitters operating in stationary mode, the energy efficiency is comparable to or slightly higher than the value for thermal cathodes ($H_э$ = 10^{-2} – 10^{-3}). In a pulsed mode with a sufficiently large duty cycle (when using pulsed discharges in PES), the energy efficiency increases by orders of magnitude [3].

The value of the flow rate of the plasma-forming gas *Q* characterizes the gas efficiency of the PIEL and is determined by the necessary pressure in the gas-discharge structure, at which the plasma with the necessary parameters is formed. Since the final element of the gas-dynamic system providing gas inlet is the emission channel through which gas enters the accelerating gap, the maximum value of *Q* is determined by the required electric strength of the electron beam acceleration gap.

Complex characteristics of electron beams. When assessing the technological suitability of an electron beam for the implementation of a specific technological process, as a rule, they are limited to comparing the density of the beam power and the electron energy in the beam ($p = jU$ and $W_e = eU$, where *j* – beam current density, *U* – accelerating voltage) with required parameters [4]. However, at the stage of designing electron-beam devices, optimizing the geometry of the EOS to increase the efficiency of the electron gun in specific gas-dynamic conditions, as well as developing new technologies, it becomes necessary to obtain, compare, and correct as more specific parameters (divergence, current density distribution, electron plasma temperature, maximum beam diameter), as well as complex characteristics that allow you to compare beams (emittance, brightness) by determining their quality. To evaluate each of the particular characteristics, there are developed methods that allow them to be studied depending on external conditions. However, all these parameters are interconnected and a change in one leads to a change in the other. This situation makes it difficult to compare the quality of the beams based on one of the parameters. Therefore, to obtain an integral characteristic of the quality of the beam and their comparative analysis, it is advisable to use complex characteristics, which, in particular, include the following:

Beam brightness - the value corresponding to the beam current, which passes into a unit solid angle, based on a unit area $B = \frac{dI}{d\Omega dS}$, where $d\Omega$ – solid angle at which the beam passes, dS – area on which the solid angle rests.

Another complex characteristic of the beam is emittance. In a first approximation, the emittance is the area of the phase portrait of the electron beam in the plane (x, x ') and / or, if necessary, in the plane (y, y'), if the beam does not have radial symmetry. If x and y coordinates are in the plane perpendicular to the direction of beam propagation (z axis), and x 'and y' are the components of the radial velocity of the electron beam, which determine the beam divergence ($\Delta\Theta_{x,y}$) in the xz and yz planes, respectively, the emittance can be determined by the following expressions

$$Э_x = \frac{1}{\pi}\int dxdx' \qquad Э_y = \frac{1}{\pi}\int dydy' \qquad Э_z = Э_x Э_y$$

If the phase portrait is an ellipse, then the brightness and emittance are interconnected by the ratio $B = \frac{dI}{d\Omega dS} \approx \frac{I}{(\pi\Delta r^2)(\pi\Delta\Theta^2)} \approx \frac{I}{\pi(x_0x_0')\pi(y_0y_0')} = \frac{I}{\pi^4 Э_x Э_y}$. To estimate the brightness of an axisymmetric beam, one can use the expression $B = \frac{I}{\pi^4 Э_x^2}$

The beam divergence angle can be estimated as $\Delta\Theta = x'_{\max} = \frac{\bar{\upsilon}_x}{\upsilon_z} = \frac{1}{\upsilon_z}\sqrt{\frac{2kT_e}{\pi m_e}} = \sqrt{\frac{2kT_e}{\pi m_e \upsilon_z^2}} = \sqrt{\frac{kT_e}{\pi eU_{уск}}}$, where T_e – electron temperature in electron volts, which can be defined as: $kT_e = \pi eUx'^2_{\max}$

Of greatest interest are three-dimensional surfaces constructed by measuring emittance. Such surfaces make it possible to effectively conduct visual comparisons of the quality of the beams when any external parameters change, and also to calculate most of the parameters of the electron beams (divergence, diameter, current density distribution, etc.). However, to build three-dimensional surfaces, it is necessary to provide storage and processing of a large amount of information, as well as high speed of its reading. Therefore, to carry out such measurements, it is necessary to develop and produce diagnostic equipment that allows one to construct a

three-dimensional image of the phase volume of the beam, determine the beam diameter in a certain plane, the divergence, emittance, brightness, and a number of additional parameters. The structural diagram of the developed diagnostic complex can be represented as follows (Figure 1).

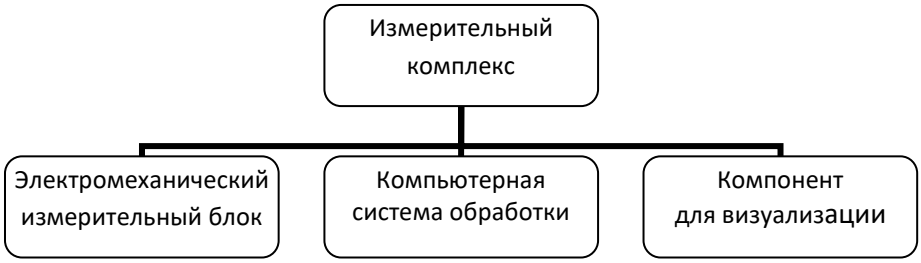
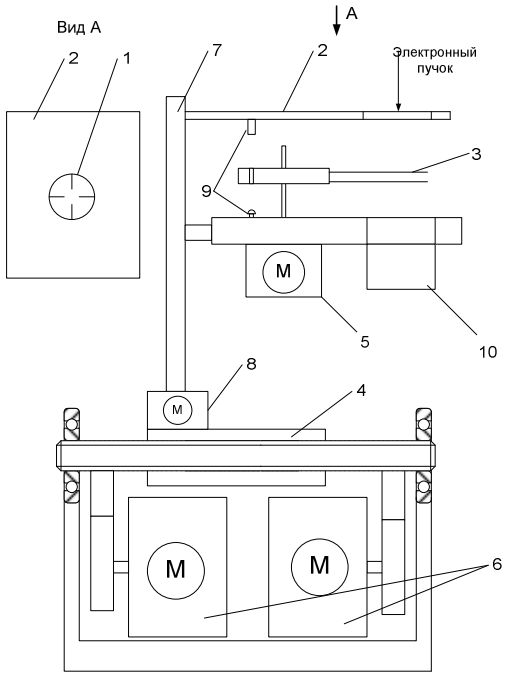


Figure 1. - Block diagram of the measuring complex

Electromechanical measuring unit. There are various methods and devices for measuring the parameters of an electron beam. Most of them contain sensors that are in direct contact with the electron beam. A thin wire [5], periodically crossing the beam, or a collector, which receives a part of the beam separated by a narrow slit, a calibrated hole, or by the straight edge of the refractory plate, can act as a sensor [5]. The sensors make it possible to obtain a current distribution in the selected part of the beam. This distribution contains information about the geometry of the electron beam, current density and power density in it, brightness and angle of convergence. Having such a set of beam data, based on the above relations, it is not difficult to establish the relationship between the beam parameters and the characteristics of the electron gun. The listed types of sensors are very similar in the way of obtaining primary information about the beam. However, there is a fundamental difference between the two. All sensors, except for a rotating probe, use to deviate or scan the beam along the required path to obtain a probe. The trajectory of the electron beam is determined by electromagnetic deflecting systems. When studying powerful focused electron beams, the contact time of the beam with the elements of the beam diagnostic system should be as short as possible. This is to prevent damage to the diagnostic device. Therefore, the deflecting coils of the gun must be high speed. In addition, additional difficulties may arise if it is necessary to measure the parameters of the beams at small distances from the deflecting coils. In such cases, the deflection angles may be unacceptably large due to possible beam distortion introduced by the deflecting coils. Creating such coils is a rather difficult task.

This paper presents one of the possible options for implementing the contact diagnostic method, in which there is no need to deflect the electron beam to measure its parameters. As a sensor, a wire double rotating probe was chosen.

The block diagram of the electromechanical unit is shown in Figure 2. The principle of operation of such a unit is as follows: the electron beam from the source passing through the positioning system sensor generates a signal to the PLC (industrial logic controller, not shown in the figure), the control signal from which is supplied to the positioning system motors and centering the equipment. Under the plate is a sensor, which is a system of two scanning probes 3, spaced vertically in space and offset by an angle relative to each other. A wire made of refractory material (nichrome, tungsten) with a diameter of about 0.1 mm and a length of 50 mm is used as sensor material. This choice is due to the criteria of heat resistance (heating up to 1000 K), mechanical strength and stiffness to prevent sagging during engine shutdown and acceleration. The probes are rigidly attached to the disk. The disk is necessary to protect the engine from exposure to the electron beam, so the diameter of the disk is larger than the diameter of the engine. The disk and the motor axis are isolated from each other. The diameter of the disk and the length of the probe are selected so that in the working area the position of the probe can be considered parallel to the centering hole through which the electron beam passes. To remove current, a needle is fixed in the center of the disk, the other end of which is gently connected to the spring-loaded current collection plate. This design does not additionally load the engine and avoids contact bounce, as the needle rotates at one point in soft metal (tin). The probe system is rotationally driven by the engine 5. The engine and plate are mounted on the shaft 7 and can be moved vertically. The rotation control and signal transmission of the measured parameters is carried out by means of a PLC. The beam is received in a grounded water-cooled Faraday cylinder.



1 - positioning system sensor; 2 - plate; 3 - system of a double scanning probe; 4 - two-position coordinate table; 5 - rotation motor; 6 - positioning engines; 7 - shaft vertical movement; 8 - engine vertical movement; 9 - optocoupler; 10 - Faraday Cylinder

Figure 2. - Structure of the electromechanical unit of the diagnostic equipment

Conclusion. The presented electromechanical unit allows you to automatically remove the current distribution to the probe and translate it and the main characteristics of the electron beam into the software environment to calculate the required characteristics and visualize the measured parameters and can be a prototype for the development of industrial systems for diagnosing the parameters of electron beams.

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THE ANALYSIS OF ELECTROMAGNETIC ENVIRONMENT CREATED BY A LINEAR SERIES OF PERSONAL COMPUTERS IN CLASSROOM OF UNIVERSITY OF CLASSICAL TYPE

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Analysis of the electromagnetic environment created by a linear series of personal computers in the classroom of university of classical type. The zones of the most significant impact of EMR from computer-class equipment on students are identified.

Keywords. Personal computer; electromagnetic radiation; university

Introduction. The electromagnetic environment in computer classes of educational institutions is characterized by the presence of various sources of electromagnetic fields of different intensity and a fairly wide frequency range. the most dangerous local source of electromagnetic fields is the video terminal – VDT) - a computer complex: displays, system blocks, uninterruptible power supplies [1].

Method of research. The analysis of the electromagnetic environment generated in a training facility of the belarusian University of linear rows of computers, additionally the study of light levels and weather conditions in the area. The object of study is the process of forming the electric and magnetic field intensity created by a linear series of computers in the computer class of the University.

The purpose of the study was to perform an analysis of the electromagnetic environment created by a linear series of personal computers in a classical-type University classroom. To achieve this goal, the following tasks were solved: 1. To investigate the sanitary and hygienic parameters of the computer class of the University of the classical type; 2. To study the features of the distribution of the electromagnetic field created by computers in educational premises. 3. Develop recommendations for controlling the field strength in computer classes.

Research result. The study of weather conditions in the room was performed using the meteomer МЭС-200А. Results are presented in table 1.

It is determined that the parameters of microclimate after one hour after the start of class do not exceed the limits regulated by norms [2].

Table 1. – The parameters of the microclimate of a computer class

Parameter	Actual value	Optimal microclimate parameter for [2]
Air temperature, °C	20.3	19-21
Relative humidity, %	58	58 at a temperature of 20°C
Air speed, m/s	0.06	No more than 0.1

An equally important parameter that is normized in educational institutions is the illumination in classrooms. The room where students or employees use the video display terminal must have both natural and artificial lighting. Natural lighting should be provided through North -, North-East -, East -, West -, and North-West-oriented light openings, and the natural light coefficient shouldn't be lower than 1.5 %. The study was carried out under combined lighting (a combination of natural one-sided lateral with artificial General uniform), with the orientation of the light opening to the North-West. Figure 1 shows the change in the natural light coefficient (%) and the light index at a height equal to the table surface (E, in Lux) at distances from 1 to 6 meters from the light opening. At a distance of 6 m from the window, the indicators of the light environment increase, because artificial light begins to prevail.

Despite the fact that the value of the natural illumination coefficient corresponds to the standards in all points of the room (more than 1.5%), the illumination at the height of working surface is several times lower than the required 300-500 Lux [2], which significantly reduces the efficiency of visual work.

It is well known that the side and back walls of a computer monitor and other components are powerful source of electromagnetic radiation, with different frequency ranges of operation, for example: the frequency of 50 Hz is typical for a network monitor, a power supply transformer; 20-100 kHz of a static voltage Converter in a pulse power supply; 48-160 Hz of frame scan and synchronization units; 15-110 kHz-a line scan and synchronization unit; 50 Hz -1000 MHz of a system unit (processor); 20-100 kHz of uninterruptible power supplies, etc. [3]. According to [2], the following maximum permissible levels of electromagnetic fields from VDT are set, given in table 2.

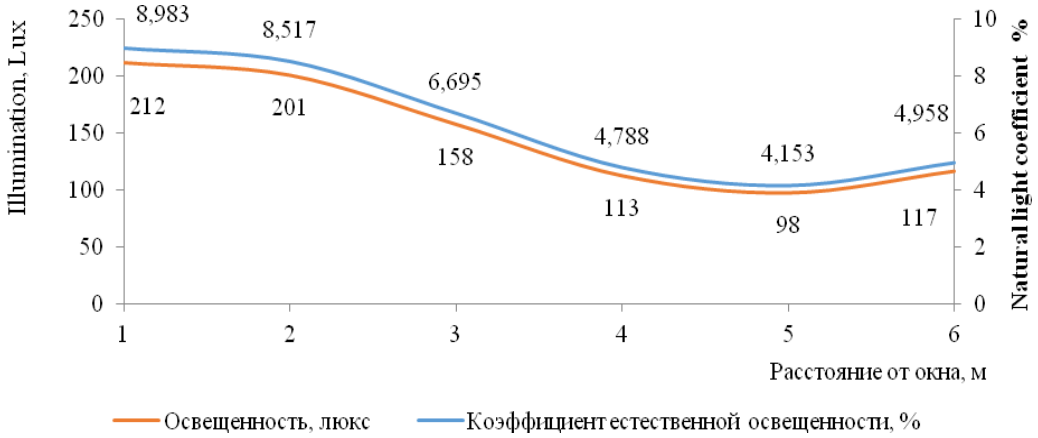

Figure 1. - Changing the conditions of the light environment depending on distance from the light opening

Table 2. – Maximum permissible levels of electromagnetic fields from VDT

Name of parameter	Permissible level
Electric field strength in the frequency range:	
5 Hz - 2 kHz	less than 25.0 V/m
2-400 kHz	less than 2.5 V/m
Magnetic flux density of the magnetic field in the frequency range:	
5 Hz - 2 kHz	less than 0.250 MTL
2-400 kHz	less than 025 nTl

Measurement of electric field intensity and magnetic flux density of the magnetic field was performed using a device «ВЕ-метр-АТ-002» in half an hour after powering the computer on a horizontal surface at distances of 10, 30, 50, 70 and 90 cm in front of LCD displays, their rear surfaces with left and right side surfaces, and at distance of 100 cm in the centre front between the side surfaces of adjacent displays.

Distribution dependences on the distance to the source of the highest values of electric field strengths and magnetic flux densities in the frequency range 2-400 kHz (Figure 3), created by a linear series of computers located along the walls of the University's classroom, are shown in figures 2 and 3, respectively.

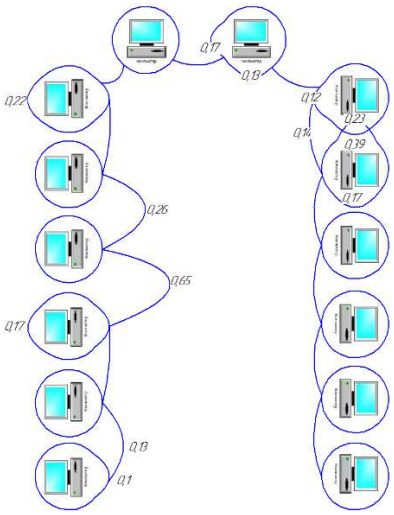

Figure 2. - The electric field Strength generated by a linear series of computers in the frequency range 2-400 kHz in V/m

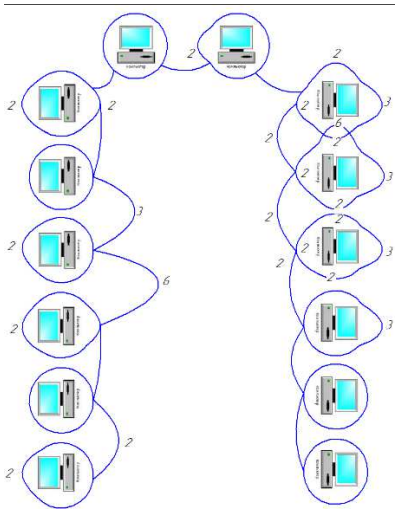

Figure 3. - The magnetic flux Density created by a linear series of computers in the frequency range 2-400 kHz in nTl

It should be noted that in the frequency range from 5 Hz to 2 kHz, the electric field strength values at all observation points do not exceed 0.01 V/m, which means that there is minimal or no EMI influence in the specified frequency range.

Analysis of the characteristics of the distribution of the intensities of electric fields in the frequency range of 2-400 kHz, is shown in figure 2 allowed us to establish that despite the absence of exceeding the RC (the value of 0.65 V/m 4 times below the permissible limits) the range of VDT manifests itself as antenna array, there is a growth with distance from sources, likely because of the imposition of AMY. A similar relationship is observed in the distribution of the magnetic flux density shown in figure 3. There is also no excess of norms for this indicator, the maximum value of 6 nTl is 4 times lower than the PDU. The maximum EMI falls in the middle of the linear row of computers, and closer to the edges of the row it falls off.

For one of the VDT, an in-depth analysis of the EMR propagation from the distance from the source in the horizontal plane (on the sides of the world) at a height of one meter from the floor was performed, the results of which are shown in figures 4-6.

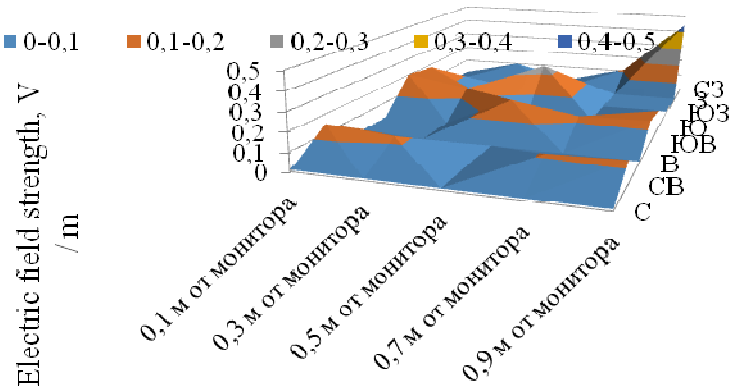

Figure 4. - Value of the intensity of the alternating electric field VDT in the frequency range 2..400 kHz in V/m

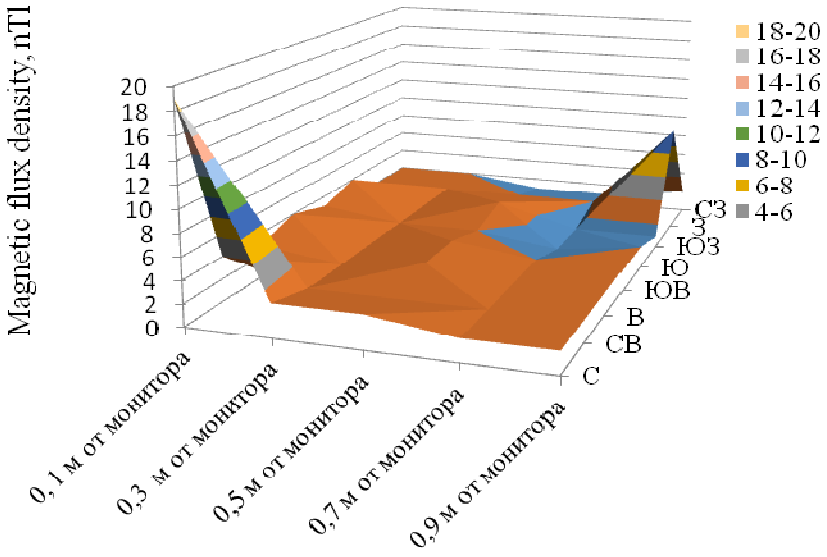

Figure 5. - Value of the magnetic flux density, VDT in the frequency range 2..400 kHz in nTl

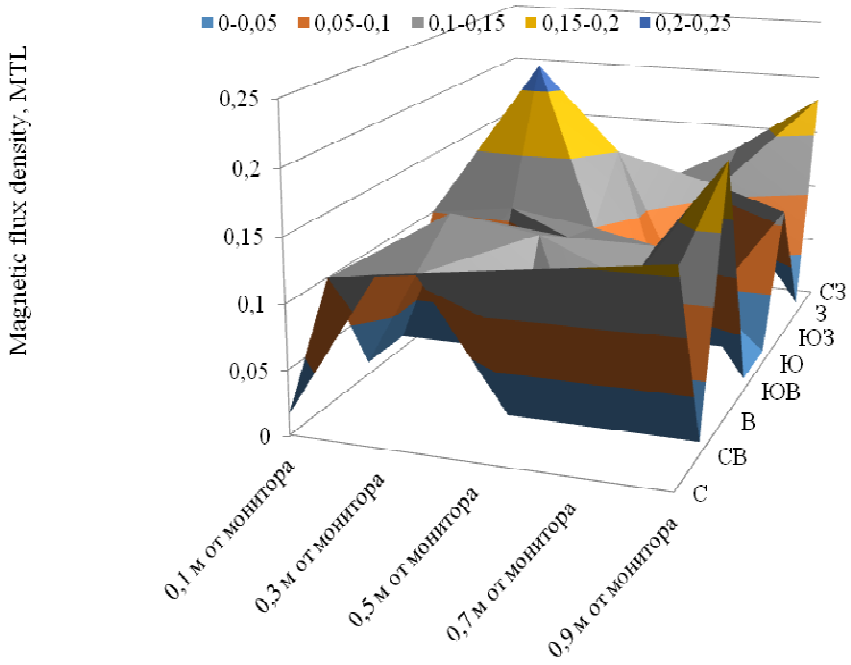

Figure 6. - Value of the magnetic flux density, VDT in the frequency range of 5 Hz-2 kHz in MTL

Analysis of the EMI prevalence from the distance from the source in the horizontal plane showed that with increasing distance from one VDT, which is part of a linear series of computers, both the field strength and the magnetic flux density increases and exceeds the field strength and magnetic flux density created by one individual computer.

Conclusion. The analysis of the electromagnetic environment created by a linear series of personal computers in a classical-type University classroom allowed us to come to the conclusion that it is necessary to measure the electric field strength and magnetic flux density in the range 2..400 kHz at a distance of 0.5 meters from the monitor, as prescribed by the rules, and 1 meter, where it is possible to exceed the remote control for EMI, due to the fact that the linear range of VDT can manifest itself as an antenna array.

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MOLECULAR WEIGHT DISTRIBUTION OF N-PARAFFINS IN COMPLEX FUEL MIXTURES AND THEIR EFFECT ON COMMODITY DIESEL FUELS SPECIFICATION

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A comparative analysis of the molecular weight distribution of n-paraffins in diesel fuel mixtures is made and the impact of n-paraffins on the specification of commercial diesel fuels is studied.

The effectiveness of depressant-dispersant additives is largely determined by the composition of diesel fuel (DT) and its characteristics. Fuels with various hydrocarbon compositions and qualitative characteristics have different abilities for injectivity of depressant-dispersing additives. Based on this, the interaction of the additive with diesel fuels of various fractional and group hydrocarbon composition and the effect of n-paraffins contained in the fuel were evaluated.

It has been noted more than once that diesel fuels with wide boiling ranges are more susceptible to depressant-dispersant additives than fuels of narrow fractional composition. For this reason, depressant-dispersant additives differ in sensitivity to the fractional composition of fuels [1].

Objective: to determine the optimal potential of the intermolecular distribution of n-paraffins with a chain length of C_{17} to C_{33} in diesel fuel. The detailed study of the qualitative and quantitative composition of n-paraffins contained in diesel fuels grade F and class 2, and their direct effect on the operation depressant-dispersant additive is carried out with the method of ASTM D 5442-2017. The standard method to test petroleum paraffins by gas chromatography ASTM D 5442-2017 describes the quantification and distribution of paraffins by the number of carbon atoms in the range from n-C_{17} to n-C_{44}. Based on the obtained data, graphical dependencies of the n-paraffins molecular distribution on their content and mass concentration in oil products were derived.

The high susceptibility of n-paraffins to depressants and dispersants is due to action of the additives, which interact with crystallizing paraffins. N-paraffins in fuels significantly worsen its low-temperature properties, since they have a high pour point. There is an optimum content of paraffins in the fuel in which the additive effect manifests itself best. If there are too many paraffins, then the effectiveness of any additives is reduced. Heavy paraffin hydrocarbons readily form crystal nuclei, deteriorating low-temperature properties of diesel fuel. However, they are necessary so that the depressor can be sorbed on their surface. This means that paraffins have a positive effect on the fuel injectivity to depressants and dispersants.

The solid phase released from the fuel is a high-melting hydrocarbon mainly of the paraffin series, as well as aromatic and naphthenic hydrocarbons with long side chains.

DT consists of the following n-paraffins: C_{20} –, BP 345°C
C_{21} – BP, 358°C
C_{22} – BP, 371°C
C_{23} – BP 383°C
C_{24} – BP, 394°C
C_{25} - C_{30} – MP, 53-65°C
C_{31} – C_{34} - MP, 67-72°C

In this case, the temperature lowers, and high-melting hydrocarbons primarily fall out on the crystal lattice of which hydrocarbons with a lower melting point containing a smaller number of atoms in the molecule, successively crystallize. Their growth rate depends on the cooling rate of the fuel, the intensity of mixing, viscosity and the presence of additives. The magnitude of the pour point and the cloud point are mainly dependent on the total wax content, as well as on the fuel composition and solubility. Equally important are such characteristics of paraffins as molecular weight, normal paraffinic chain length, and the molecular weight distribution.

The results of OJSC "VNII NP" research [2] showed that each DT type is characterized by an optimal content of paraffinic hydrocarbons, in which the effect of depressants appears best. Practical data: content C_{19+} about 3 % mass. (a boiling range of diesel fuel 160-370 ° C).

It was found that for each type of fuel there is its own optimal paraffin depressant-dispersant composition in which the desired effect is observed. Effect of temperature input is also important for the additive. 40-50°C is the optimum temperature.

The prototype of the study is a patent [3], which is based on the addition of a heavy component to the diesel fraction with further consideration of the effect of high-boiling paraffins on the low-temperature properties of diesel fuel and additive injection.

To conduct research, we used samples of diesel fuel and petroleum products of various fractional composition, and atmospheric gasoil and the residue of mild hydrocracking as fractions containing saturated hydrocarbons, (Table. 1, Fig. 1), and the additive of the Clariant company *(Switzerland)*.

Table 1. – Oil products quality indicators

Diesel Fuel	DT Fraction (180-300)°C	Mixed DT Fraction (180-360)°C	Atmospheric Gasoil	Mild Hydrocracking Residue
Fractional Composition				
Initial Boiling Point, °C	174	184	213	358
10%, °C	205	216	279	380
50%, °C	243	278	329	390
90%, °C	282	338	358	410
95%, °C	291	351	364	418
Final Boiling Point, °C	297	357	367	433
Total Distillation, % об	98.5			
Cloud Point, °C	-29	-7		
Limit Temperature Filterability, °C	-30	-8		

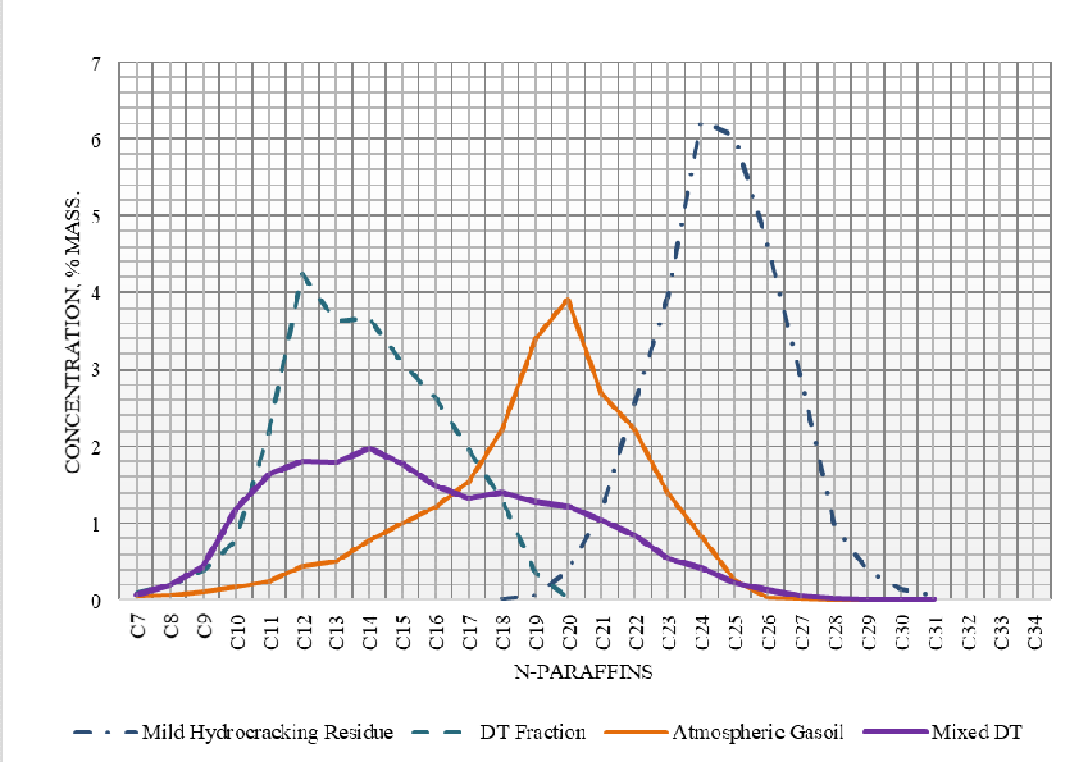

Figure 1. – Molecular weight distribution of n-paraffins in diesel fractions

With a constant amount of depressant-dispersant additive, changing only the amount of mild hydrocracking residue introduced into the diesel fraction, a significant decrease in the limiting filterability temperature and an increase in the cloud point are observed (Table 2). The greatest effect and decrease in the limiting filterability temperature is observed with the addition of 3.8% of the mass of the residue.

By varying the amount of the atmospheric gasoil, we observe the same changes of the low temperature properties. The only difference is that in this case, atmospheric gasoil consumption is much greater. The best results in terms of "limiting filterability temperature" were obtained by using the mild hydrocracking residue containing high molecular paraffin hydrocarbons.

Table 2. – Change of the low-temperature properties of diesel fuel by the amount of mild hydrocracking residue

Diesel Fuel	DT Fraction(180-300)°C					
Amount of Mild Hydrocracking Residue, % mass.	0	1.3	2.5	3.8	5	6.1
Amount of DT Fraction, % mass.	100	98.7	97.5	96.2	95	93.9
Dodiflow S-142, ppm	200	200	200	200	200	200
Limiting Filterability Temperature, °C	-30	-30	-36	-43	-22	-18
Cloud Point, °C	-29	-26	-23	-20	-16	-11
Limiting Filterability Temperature of the 20% Lower Layer, °C	-30	-29	-25	-28	-17	-18

A similar dependence of the low-temperature properties on the amount of the mild hydrocracking residue is observed for mixed DT (Table 3). In this case, we considered only the effect of adding the mild hydrocracking residue, since atmospheric gasoil is already present in the DT mixture.

Table 3. – Change of diesel fuel properties by the amount of mild hydrocracking residue and atmospheric gasoil

Diesel Fuel	DT Fraction (180-300)°C									Mixed DT Fraction (180-360)°C				
Amount of Atmospheric Gasoil, % mass.	0	1.3	2.5	3.8	4.9	6.1	7.2	8.3	9.4					
Amount of Mild Hydrocracking Residue, % mass.										0	0	0.8	1.6	2.4
Amount of DT Fraction, % mass.	100	98.7	97.5	96.2	95.1	93.9	92.8	91.7	90.6	100	100	99.2	98.4	97.6
Dodiflow S-142, ppm	200	200	200	200	200	200	200	200	200	0	600	600	600	600
Limiting Filterability Temperature, °C	-30	-30	-30	-30	-31	-32	-33	-35	-37	-8	-21	-23	-28	-33
Cloud Point, °C	-29	-28	-28	-26	-25	-24	-23	-20	-16	-7	-7	-6	-6	-5
Limiting Filterability Temperature of the Lower Layer, °C	-30	-29	-29	-29	-30	-30	-31	-31	-34		-16	-18	-25	-33

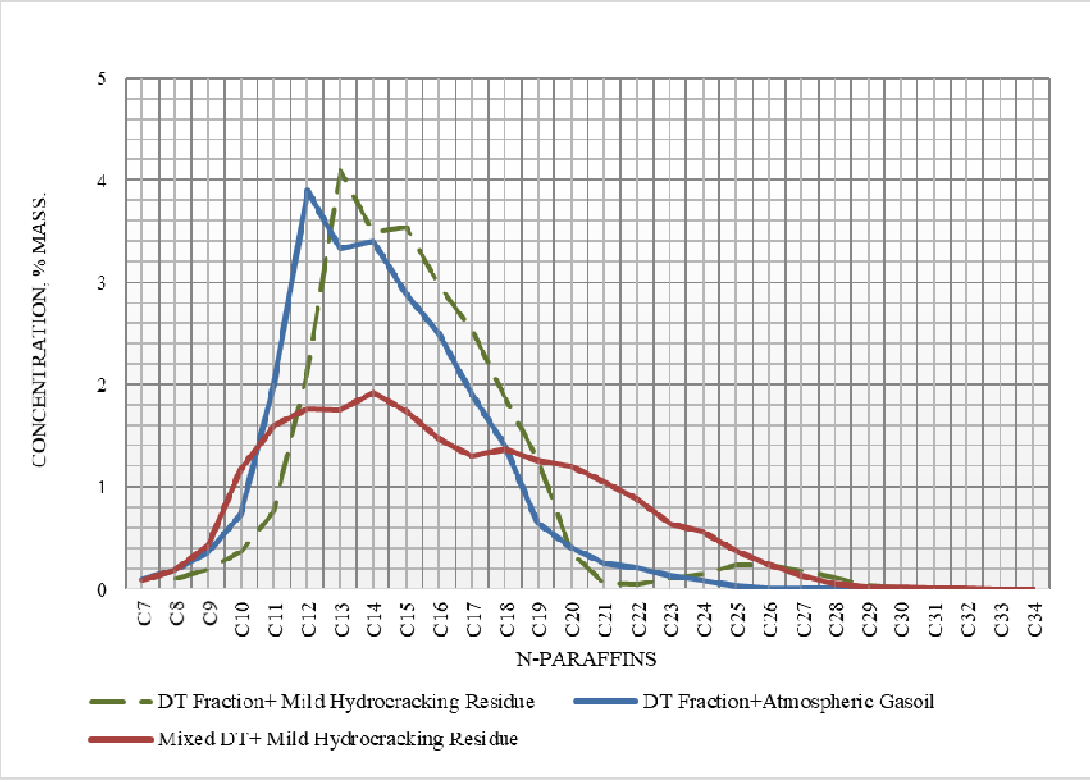

Figure 2. – Molecular weight distribution of n-paraffins in mixtures of analytes

The graph (Fig. 2) shows that paraffin hydrocarbons C23-C31 and higher provide the injectivity of additives and promote their action, thereby improving the low-temperature properties of diesel fuel. The heavier fractions of atmospheric gasoil and the mild hydrocracking residue can significantly lower the temperature of the limiting filterability temperature.

Thus, the method and systematic approach to studying the effect of n-paraffins in the composition of complex fuel mixtures allows to increase the forecast of the operation and quality characteristics of commercial fuels.

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THE DIRECTIONS FOR RATIONAL USE OF RESIDUAL PRODUCT OF THE PROCESS «UNICRACKING»

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Introduction. *The possibility of obtaining white oils from petroleum raw materials is considered. The properties of the residual product of the hydrocracking process purified with activated clay are studied. The possibility of using the adsorption method of purification in the production of white oils is shown.*

The residual product of the hydrocracking process of vacuum gasoil obtained by the "Unicracking" technology is a complex mixture of high-boiling compounds, consisting mainly of paraffinic and naphthenic hydrocarbons with ultra-low sulfur content. This product can be used not only as a component of low-sulfur fuel oil, but also as a raw material for the production of lower olefins [1], which are the raw material base of the modern petrochemical industry; obtaining base oils corresponding to group III according to API classification [2]; and greases [3].

One of the perspective areas of complex processing for refining residual product of the process "Untracking" is the production of white oils. These oils can be used both for technical purposes and in medicine, pharmacology and cosmetology. The most important indicators of the white oils quality, in addition to kinematic viscosity, density and flash point, are: pour point, color and content of aromatic hydrocarbons. White oils should be a colorless oily, transparant, non-fluorescent, odorless and tasteless liquid.

To prepare white oils, the residual product of the "Unicracking" process must be dewaxed and thoroughly cleaned. The traditional method of producing white oils is sulfuric acid purification of oil fractions. But this method is not effective for the purification of the studied raw materials. White oils can be obtained by deep hydrogenation of the residual product of the hydrocracking process [4]. However, the implementation of this technology requires large investments.

One of the most effective and relatively simple ways to obtain white oils from the residual product of the hydrocracking process is the adsorption purification method.

One of the most important technical indicators for white oil is the percentage distribution of hydrocarbons. Special requirements are imposed on the content of aromatic hydrocarbons, since they are toxic. Technical white oils should contain aromatic hydrocarbon less than 7% of the total mass, and medical white oils should contain less than 0.1%. Another important indicator is color in accordance with ASTM D 1500. For both technical and medical white oils, this indicator, as determined by ASTM D 1500, should be less than 0.5 [5].

To achieve these indicators by adsorption cleaning of the residual product of the vacuum gas oil hydrocracking process, it is necessary to select an effective adsorbent. In industry, bleaching clays are used as adsorbents. Adsorption cleaning can significantly improve the color and storage stability of oils and fats. Different classes of bleaching clays are used for cleaning.

The first group forms a class of highly active, mainly based on montmorillonite, selected HPBE clays (high performance bleaching earth). This group includes, in particular, acid-activated montmorillonites, and acid activation is carried out in an expensive way: by dealumination of unburned clays with concentrated acids at high temperatures. Using this method, the selected clays are obtained with a very high specific surface area and a large pore volume. The disadvantage of these highly active bleaching clays is that due to acid dealumination, large amount of acidic, salt-rich wastewater accumulates during production, which can only be treated or disposed of using expensive processes.

Another group forms a class of naturally active clays. These natural bleaching clays have been used for cleaning fats and oils for hundreds of years. These naturally active systems (also known as floridine or fuller's earth) can be obtained at a very low cost. However, they have very little bleaching ability, so most of them are not suitable for cleaning difficultly bleached oils and fats.

The trade-off between low production costs and acceptable activity is represented by the third class of bleaching clays, the so-called surface-activated SMBE systems (surface modified bleaching earth; surface-activated bleaching clays). Here, small amounts of acid are introduced into the naturally active unburned clay and this achieves "in situ" activation. For this method, unburned clays containing attapulgite and hormite are used. They have a very high specific surface area for natural unburned clays: from about 100 to 180 m^2/g, and the pore volume from about 0.2 to 0.35 ml/g. Since the salts formed during acid activation, or the unreacted

portion of the acids are not washed out, they remain on the product and at least partially also precipitate in the pores. Because of this, acid-activated bleaching clays usually do not achieve the same efficiency as is achieved with highly active bleaching clays (HPBE) obtained by acid dealumination. However, the simple production method allows for relatively economical production, since acidic wastewater does not accumulate. [6].

Studies have shown that the adsorption purification of the residual product of the hydrocracking process using active clay can produce white oil. The properties of the purified product are shown in the table.

Table. – The properties of the purified product

Parameter	Value
Kinematic viscosity at 40°C, mm^2/sec	40,82
Kinematic viscosity at 100°C, mm^2/sec c	6,88
Viscosity index	127
Refractive index at 50°C	1,4558
Refractive index at 20°C	1,4661
Colour, units (ASTM D 1500)	0
Density at 20°C, kg/m^3	842,0
Acid value, mg KOH/gr.	0,0014
Group composition, % by weight.:	
– paraffin-naphthenic hydrocarbons	99,72
– 1 group of aromatic hydrocarbons	0,27
– 2 group of aromatic hydrocarbons	0
– group of aromatic hydrocarbons	0
– group of aromatic hydrocarbons	0
– resins	0,01

Based on the quality indicators of the resulting product, we can conclude that this oil is suitable for technical needs. During the adsorption process on activated clay, the adsorbent is tarred and it changes its color from white to coal-black. In this regard, there is a need for further purification and regeneration of the adsorbent [7].

Conclusion. One of the promising and relatively simple ways to obtain technical white oils is the adsorption purification of the residual product of the vacuum gas oil hydrocracking process using active clays. The resulting product can be used as technical white oils.

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INFLUENCE OF TECHNOLOGICAL PARAMETERS OF HIGHPRESSURE POLYETHYLENE SYNTHESIS ON THE CONDITIONS FOR SAFE REMOVAL OF RESIDUAL MONOMER

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The article presents the research results concerning the influence of highpressure polyethylene synthesis plant parameters on the content of residual ethylene in the polymer. The developed method for determining dissolved ethylene in obtained fresh polyethylene is shown.

Incomplete conversion of ethylene during polymerization (no more than 20%) requires separating the polymer from the monomer and returning unreacted ethylene to the cycle. Separation is usually carried out in two stages: in the highpressure separator at a pressure of 18-25 MPa and in the lowpressure separator at a pressure of 50-400 kPa.At the same time, up to 0,2% ethylene remains in granulate, depending on the previous separation conditions in the separators [1,2]. To determine the relationship, the influence of such technological parameters as pressure and temperature in separators, the melt flow index, and the productivity of synthesis plants on the monomer content in the fresh polymer is considered.

To determine the content of the residual monomer in polyethylene, the method of chromatography of the gas environment in which the polymer was degassed was used. The selected sample of polyethylene weighing 1±0,2 kg was distributed evenly for its degassing. At the same time, the necessary technological parameters were registered for the research. At intervals, a sample of polyethylene weighing 3±0,05 grams was transferred to a 500 cm^3 gas pipette. Polyethylene was degassed in a gas pipette for about a day to establish equilibrium state (figure 1).

Figure 1. – Degassing of the samples of polyethylene

The first sample was introduced into the pipette immediately after the selection of granules to determine the initial content of ethylene in polyethylene. After holding the air sample was sent for chromatographic analysis [3-7].

The obtained values of the hydrocarbon concentration in the air sample were recalculated to obtain the value of the ethylene content in the polymer (1):

$$C = \frac{T_0 \cdot V \cdot C \cdot M}{22{,}4 \cdot T_1 \cdot m} \quad (1)$$

Where m – weight of a polyethylene sample in a gas pipette, g.; V –volume of the gas pipette, L.; C– concentration of hydrocarbon in the air sample, % vol.; M –molar mass of the hydrocarbon, g/mol; T_0– air temperature under normal conditions, K; T_1 – air temperature during the research, K.

The content of residual ethylene in the polymer is determined by the formula (2):

$$x = \frac{Y \cdot P}{H} \quad (2)$$

Where *x*- ethylene content in the liquid phase, mass fraction; *H*- Henry's constant; *P*- pressure, atm.; *Y*- molar fraction of ethylene in gaseous phase.

The dependence of the Henry's constant on the temperature for ethylene is described by the equation (3):

$$ln\ H = 8{,}173 - \frac{148300}{T^2} \quad (3)$$

Where T – temperature, K [8].

Results, their discussion and perspectives. The results of the research are shown in table 1.

Table 1. – Results of the research on the content of residual ethylene in polyethylene

Low pressure separator		High pressure separator		Melt flow index, g/10min	Productivity, kg/h	Content of ethylene in LDPE, mg/kg		Deviation from the calculated,%
Pressure, atm.	Temperature, °C	Pressure, MPa	Temperature, °C			calculated	factual	
Autoclave reactor								
Grade 12203-250								
1,49	193	20,1	225	26,5	990	832,3	537,24	35,5
1,7	191	20,7	209	25,3	1940	955,2	736,39	22,9
Grade10903-020								
1,53	194	20,6	222	2,06	1480	852,2	647,36	24,0
1,66	196	21,7	223	2,04	2170	919,2	749,37	18,5
Tubular reactor								
Grade 15803-020								
3,03	193	23,9	208	2,11	10000	1692,6	1210,6	28,5
3,55	195	24,5	209	2,18	11500	1971,5	1448,8	26,5

As seen in the table, there is a good convergence of the results of the calculated and actual content of residual ethylene in polyethylene. The existing discrepancies (from 18,5 to 35,5%) are explained by removing some of the ethylene from the LDPE directly at the granulation stage and cooling granulate with water from 190-200°C to 40-60°C. Ethylene released at this stage is quantified in the exhaust air.

Dependence of the ethylene content in granulate on the pressure and temperature in high and low pressure separators. The results of the study of the parameters of the lowpressure separators show that the increase in pressure in the lowpressure separator leads to a significant (almost proportional) increase in the calculated and actual content of residual ethylene in polyethylene.The content of the residual monomer in the polymer increases by 20% when the pressure increases from 3,03 to 3,55 atmospheres (absolute) for the 15803-020 polyethylene grade. Double increase of the residual monomer content was observed at the pressure increase in the separators from 1,66 to 3,55 atmospheres (absolute) when comparing polymers of grades 10903-020 and 15803-020 with melt flow indexes of about 2g/10min.

The effect of pressure in highpressure separators on the content of dissolved ethylene in the polymer is also observed. When comparing the analyses results for each grade of polyethylene it can be seen that the increase in pressure in the high pressure separators leads to insufficient degassing of the polyethylene melt, which transported to the lowpressure separator with higher ethylene content. At the same time, with pressure increase in the highpressure separator, the increase in pressure is observed in the lowpressure separator, as a result of which the concentration of residual ethylene in the melt increases.

The research of the dependence of the monomer content in the polymer on the temperature in the separators showed that this parameter affects the quality of LDPE degassing to a lesser extent than the pressure. At the same time, temperature decrease in the highpressure separator leads to deterioration of degassing of the melt. This can be observed on polyethylene of the grade 12203-250. The decrease of the melt temperature from 225°C to 209°C negatively affected its degassing in the highpressure separator and the subsequent increase of

the load on the lowpressure separator, which led to the increase of residual ethylene concentration in polyethylene [9].

Dependence of the ethylene content in granulate on the polymer melt flow indexes. The research showed that polyethylene grade 12203-250 with a melt flow index of 25g/10min is degassed more completely in comparison with LDPE grade 10903-020, which has a melt flow index of 2g/10min. When comparing the ethylene content in polyethylene with a melt flow index of 26,5g/10min and polyethylene with a melt flow index of 2,06 g/10min it was observed that at almost the same pressure in the lowpressure separator, the ethylene content in polyethylene of 12203-250 was 20% lower than in LDPE of 10903-020. As a polymer with a high melt flow index has lower viscosity, this allows to degas it better in high and low pressure separators, especially after removing ethylene from the melt, which is in the form of bubbles.

The relationship between the productivity and ethylene content in fresh polyethylene.The effect of synthesis productivity on polymer degassing can be seen in all three grades of polyethylene. When comparing the process parameters and the content of dissolved monomer in the LDPE, it can be seen that an increase in productivity leads to pressure increase in the separators. This is due to the fact that increase in productivity leads to decrease of time the melt presence in the separators. There is also increase in the pressure drop between apparatuses, resistances of which increase with increasing productivity.

Thus, the influence of such parameters as temperature and pressure in separators, melt flow index, and plant productivity on the concentration of residual ethylene in granulated polyethylene was confirmed.

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DETERMINATION OF THE WEAR VALUE OF ULTRAHIGH MOLECULAR WEIGHT POLYETHYLENE DEPENDING ON ADDITIVES

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Introduction. In recent years, there has been increased interest in new synthetic polymers that have a number of unique properties. Among these polymers, the most interesting is ultra-high molecular weight polyethylene (UHMWPE) due to the presence of a whole complex of valuable properties.

UHMWPE includes polyethylene (PE) having a molecular weight of more than $1.5 \cdot 10^6$. Products obtained from UHMWPE are characterized by a low coefficient of friction, as well as high wear resistance. In addition, they have high resistance to aggressive environments, as well as increased frost resistance.

UHMWPE is used where conventional PE grades and many other polymers cannot withstand harsh operating conditions. UHMWPE can act as a substitute for other, more expensive materials, such as steel, bronze, polyamides, fluoroplastics, and can become the only material suitable for the purpose.

The main methods for producing UHMWPE are: sintering, pressing, gel-forming, REM-extrusion, as well as spraying on the surface of products using electrostatic method and hot-flame spraying. [1]

Sintering is the heating process when UHMWPE powder compressed to a different degree changes into a monolithic or porous body.

The process of obtaining blanks (products) by sintering consists of two operations:

1) pressing the powder in a mold without heating;

2) sintering of the obtained blanks (products) in the free state when heated.

The sintering method can be used to produce blanks (products) weighing from tens of grams to several tens of kilograms.

If it is necessary to obtain a porous product with a density of 600 kg/m^3, it is advisable to maintain a specific pressure of about 8 MPa, and if it is necessary to produce a monolithic product with a density of 930 kg/m^3, then the specific pressure should be increased to 85-90 MPa. [2]

Task formulation: to determine the degree of wear of UHMWPE depending on the additive and determine the most effective modification.

Results and discussion. The following types of samples were used to determine wear depending on the UHMWPE modification:

- Sample #1: UHMWPE without additives;
- Sample #2: UHMWPE + 70% Fe/B_4C;
- Sample #3: UHMWPE + 70% W/B_4C.

All samples are made by sintering and represent a cylinder with a diameter of 10 mm. As a counterbody, a disk Ø 70 x 6 mm from hardened steel ШХ - 15 was chosen.

Tribological tests were carried out on a universal friction machine MODEL: MMW-1A of a vertical type with computer control. This model allows you to keep the load force constant with a deviation of ± 2 N. The relative error in measuring the friction force did not exceed ± 2% in the liquid lubrication mode.

Before conducting the study in order to reduce the surface roughness and, as a result, to improve the accuracy of the data obtained, the samples were subjected to grinding on emery paper with P600 grit.

All samples were tested under the same friction mode, with the following parameters: loading force: 471 N; specific load: 2 MPa; sliding speed: 0.1 m/s; distance traveled by samples: 1000 m.

Samples without modifiers were also tested at a speed of 0.5 m/s and 1 m/s, but during the tests, the friction force exceeded the maximum recorded by the friction machine. At a speed of 0.5 m/s, the friction force reached a critical value after 300 s, while at a speed of 1 m/s it occurred within the first 10 seconds. This is due to the fact that the samples were tested in the absence of a lubricant. Therefore, samples with modifiers were not tested at these speeds.

During the tests, the values of the friction force and the friction coefficient with a frequency of once every 1 s were recorded in real time with the ability to save to a file. The obtained data were accumulated in a graphical and textual form and, after approximation, were analyzed.

A weighting method was used to estimate the amount of wear. The samples were weighed on RADWAG AS 60/220/C/2/N scales, which allow measuring the weight with an accuracy to 10 micrograms. This method

consists of determining the difference between the weight of the samples before the test and after. Subsequently, the mass wear was converted to absolute wear . The density of samples without modifiers was assumed to be 0.94 g/cm^3, and with modifiers 0.95 g/cm^3.

The histogram (fig.1) shows a comparison of the absolute wear of the samples in µm. Moreover, the wear of the first and second samples differs slightly, which can be due to the error of converting mass wear to absolute. It can be said that the Fe/B_4C additive does not affect the wear of UHMWPE. The wear of the third sample is 10 times less than the wear of the first two samples. This indicates that the effectiveness of the W/B_4C additive is quite high. The high wear resistance of the third sample indicates that this composition is applicable to the manufacture of parts that work in heavily loaded nodes. For example, rollers, gears, support bushings, grease-free bearings, guides, and more. [3]

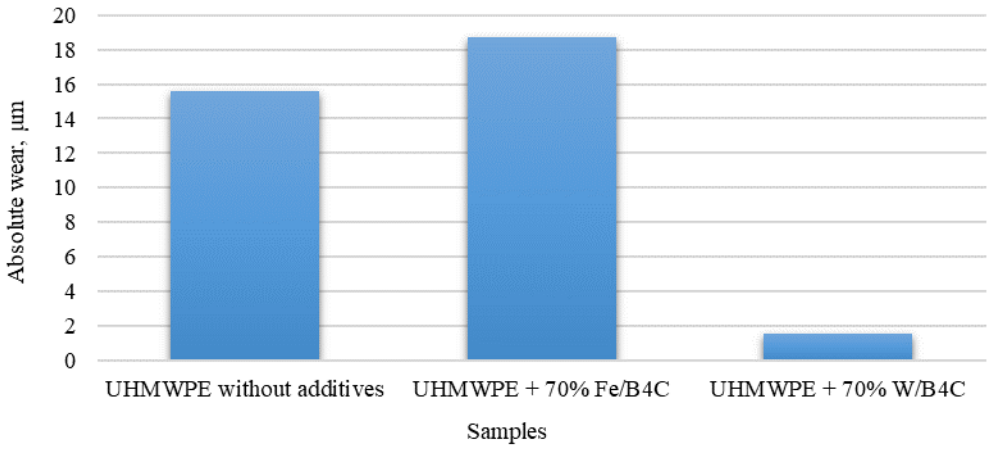

Figure 1. – Histogram of friction surface wear

Conclusion. Testing of samples with various additives showed that the lowest degree of wear is observed in the sample No. 3 containing the additive W/B_4C. The use of this additive can significantly reduce wear compared to the samples without additives, while the additive Fe/B_4C does not give a positive effect.

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EFFICIENCY IMPROVEMENT OF THE AROMATIC HYDROCARBONS EXTRACTION PROCESS FROM CATALYSATE OF REFORMING AND CO-PRODUCTS OF AROMATIC SECTIONS AT A REFINERY

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The issues of relevance of the production of aromatic hydrocarbons and, accordingly, the intensification of the extraction of aromatic hydrocarbons by selective solvents are considered. The performance characteristics and physicochemical properties of various extractants are compared. The optimal component for TEG was determined to obtain a mixed solvent. The effectiveness of the usage of such an extractant in the intensification of the aromatic hydrocarbons extraction by selective solvents is estimated.

Introduction.Proclivity by UN human rights activists and environmental activists to the idea of abandoning fossil fuels are gradually gaining popularity both among some countries and among automobile concerns, and oil companies carry out unitary reorientations of their refineries to zero fuel production, as it is supposed, to search the economic efficiency of such an operating mode of oil refineries in the current global market and the possibility of transition to a policy of companies to completely refuse to produce fuel. In addition, the existing environmental zones and the policy of banning certain types of internal combustion engines in some cities, as well as the production of cars with low fuel consumption, coupled with the policy of updating an outdated fleet, actually set the volume of fuel output at oil refineries, the need for which is constantly decreasing in Europe.However, in general, an increase in demand for petroleum fuels for the next 20 years is forecasted throughout the world [1].

The reorientation of refineries is possible in the direction of reducing production capacity or with an increase in the production of raw materials for petrochemistry or its final products.

Demand for petrochemicals in the world continues to grow rapidly, far outstripping global GDP growth.Therefore, from the point of view of maintaining the profitability of the enterprise and the guaranteed return on investment projects, the priority direction of the development of the oil refinery is to increase the production of the feedstock for the petrochemistry or its finished products. This policy can be seen in the "Strategy of the petrochemical complex until 2030" of the Belarusian State Concern for Oil and Chemistry, in China, measures are being taken to accelerate the development of petrochemistry; in Russia, the aim is to increase non-resource exports.

Task formulation. Aromatic hydrocarbons are the basic substances used in industry for the production of a variety of chemical products.The global growth in demand for low molecular weight aromatic hydrocarbons is, on average, 3-5% per year. This is due to the increasing demand for aromatic hydrocarbons produced, primarily paraxylene [2, 3].

Currently, the main source for the production of monocyclic aromatic hydrocarbons (benzene, toluene, xylene) are catalysts for the reforming of gasoline fractions [4]. Catalytic reforming products represent a mixture of aromatic, naphthenic and paraffinic hydrocarbons mixed with unsaturated hydrocarbons.It can be either narrow fractions containing, respectively, benzene, toluene or xylenes, or wide fractions containing a mixture of aromatic hydrocarbons. In addition to catalytic reforming products, by-products of the aromatic section of the refinery are also used to produce monocyclic aromatic hydrocarbons. The separation of high purity individual aromatic hydrocarbons (99 - 99.9%) from these blended products is a complex task associated with the usage of a number of processes [5].

Monocyclic aromatic hydrocarbons are recovered from these mixtures by liquid extraction with selective solvents. Refinery process units using 90–95% glycol solutions (DEG, TEG, and tetraethylene glycol) are widely used [6].The disadvantages of the existing process used at most refineries in the CIS countries, using the LG-35-8 / 300B unit as an example, are mainly due to the imperfection of the technological scheme of the extraction unit designed by Lengiproneftekhim (Lengiprogaz in the 1960s) according to the extraction laboratory of VNIIneftekhim.One of these is the high consumption of risicle (100–110% for raw materials), which leads to a decrease in the extractor productivity and a decrease in the actual concentration of extractant in the system and its selectivity.

For the successful realization of the separation of hydrocarbon raw materials, the used extractant must satisfy a number of requirements, the most important of which are high selectivity and solvent ability. However, an extractant that fully complies with the requirements of modern technology hasn't been found yet. The solvent triethylene glycol (TEG), currently used in the domestic industry, has a good capacity in relation to aromatic

hydrocarbons for the separation of aromatic hydrocarbons, but it has low selectivity and solvent ability, which forces the process to be carried out at high extractant ratios to raw materials and elevated temperature and pressure, which leads to additional material and energy costs. In addition, it has a high viscosity and heating capacity, which contributes to a decrease of coefficient of efficiency of contact devices; it is necessary to maintain a high mass ratio of solvent to raw materials and a large consumption of recycle stock and high costs for the separation of the extract with the solvent [2, 7].All these disadvantages are associated with the fact that TEG is a strongly associated solvent due to the existence of two hydroxyl groups and the formation of stable intermolecular hydrogen bonds. Besides, triethylene glycol has strong toxic properties.By the degree of impact on the human body, triethylene glycol is a moderately dangerous substance, it belongs to the 3rd substance hazard category. The maximum allowable concentration (MAC) of technical triethylene glycol in the air of the working area of industrial premises is 10 mg / m^3.

The low dissolving capacity of TEG leads to the necessity to increase the temperature of the extraction process to 150 ° C, however, this reduces the stability of π-complexes with arenes and the selectivity of the extractant.The high selectivity of TEG by molecular weight is also due to the strong association of its molecules. In the transition from benzene to xylenes, the energy expenditure sharply increases when the arene molecules dissolve to form a cavity in the solvent structure, as a result, the critical solution temperature increases sharply, and the distribution coefficients and the degree of extraction decrease.

The high viscosity of the TEG leads to a decrease in the efficiency of the plates of extraction columns, which is much lower than for plates of columns of extractive distillation.

Therefore, improving the technology for the separation of complex hydrocarbon mixtures in order to reduce energy costs by reducing the solvent to feed ratio and the process temperature is an urgent scientific and technical task.

Methods of research. One way to solve this problem is to use mixed-type extractants.Their use allows more flexible implementation of extraction processes for the separation of hydrocarbon mixtures during processing of raw materials of variable composition due to changes in the extraction and physicochemical properties of extractants [4].

There are solvents that are devoid of the above drawbacks, however, a complete replacement of the solvent would lead to a partial or complete replacement of technological equipment, which, given the growing costs of reorienting to the course of petrochemicals, does not have a high profitability.

Therefore, the best of the methods of intensification of extraction, which avoids significant material costs, and especially reconstruction / change of the technological scheme, is the use of mixed solvents [2, 8].

Results, their discussion and perspectives. Currently, there are many options for additions to TEG: sulfolane, N-methylpyrrolidone, diglycolamine, dimethyl sulfoxide, N-formyl morpholline, ethyl alcohol, etc. [2, 9-11]. Their comparison, presented in [11], defines N-methylpyrrolidone as the most suitable.

Table 1 shows the comparative characteristics of selective solvents used in industry, where $\left(\frac{\gamma_h^0}{\gamma_b^0}\cdot\frac{1}{\gamma_b^0}\right)$ – is the efficiency criterion.

Table 1. – The selectivity and dissolving capacity of aromatic hydrocarbon extractants

Extractant	T, °C	γ_h^0	γ_b^0	$\frac{\gamma_h^0}{\gamma_b^0}$	$\frac{\gamma_{ch}^0}{\gamma_b^0}$	$\frac{\lg(\gamma_{oct}^0)}{\gamma_{hep}^0}$	$\frac{1}{\gamma_b^0}$	$\left(\frac{\gamma_h^0}{\gamma_b^0}\cdot\frac{1}{\gamma_b^0}\right)$
Triethylene glycol	30 80	60,6 30,4	3,86 3,02	15,7 10,1	7,24	0,168 0,126	0,259 0,331	4,1 3,3
Tetraethyleneglycol	30 70	37,7 24,8	2,46 2,48	15,3 10,0	7,54	0,171 –	0,407 0,403	6,2 4,0
Sulfolane	30 80	72,0 38,4	2,43 2,49	29,6 15,4	13,9	0,154 0,112	0,412 0,402	12,2 6,2
Dimethylsulfoxide	20 60	92,0 48,0	3,83 3,03	24,0 15,8	11,4	0,169 0,126	0,261 0,330	6,3 5,2
N-formylmorpholine	30 61,7	34,6 24,7	2,03 1,99	17,1 12,4	10,0	0,133 0,115	0,493 0,503	8,4 6,2
N-methylpyrrolidone	30 60	14,2 9,9	1,08 1,08	13,1 9,17	7,90	0,086 0,057	0,926 0,926	12,1 8,5

According to the efficiency criterion, when separating the model system "hexane-benzene", sulfolane and N-methylpyrrolidone are at the same level, and when separating the system "cyclohexane-benzene" N-

methylpyrrolidone should be more effective even in comparison with sulfolane. When comparing the physicochemical properties of the extractants (Table 2), the following conclusions can be drawn: sulfolane has a high melting point, which may limit its use; N-methylpyrrolidone has the lowest dynamic viscosity, which will increase the efficiency of the contact steps; N-methylpyrrolidone is less toxic than sulfolane.

Table 2. – Physico-chemical properties of arene extractants

Extractant	ρ_4^{20}	B.P.,°C	M.P.,°C	η^{20}, MPa·s	$C_p^{20}, \frac{kJ}{kg \cdot K}$	$H_{vap}^{25}, \frac{kJ}{mol}$	$\sigma^{20}, \frac{mN}{m}$	MAC, $\frac{mg}{m^3}$
Triethylene glycol	1,1242	285	-4,3	49,0	2,17	71,6	45,57	10
Tetraethyleneglycol	1,1247	327,3	-6,2	61,3	2,14	88,8	45 (20 °C)	10
Sulfolane	1,2604 (30 °C)	285	28,4	10,0 (30 °C)	1,34 (30 °C)	61,5 (30 °C)	60,33 (40 °C)	50
Dimethylsulfoxide	1,0960	189	18,45	2,473	2,05	57,28	43,49	20
N-formylmorpholine	1,1528	244	20…21	9,37	1,97	46,06	–	–
N-methylpyrrolidone	1,0328	202	-24	1,65	1,97	53,06	39,91	100

When choosing the optimal extractant, it is also necessary to take into account their thermal and chemical stability and corrosion activity. Sulfolan is a chemically inert substance and is thermally stable up to 220 ° C. Sulfolan, both watercut and anhydrous, has insignificant corrosion activity even at 200 ° C. N-methylpyrrolidone is a corrosive substance. However, corrosion is caused by the corrosive activity not of N-methylpyrrolidone itself, but of the products of chemical transformation during its heating, hydrolysis and contact with air. N-methylpyrrolidone has almost the same comprehensive efficiency criterion with sulfolane, however, its operation is hampered by its corrosivity, which is easily leveled out by introducing a corrosion inhibitor into the system, lowering the process temperature, and maintaining the system under a slight overpressure. Upon that the main disadvantage of sulfolane is that under normal conditions it is a solid. Therefore, for its keeping and pumping, it is necessary to keep it in a heated state. Also, sulfolane has a maximum allowable concentration 2 times lower than that of N-methylpyrrolidone, which requires additional measures to protect people when using it.

However, with a logical attempt to add N-methylpyrrolidone to TEG to obtain a mixed extractant, it is not as effective.In the 1990s, studies were conducted at the St. Petersburg State Technological Institute in conjunction with Kirishinefteorgsintez LLC to develop a mixed extractant for the extraction of aromatic hydrocarbons from reformate of fraction 62 - 105 ºC, the results of which were implemented on the LG-35- 8 / 300Bunit LLC "PO" Kirishinefteorgsintez "in 1999 –2000.

To increase the dissolving capacity of TEG, it was proposed to use mixtures of it with various solvents: N-methylpyrrolidone, dimethylformamide, furfural, propylene carbonate, morpholine, acetone, dioxane. However, all these solvents, increasing the dissolving ability, reduce its selectivity.

The TEG-sulfolane mixture is devoid of this drawback, exhibiting both higher selectivity and increased dissolving capacity with respect to arenes.A complete replacement of TEG with sulfolane would lead to the need for a substantial reconstruction of existing extraction plants.When using sulfolane, the recycle stock and extract are stripped in separate columns, and in the process with TEG, in a combined column.The arenas are steamed from sulfolane in a larger diameter vacuum column; a vacuum-generating system is necessary (due to the low partial pressure of aromatic hydrocarbons over the solvent).

Effective mixed extractants, as well as individual solvents, should not be strongly associated.

The mixing of TEG with N-methylpyrrolidone, dimethylformamide, N-methylcaprolactam is accompanied by an exothermic effect ($\Delta H^E<0$)which can be explained by the formation of intermolecular hydrogen bonds. In contrast to these systems, the mixing of TEG with sulfolane occurs with an endothermic effect. Positive deviations from Raoul's law in the TEG – sulfolane system, taking into account close boiling points and pressures of saturated steam of the components, leads to the formation of an azeotropic mixture and a decrease in the temperature in the stripping column when arenes are distilled from the extract phase.Thus, the regeneration of the mixed extractant is facilitated in comparison with the regeneration of individual TEG and sulfolane.

The most important advantage of using the mixed TEG – sulfolane extractant is that the mass ratio to the feed is reduced from 8: 1 for TEG to 4.9: 1 when the sulfolane content in the mixture with TEG is 28-30% wt. At the same time, the transfer of the LG-35-8 / 300B installation to a mixed solvent with a sulfolane content of 28-30% wt. mixed with TEG was carried out without a significant change in the technological scheme.

The increase in the ratio of sulfolane: TEG to 60: 40% wt. would reduce the temperature of the extraction process, as well as the mass ratio of the mixed extractant to the raw material to 3: 1 and the recycle stock con-

sumption from 80 - 100 to 30% wt. on raw materials. However, to reduce the temperature of the extraction process, it is necessary to install a heat interchanger for cooling the regenerated extractant discharged from the stripping column at 150 ° C [12, 13].

According to the research results, the amount of saturated hydrocarbons in the extract remains less, which is due to the increased selectivity of the extractant with a weight ratio TEG: sulfolane ratio of 1: 1, compared with 0.27 : 1 [13].

Reducing the water content in the mixed extractant is possible only to a level that ensures its boiling point at a normal pressure of not more than 150 ° C, which allows the use of water vapor with a pressure of about 1 MPa in the boiler of the stripping column. In this case, selective solvents (sulfolane and TEG) are thermally stable. An increase in the content of sulfolane in the mixed extractant with the same water content also leads to a decrease in the boiling point of the mixture. This can be explained by the greater degree of non-ideality of the water - sulfolane system compared to the water - TEG system. At the same time, an increase in the sulfolane content, as well as a decrease in the water content, leads to an increase in the solvent ability of the mixed extractant.

Conclusion.Thus, the use of such a mixed extractant allows not only to reduce the energy costs of the process, but also by reducing the weight ratio of the extractant to the raw material to increase the productivity of the plant, which affects the determination of design capacity and, accordingly, the cost of new extraction plants, if necessary for the modernized / new aromatic block.Both reducing energy costs and increasing plant productivity reduces the cost of production of aromatic hydrocarbons, which allows you to increase the profit of the enterprise.

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UDC 661.715.6

RECEIVING OIL COKE ON THE BASIS OF HEAVY RESIDUAL OIL FROM THE CHEMICAL WORKS "POLYMIR" (OJSC "NAFTAN")

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Heavy residual oil (HRO) as a by-product of hydrocarbon pyrolysis, is a mixture of various groups of hydrocarbons, mainly aromatic, with a boiling point above 160^{0}C. At present this product does not find rational use. It is used as boiler fuel. This article presents the results of a study on the possible use of HRO as a raw material for the production of petroleum coke.

The creation of a raw material base for the production of electrodes is one of the current directions in the industry, as coke with a sulphur content of up to 1% is used in the production of graphitized electrodes, purchased by import [1,2].

Needle coke is used to produce high quality graphite electrodes. Electrodes should have high mechanical strength, electrical conductivity, low sulphur content and low thermal expansion coefficient (TEC) [3].

This study assesses the suitability of use of heavy residual oil from the Polymir plant of OJSC Naftan to produce petroleum coke and petroleum pitch.

The heavy residual oil from "Polymir" plant of OJSC "Naftan" has been studied taking into account several points connected with the suitability of raw materials use for oil coke production. The main quality markers of raw materials for oil coke production are the composition and molecular structure of all its components. The composition of raw materials and the molecular structure of its components depend on the reactivity of raw material, quantitative and qualitative indices of the coking process and the main operational properties of the obtained coke.

The chemical composition of raw materials is determined by simple methods of chemical analysis. However, data on molecular structure are still extremely insufficient. But data on the structure of high-molecular oil compounds which are available at this moment in some cases can be considered orientative when solving certain scientific and practical problems [4].

A very important characteristics in the analysis of coking feedstocks is the amount of carbon residue. Conradson method is usually used and feedstock is heated in a standard gas-heated instrument [5]. Toluene insoluble substances/a-fraction asphaltenes are determined by the Marcusson method. Also, the pitch of the pyrolysis resin was extracted with a mixture of aliphatic and aromatic solvents to study its suitability for coking feed.

Initially, a heavy pyrolysis resin was dispersed in Engler. Essence of method lies in separation of oil product into its component fractions due to their different final boiling points. The results obtained show that about 1-1.5% hydrocarbons contained in the HRO boil at temperatures up to 180 ° C. The largest amount of hydrocarbons boil in the range 180-210 ° C (the so-called "blue-green oil"). Fractions boiling in the ranges 210-220 ° C, 210-230 ° C, 210-240 ° C make up 15%.

Thus, at the fractional distillation of HRO about 50% is the solid vat residue (pitch).

The next step was to determine toluene insoluble substances/a-fraction. The method is based on different solubility of pitch components and consists in treatment of weighed sample with toluene followed by weighing of filtered and dried undissolved residue. Three pitch weighed samples were taken for analysis with boiling temperature intervals of 220 - end of boiling, 230 -end of boiling, 240 - end of boiling.

The results showed that the content of substances insoluble in toluene in the tested samples is minimal and makes up 0.2% wt. For each fraction tested. Thus, the raw material is suitable for producing petroleum coke, including needle coke, as according to the current standards, the content of α-fraction should not be more than 8-11 wt%.

The pakes were extracted with a mixture of solvents. Essence of method is in extraction of pitch with mixture of aliphatic and aromatic solvents for subsequent coking of extract. Mixture of nefras and solvent with end boiling point in the range 130-185 °C was used as mixture of aliphatic and aromatic solvents. The ratio of mixture of nefras and solvent and resin residue was 2:1 - 3:1 by weight.

During the study, it was found that with the increase of the solvent content in the solvent mixture and with the increase of the extraction time, the amount of insoluble residue also increased, so that the quality of the resulting coke would decrease.

As the extraction temperature increases, the yield of the insoluble residue also increases, which will adversely affect the yield of the possible coke produced.

The isolation of asphaltenes by Marcuson method showed that the weight of asphaltenes was 1.5 g or 15% by weight for the 220-fbp fraction, 17% for the 230-fbp fraction and 20% for 240-fbp fraction..

The obtained data are consistent with the norms for asphaltenes content in the raw material for production of needle coke.

The presented results of the study suggest that heavy pyrolysis resin can be used as raw material for production of petroleum coke for electrode industry.

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UDC 665.7.038.2:547.29

INFLUENCE OF CARBOXYLIC ACIDS ON FILTERABILITY AND QUALITY LEVEL OF SYNTHETIC LOW ALKALINE CALCIUM SULFONATE (DETERGENT-DISPERSANT MOTOR OIL ADDITIVE)

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The study examined the conditions of synthetic low alkaline calcium sulfonate (SLCS) synthesis, which is added to motor oils as a detergent-dispersant additive. In particular, the effect of the introduction of carboxylic acids at the stage of SLCS synthesis on such characteristics of the additive as the observable filterability, volume filtration rate, volume fraction of sediment and kinematic viscosity was studied. For the obtained additive samples the average sizes of particles dispersed in the volume were measured using the dynamic light scattering method (DLS) and the basic physicochemical parameters were determined.

Keywords: *detergent-dispersant oil additives, lubricants, filterable sulfonate additives, calcium sulfonate.*

Introduction. This article discusses the preparation of synthetic low-alkaline calcium sulfonate (total base number< 50 mg KOH/g) based on high molecular weight sulfonic acid (dialkylbenzenesulfonic acid (DABSA)) as a detergent-dispersant additive to motor oils. Synthesis of low alkaline sulfonates using synthetic high molecular weight sulfonic acids (synthetic acids of average molecular weight 450 Da or more) is associated with certain problems. Calcium salts of high molecular weight sulfonic acids are viscous materials prone to the formation of supramolecular complexes with irregular structure. This creates certain problems in the process of their synthesis and then utilization. Moreover, it is possible that calcium hydroxide particles can be included in the formed aggregates during the synthesis process. This kind of dispersed system can be classified as filled concentrated, in which interactions between existing supramolecular formations are possible. So, this leads to the enlargement of the latter. The dispersed system in this case is thermodynamically and kinetically unstable due to aggregation and subsequent sedimentation of the existing particles. Inability to resist aggregation leads to coagulation of sol particles of calcium hydroxide with their subsequent coalescence (irreversible fusion), which leads to sedimentation as a result. Moreover, the aggregation of sol particles can lead to the formation of a macrophase of calcium hydroxide or to the transition of the sol into a gel in the case of presence of a surfactant. Furthermore, by rheological properties such structures can be considered as dilatants, i.e. they tend to increase their viscosity with an increase in shear deformations. This fact complicates filtration or makes it completely impossible. Thus, in order to create calcium sulfonates stable in quality level, it is necessary to increase somehow their ability to resist aggregation.

There are methods of producing sulfonates with a low alkaline number in which carboxylic acids are used [1]. It is expected that carboxylic acids prevent the formation of gel-like products, reduce the viscosity of the obtained additive and reduce the amount of sediment. As a result, this provides fluid, filterable products. This effect is probably a consequence of the interaction of carboxylic acid with the fractions of calcium hydroxide particles of the size lying in the region of tens of nanometers. Such particles have a large free energy reserve and therefore easily undergo various transformations. This allows their selective removal. Also, particles of such sizes are presumptively able to clog the pores of the filter, and this also complicates the filtering process.

The purpose of this study is to synthesize SLCS with acceptable filterability. To accomplish this task acetic acid is added at the stage of additive synthesis. Acetic acid reacts with the excess base to form an acetate which can be dispersed in the sulfonate soap media in the product.

Experiment

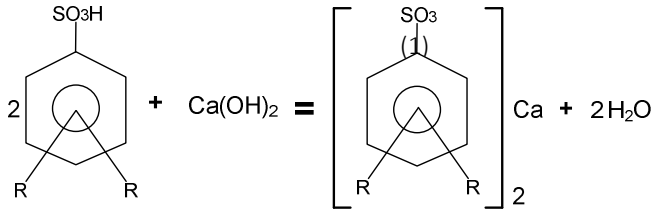
Reagents. Using the previous studies on the selection of raw materials for the synthesis of low alkaline calcium sulfonate and results received by JVLL "LLK-NAFTAN", high molecular weight DABSA (M = 460 g /mol) with an active component content of 84% by mass was selected. The spindle oil SN-150, calcium hydroxide, technical toluene, technical acetic acid "analytical grade", distilled water satisfy all quality requirements. At the filtration stage of the obtained product, Celite-545 diatomaceous earth was used.

Apparatus. For the neutralization reaction, a three-necked flask connected to a mixer, a thermometer and a backward cooler was used. A water bath was used to control the temperature in the reactor. A rotary evaporator was used to remove toluene and water. A Malvern Zetasizer Nano ZS DLS spectrometer was used to determine the average particle sizes.

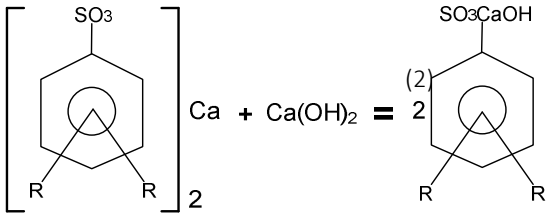
Tests. The average molecular weight of the DABSA was determined in accordance with ASTM D-3712. The ASTM D-664 test was used to determine the total acid number. The total base number of products was determined potentiometrically in accordance with ASTM D4739-17.

Procedures. The reactions occurring during the synthesis are described by the following chemical equations:

1) Preparation of neutral calcium sulfonate:



2) Preparation of basic calcium sulfonate:



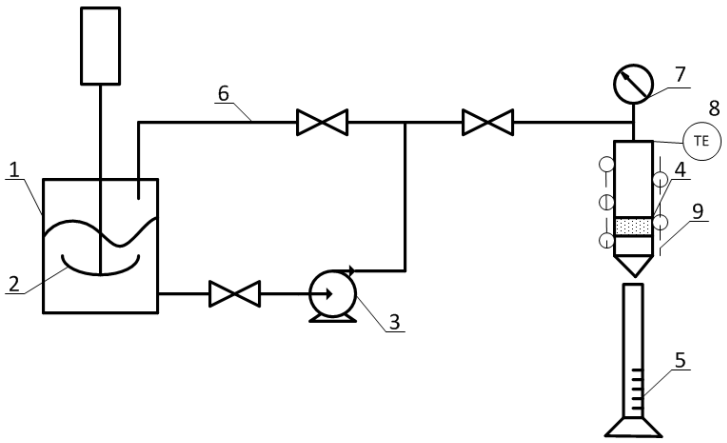
3) Preparation of calcium acetate:

$$2CH_3COOH + Ca(OH)_2 = (CH_3COO)_2Ca + 2H_2O \quad (3)$$

As part of the study, a number of SLCS (with the active substance content of 42% wt.) syntheses were carried out using variable amounts of acetic acid relative to the amount of calcium hydroxide used in the synthesis (see reactions 1,2).

After completion of the synthesis process, 100 ml of the product was centrifuged to determine the volume fraction of sediment. Also, after completion of the synthesis process, the SLCS solution was subjected to the removal of toluene and water on a vacuum rotary evaporator at 150°C and 15 kPa since, according to literature, even a small amount of water can significantly impair the filterability of the product [2].

The dehydrated product was then filtered in an apparatus simulating the operation of a press filter (Figure 1). Filtration was carried out at elevated temperature (in the range of 80 – 90°C) and at 0,2 MPa. A diatomaceous earth fill layer was used as an aid. The layer was poured over ashless paper filter.



1 - tank; 2 - mixing device; 3 - pump; 4 - pressure vessel with support for the filter; 5 - measuring cylinder; 6 - filtrate circulation line; 7-manometer; 8 - electric heater; 9 - thermocouple with temperature indication

Figure 1. – Sketch of a laboratory filtration unit

Results and discussion. The preferred kinematic viscosity of the low alkaline sulfonate additives at 100°C is 300 cSt or less, most preferably 30-100 cSt. The volume fraction of sediment in the product before filtration in the most preferred variant is in the range from 0,1 to 0,6% vol. To establish the filtration intensity, the volume filtration rates were determined and the filtration diagrams for three samples were plotted (Fig. 2). On that basis, to compare the obtained filtration results, such terms as "well-filtered sample" and "poorly filtered sample" were introduced.

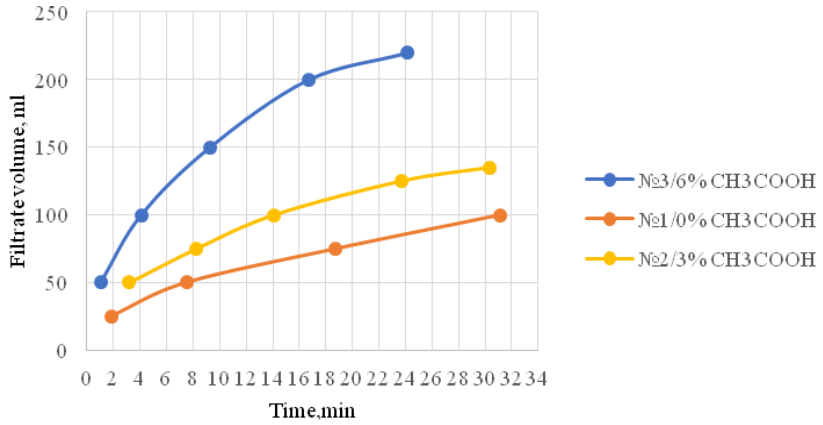


Figure 2. – Filtration diagrams of SLCS samples

The attempt to filter sample №1 was unsuccessful due to the high sediment content in combination with high viscosity, the observed filterability was unsatisfactory. This example shows that the preparation of low alkaline calcium sulfonate from high molecular weight sulfonic acid in accordance with the known [2] method, using the raw materials adopted in this study, leads to the formation of an unfilterable product. The observed filterability in the case of samples №2 and №3 improved as evidenced by the positive dynamics of the volume filtration rate increase compared to sample №1. However, during the filtration of the sample № 2 the filter quickly clogged as can be seen from the fall-off in the volume filtration rate. Physicochemical quality characteristics of the filtered samples are presented in the Table 1.

Table1. – Quality characteristics of SLCS samples

Characteristic	Sample number		
	№ 1	№ 2	№ 3
Observed filterability	Poor	Poor	Good
Volume fraction of sediment, % vol.	3,50	1,50	1,00
Volume filtration rate, ml/hour	192,93	266,89	547,72
Total base number, mg KOH/g	3,72	7,48	12,58
Total acid number, mg KOH/g	1,87	2,07	2,00
Kinematic viscosity at 100 °C, cSt	760,00	561,00	356,00

There are trends of decrease in the volume fraction of sediment and the kinematic viscosity of the obtained products with the increase of the acetic acid amount. The increase in alkaline number is due to an increase in the amount of calcium acetate in the product.

For the filtered samples the average size of the dispersed particles was determined using DLS spectrometry. The results are presented in figure 3.

As can be seen from the PSDs of the obtained samples, the amount of small-sized dispersed particles tends to decrease as the acetic acid content in the starting mixture increases.

Analyzing the total results one can conclude that in the synthesis of SLCS based on high molecular weight dialkylbenzenesulfonic acid, the addition of some carboxylic acid, in particular acetic acid, has a positive effect on the quality of the product. The tendency to form gel-like viscous products is reduced. The product has better filterability than the product obtained according to the existing technology. However, not all quality characteris-

tics have reached acceptable levels. The product still has too high viscosity and a volume fraction of sediment. This article does not establish the exact reasons for all the above-mentioned facts - this will be the basis for further research.

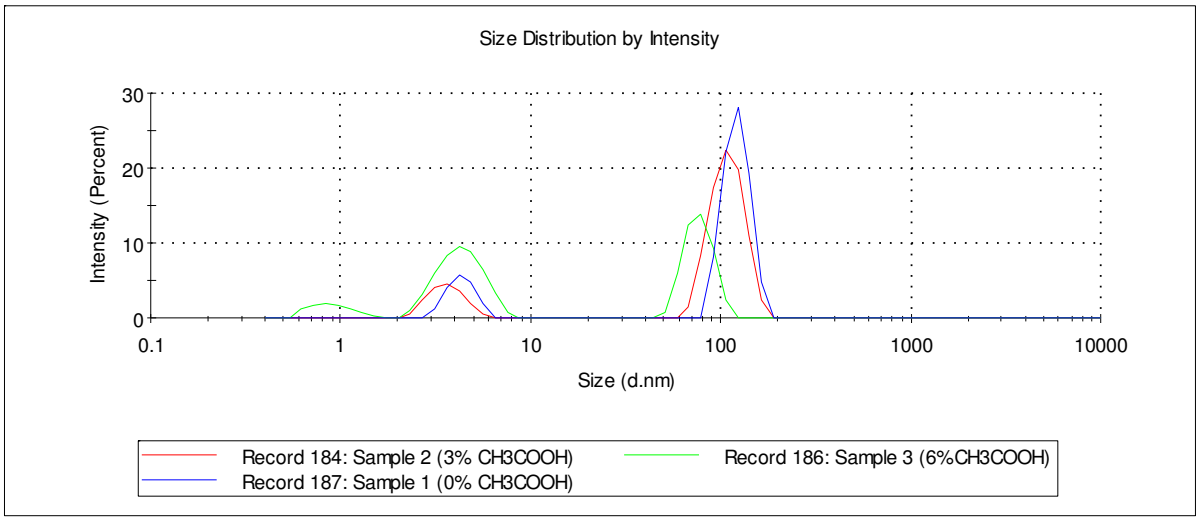


Figure 3. – Particle size distributions (PSDs) for the obtained SLCS samples

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ICT, ELECTRONICS, PROGRAMMING, GEODESY

UDC 551.24

GIS-MODELLING OF THE CRYSTALLINE BASEMENT OF THE TERRITORY OF BELARUS IN DIFFERENT GEOLOGICAL AGES

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As part of this work, GIS modeling of the crystalline basement of the territory of Belarus for various geological epochs, including data on the fault network, was performed using ESRI ArcGIS software. As an example, a comparison of surfaces in the modern era and in the late Devonian is given. A map of the difference in basement marks between the specified epochs is constructed. This work is important for understanding modern geodynamics of fractal zones in Belarus.

The crystalline basement of the earth's crust is a complex natural structure. The main interrelated factors determining the structure of the crystalline basement specific areas include: the capacity of the asthenosphere, the topography (the folded deformations), the pattern of the fractures (disjunctive breaks), age and composition of rocks composing the basement, neotectonic activity of its structures.

The territory of Belarus has a heterogeneous structure of the crystalline basement. The power of the asthenosphere varies from 30 to 130 km. The surface of the crystalline basement is within the range of 0 to 6.5 km below the ground surface. According to the structural zoning, there are three granulite complexes in the crystalline basement of Belarus: the Belarusian-Baltic, Vitebsk, and Braginsky zones; the Osnitsk-Mikashevichi volcanoplutonic belt, as well as the Central Belarusian, Inchukalna zones, and the Central Pripyat block.

The formation of the crystalline basement took place during the archean – early proterozoic and is divided into proto-oceanic, transitional and continental stages. During the proto-oceanic stage (early archaea), the entire territory of modern Belarus was covered by the ocean. At this time, all three granulite complexes were formed, as well as the Minsk block. During the transition stage (late archaea – early Proterozoic), a Central Belarusian deflection was formed. Last, during the continental stage (the second half of the early Proterozoic), the Osnitsk-Mikashevichi volcanoplutonic belt was formed.

In accordance with the surface topography of the basement, the territory of Belarus is divided into positive, negative and transitional institutions: the Belarusian anteclise, the Latvian saddle, Orsha depression, Zhlobin saddle, Pripyat trough, the Podlaska-Brest depression, the Polesye saddle and little structures coming into the country is only marginal. Within each of them, tectonic structures of a smaller order are distinguished: protrusions, steps, horsts, grabens, domes, mulds, structural bays, etc.

All tectonic structures are intersected by a network of fractures. Fractures play a crucial role in the formation of the basement. They define the boundaries of structural complexes and tectonic structures of the highest order , as well as form structures of the lowest order - horsts, grabens, protrusions, steps. Modern movements of the earth's crust and a number of other geophysical processes are manifested along the fractures [1].

All the fractures of the crystalline basement of Belarus are divided into structure that emerged in the early Archean (mostly meridional and submeridional stretch) – early Proterozoic and postconsolidation (early Proterozoic – Riphean, latitudinal and sublatitudinal).

About half of the ancient basement fractures are active in the current geological epoch, which is confirmed by a number of studies [2,3,5].

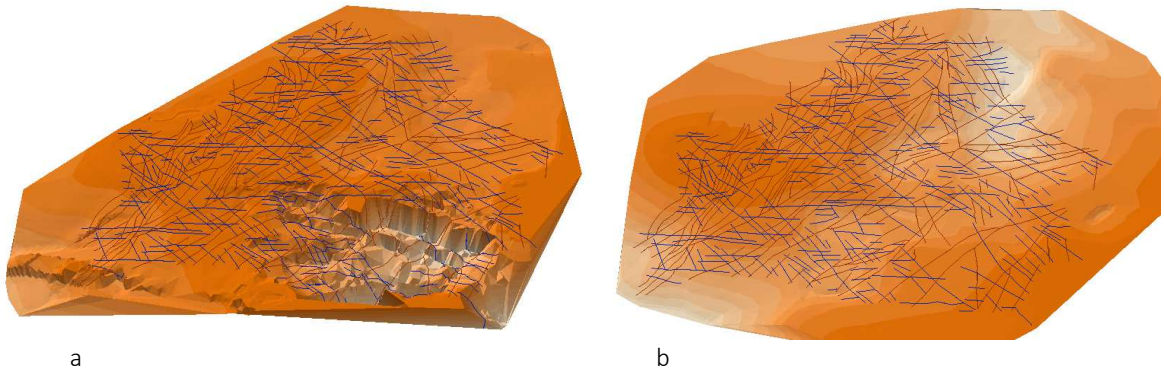
Modeling the formation of the crystalline basement will allow us to better understand the processes of modern endogenous geodynamics, and to correlate the location and dynamics of deep fractures with tectonic structures of all orders.

Modelling of the crystalline basement of Belarus was carried out according to the monograph by A.Makhnach (А. Махнач, 2001). The monograph presents maps of tectonic structures of Belarus in high detail, as well as paleotectonic maps of the Eastern European platform for different periods of geological history: the late

Baikal, Caledonian, Hercynian folds, the beginning of the Devonian period, and pre-Carboniferous time. The book also provides maps of discontinuous violations. The geographical reference of raster maps in the GIS package was performed to the geometry of the contour of the administrative borders of Belarus, plotted according to Openstreetmap data. Vector layers such as "structure-forming Fractures", "postconsolidation Fractures", and "(paleo)isohypses" (showing the absolute level of the Basement surface) were created for each of the maps. For the Pripyat trough, dot marks are also applied.

Using the 3D Analyst module of ESRI ArcGIS software, TIN models of the Basement for different epochs are constructed based on the layer height attribute "(paleo-)isohypses" and the layer height attribute of dot markers, using fractures as barriers.

For example, let's compare the surface of the crystalline basement in the modern era and in the late Frasnian time of the Devonian, on the eve of the separation of the Pripyat trough.



a b

a – recent time, b – late Frasnian time of the Devonian

Figure 1. – Model of crystalline basement of Belarus with the designation of the fractal network

Using the Surface Difference tool of the 3D Analyst module, we will find the difference between the basement surface in Devonian time and in the modern era. (fig. 2).

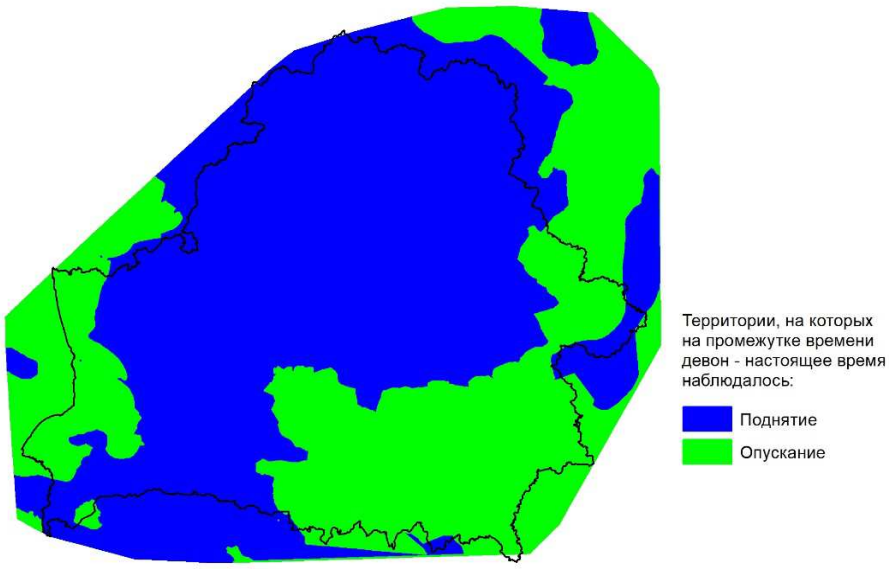


Figure 2. – Map of the difference in the height of the surface of the crystalline basement of the territory of Belarus between the late Devonian era and the recent time

According to the obtained map, it can be concluded that in addition to the Pripyat deflection, the regions in the Podlasko-Brest and Orsha depressions experienced lowering, while the rest of the country experienced a slight rise. Possible errors may be related to different details and different authorship of the source data. The research will continue with the involvement of new sources and new instruments of analysis.

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UDC 004.223.2

METHODS OF MODERN CRYPTOATTACKS

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The article discusses typical types of attacks on modern cryptosystem as the way to protect all weak sides of current security.

In the present era, not only business but almost all the aspects of human life are driven by information. Hence, it has become imperative to protect useful information from malicious activities such as attacks. Let us consider the types of attacks to which information is typically subjected to.

Attacks are typically categorized based on the action performed by the attacker. An attack, thus, can be passive or active.

Passive attacks. The main goal of a passive attack is to obtain unauthorized access to the information. For example, actions such as intercepting and eavesdropping on the communication channel can be regarded as passive attack.

These actions are passive in nature, as they neither affect information nor disrupt the communication channel. A passive attack is often seen as stealing information. The only difference in stealing physical goods and stealing information is that theft of data still leaves the owner in possession of that data. Passive information attack is thus more dangerous than stealing of goods, as this information theft may go unnoticed by the owner of the information.

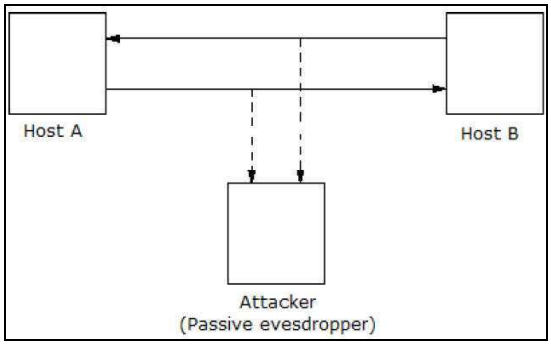

Figure 1. – Schema of passive attack

Active attacks. An active attack involves changing the information in some way by conducting some process on the information. For example,

- Modifying the information in an unauthorized manner.
- Initiating unintended or unauthorized transmission of information.
- Alteration of authentication data such as originator name or timestamp associated with information
- Unauthorized deletion of data.
- Denial of access to information for legitimate users (denial of service).

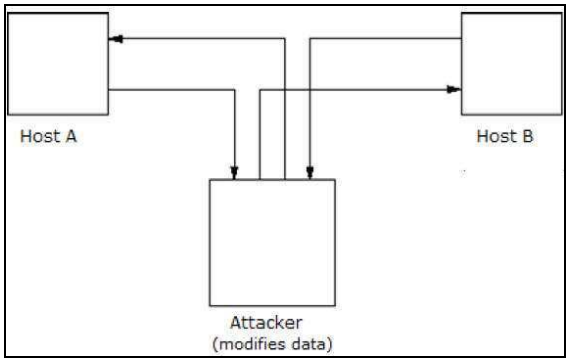

Figure 2. – Schema of active attack

Cryptography provides many tools and techniques for implementing cryptosystems capable of preventing most of the attacks described above.

Cryptographic attacks. The basic intention of an attacker is to break a cryptosystem and to find the plaintext from the ciphertext. To obtain the plaintext, the attacker only needs to find out the secret decryption key, as the algorithm is already in public domain.

Hence, he applies maximum effort towards finding out the secret key used in the cryptosystem. Once the attacker is able to determine the key, the attacked system is considered as broken or compromised.

Based on the methodology used, attacks on cryptosystems are categorized as follows –

- **Ciphertext Only Attacks (COA)** – In this method, the attacker has access to a set of ciphertext(s). He does not have access to corresponding plaintext. COA is said to be successful when the corresponding plaintext can be determined from a given set of ciphertext. Occasionally, the encryption key can be determined from this attack. Modern cryptosystems are guarded against ciphertext-only attacks.
- **Known Plaintext Attack (KPA)** – In this method, the attacker knows the plaintext for some parts of the ciphertext. The task is to decrypt the rest of the ciphertext using this information. This may be done by determining the key or via some other method. The best example of this attack is linear cryptanalysis against block ciphers.
- **Chosen Plaintext Attack (CPA)** – In this method, the attacker has the text of his choice encrypted. So he has the ciphertext-plaintext pair of his choice. This simplifies his task of determining the encryption key. An example of this attack is differential cryptanalysis applied against block ciphers as well as hash functions. A popular public key cryptosystem, RSA is also vulnerable to chosen-plaintext attacks.
- **Dictionary Attack** – This attack has many variants, all of which involve compiling a 'dictionary'. In simplest method of this attack, attacker builds a dictionary of ciphertexts and corresponding plaintexts that he has learnt over a period of time. In future, when an attacker gets the ciphertext, he refers to the dictionary to find the corresponding plaintext.
- **Brute Force Attack (BFA)** – In this method, the attacker tries to determine the key by attempting all possible keys. If the key is 8 bits long, then the number of possible keys is $2^8 = 256$. The attacker knows the ciphertext and the algorithm, now he attempts all the 256 keys one by one for decryption. The time to complete the attack would be very high if the key is long.
- **Birthday Attack** – This attack is a variant of brute-force technique. It is used against the cryptographic hash function. When students in a class are asked about their birthdays, the answer is one of the possible 365 dates. Let us assume the first student's birthdate is 3rd Aug. Then to find the next student whose birthdate is 3rd Aug, we need to enquire $1.25*\sqrt{365} \approx 25$ students.

Similarly, if the hash function produces 64 bit hash values, the possible hash values are $1.8x10^{19}$. By repeatedly evaluating the function for different inputs, the same output is expected to be obtained after about $5.1x10^9$ random inputs.

If the attacker is able to find two different inputs that give the same hash value, it is a collision and that hash function is said to be broken.

- **Man in Middle Attack (MIM)** – The targets of this attack are mostly public key cryptosystems where key exchange is involved before communication takes place.
  - Host A wants to communicate to host B, hence requests public key of B.
  - An attacker intercepts this request and sends his public key instead.
  - Thus, whatever host A sends to host B, the attacker is able to read.
  - In order to maintain communication, the attacker re-encrypts the data after reading with his public key and sends to B.
  - The attacker sends his public key as A's public key so that B takes it as if it is taking it from A.
- **Side Channel Attack (SCA)** – This type of attack is not against any particular type of cryptosystem or algorithm. Instead, it is launched to exploit the weakness in physical implementation of the cryptosystem.
- **Timing Attacks** – They exploit the fact that different computations take different times to compute on processor. By measuring such timings, it is be possible to know about a particular computation the processor is carrying out. For example, if the encryption takes a longer time, it indicates that the secret key is long.
- **Power Analysis Attacks** – These attacks are similar to timing attacks except that the amount of power consumption is used to obtain information about the nature of the underlying computations.
- **Fault analysis Attacks** – In these attacks, errors are induced in the cryptosystem and the attacker studies the resulting output for useful information.

Conclusion. The attacks on cryptosystems described here are highly academic, as majority of them come from the academic community. In fact, many academic attacks involve quite unrealistic assumptions about environment as well as the capabilities of the attacker. For example, in the chosen-ciphertext attack, the attacker requires an impractical number of deliberately chosen plaintext-ciphertext pairs. It may not be practical altogether.

Nonetheless, the fact that any attack exists should be a cause of concern, particularly if the attack technique has some potential for improvement.

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UDC 528.46:528.88

THE USE OF REMOTE SENSING DATA IN THE DESIGN OF DISTRICT BOUNDARIES

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The article is devoted to the planning and carrying out of cartographic works on the normalization of the area boundaries of the Republic of Belarus using medium and high resolution remote sensing data of Earth. It explains the introduction and use of actual satellite images as additional information for detection and design of accounting objects in order to improve the efficiency of work.

The spatial or territorial organization of the state is a dynamic entity. Processing actual location boundaries in some areas is more intensive, than in others. Therefore, it is important to establish a mechanism for clarifying the boundaries, dimensions, functions and competencies in the management structure of the administrative-territorial units. Shortcomings in the location of the borders of administrative-territorial units of the Republic of Belarus, including districts and regions, are a deterrent to improving the efficiency of state regulation and management in the field of land use and protection of lands.

Normalization and establishment of administrative-territorial units boundaries (ATU) started in Belarus in 2015. Nowadays the work has been finished in Minsk, Brest, and Grodno regions. The main goal of normalization and establishing the boundaries of the Republic of Belarus ATU is ensuring the efficient organization of state regulation and control, including the use and land conservation [1].

This work is carried out by the Republican Unitary Enterprise Belgiprozem Design Institute and its subsidiaries, in cooperation with land management agencies of local executive committees, and other organizations within in The State Committee on Property of the Republic of Belarus [2].

The main objectives of land management in order to normalize and establish the boundaries of districts (regions) under consideration are as follows:

– elimination of defects in the location of the border, including by combining physical (actual land use) and legal borders;

– uniform presentation of the normalized border on all planning and cartographic materials, as well as in the Land Information System (LIS) of the Republic of Belarus (LIS RB);

– preparation of Materials (as the main land management documentation) to establish the boundaries of regions and their constituent areas;

– the use of the above Materials in the prescribed manner when registering districts and regions in the ATU and TU registry and making changes to the credentials of the land cadastre of the Republic of Belarus [2].

The main task at the stage of laboratory works is to obtain high-quality cartographic material. The base scale is 1:10 000 (for activities on normalization and establishment of the boundaries of ATU, predetermining their precision and technology) [3]. Overview maps of village councils and district boundaries are in a scale of 1:50 000, area - 1: 200 000 [4].

To perform works on establishment of the boundaries the following cartographic materials are used in the Republic of Belarus:

– Map of administrative-territorial division of the Republic of Belarus;
– District land use maps of scale 1: 50 000;
– Common Registry data (coordinates of turning points of boundaries, cadastral maps duty);
– general plans of settlements;
– forest management plans;
– land management plans with the boundaries of rural settlements;
– last updates of topographical maps, plans and photoplans scale of 1: 50,000, 1: 25,000, 1: 10,000, 1: 5000-1: 500 [4].

The collected documents and materials are examined and evaluated in terms of accuracy and completeness, suitability for use.

An example of designing a normalized section of a district border is shown in Figure 1. It shows that it is advisable to draw a new border along the border of land types, for which it is sufficient to use orthophoto in office conditions without the need for fields surveys of the presented plot.

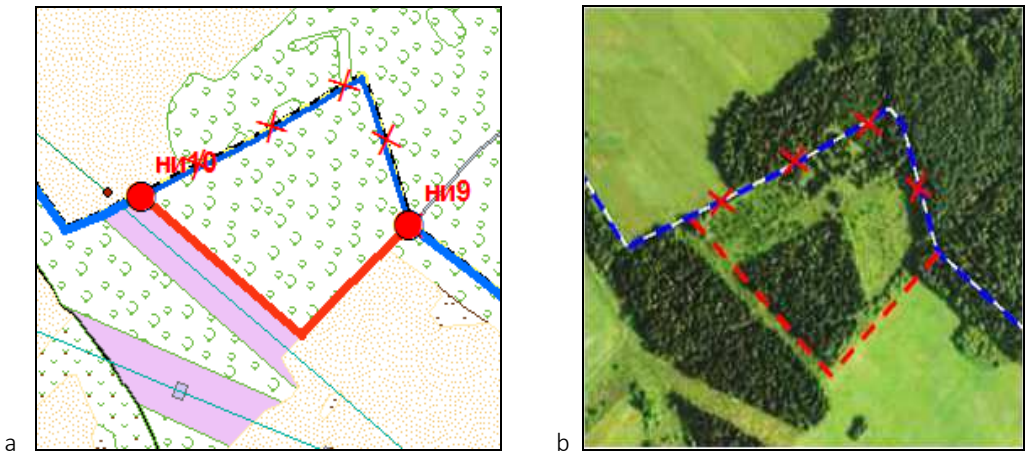

**Figure 1. – Designing a normalized border section in the LIS according to:
a) the boundaries of the types of land (shape file in LIS); b) according to the orthophototo of the area**

Currently, in the Republic of Belarus the most high-precision current source of data on the Earth's surface is digital data with a spatial resolution from 5 to 50 cm. Interpretation of the data allows you to select different elements of the terrain at the time of observation with high accuracy.

However, a one-time flying around the entire area for normalization is not possible, therefore, for this type of work alternative data sources allowing to update the information are needed. Recently remote sensing data in many cases are actually the most economical, replacing the need for field surveys of problematic parts of the border [5].

Ground markings and natural boundaries can be found in the images of medium resolution. So, according to experts, the data of the American satellite Landsat 7 (8), which are freely available allow for the geometric precision scale plan 1:25 000. As part of the study the author analyzed the readability of objects on satellite images from Landsat 8 and WorldView 1 (Table 1).

Table 1. – Analysis of readability facilities on satellite images

Objects	Identification	
	Landsat 8	WorldView 1
Territory of inhabited locality (built-up areas)		
The boundaries of the settlements	When scaling the images are well read	They are well defined
The road network		
Highway	Are well read	They are well defined
Improved earth-roads	When scaling the images are well read	When zooming the picture is clearly distinguishable
Field and forest roads	Field, forest roads are deciphered with difficulty on satellite images	They are well read on pictures with minimal vegetation
Vegetation		
The contours of the forest	The contours of the forest, felling are readable	Separate areas of vegetation are well read
Hydrography		
Lakes, reservoirs, rivers	All lakes, reservoirs, rivers are well deciphered	All lakes, reservoirs, rivers are well deciphered
Bridges	If considerably long, they are read as visible gray lines on a dark background of water; if small - can not be read	Light lines are well defined
Types of land		
Border outlines of types of land	Defined with difficulty in the growing season	Can be defined in the growing season

Open access to the images of the earth surface in various resolution and ranges from the Ikonos satellite, WorldView-2, QuickBird, SPOT, IRS, Landsat determines the opportunities to use them. For the application of satellite imagery provided by free services Yandex, Google Earth, Google Maps, Bing Maps , etc. specialized software SAS.Planeta is used.

The use of remote sensing data requires evaluation of the following factors:

– Access to the territory of satellite resources (including the possibility of obtaining data on a given date);
– Possibility of identifying natural boundaries and recognition of image borders in an area;
– The accuracy of the planned position coordinated points;
– Determination of the boundaries in the desired coordinate system;
– Time and labor for the definition and specification of borders [3].

The study of satellite images of varying resolution, obtained from imaging systems, allows us to conclude that a significant portion of linear and other facilities is needed to determine the location and boundaries of design, easily distinguishable in the photographs. The accuracy of determining the coordinates of these data can not meet the requirements of 1: 10 000. However, they can be used to update the existing data with high resolution for sparsely populated areas, or areas, where intensity of economic activity varies for the early detection of these changes [5].

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DESIGNING OF INTERNET SHOP OF TELEGRAM

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The article presents a statement about the need to create a web application that can help in acquiring Telegram channels of various contents. The basic requirements for designing the functionality and interface of a web resource are discussed.

Currently, online stores are convenient resources for users, because they allow you to quickly and easily order goods and services from personal computers without leaving your home. Therefore, we can conclude that they are also beneficial for store owners.

After analyzing the current trends in the modern market, we can conclude that the development of an online store that can effectively sell Telegram channels is of immediate interest, because at the moment there are no full analogues of such a resource. Thus, the unique character in this segment is demonstrated.

Since the online store functions as a display window representing available goods and services, it seems advisable to develop a web application that will allow you to place products, grouping them by type and price.

Therefore, basing on the analysis of the subject area, the main requirements for the development of the Telegram channels online store were identified:

- viewing news on the main page regarding the domain of the site;
- viewing reviews in the online store;
- viewing video content on the main page of the site;
- selecting channels by category;
- channel filtering;
- purchase of channels;
- contacting the site administration through the "About Us" section;
- selection of channels on the topic;
- search for channels on all pages of the site;
- site administration;
- ability to update news content on the main page;
- change of the catalog of goods;
- animated design;
- breadcrumbs.

The functional configuration of the resource being developed can be represented as a set of subsystems:

- viewing, editing and creating a news subsystem (allows you to view the latest news on various topics on the online store home page: five news pages can be placed on the online store home page; the online store administrator is the only person who can edit and create news) ;
- viewing, editing and creating feedback in the subsystem of the online store (allows you to scan reviews on the main page of the online store: you can place seven reviews on the main page; the review includes a text, a photo of the client and a link to the social network where it was made);
- viewing, editing and creating a subsystem of categories (the user can choose a category at his discretion; the administrator can edit the categories; each category has a name and its own unique URL);
- subsystem of order options (each user can buy goods through the online store, just click the "BUY" button under the goods and specify your personal data).

The process of developing an online store interface begins with a home page on which the following elements should be placed:

- a drop-down menu that allows users to select a catalog of categories of Telegram channels;
- a news carousel, which allows users to view all the news regardless of the user, the change of news occurs automatically, it is also possible to change the news using a computer mouse;
- a search panel is a search for a channel by its name (a message appears with possible hints when searching);
- a feedback carousel, which allows users to view the opinions of customers who have already used the services of the site (automatic feedback moves automatically, there is also a feedback function).

The following items should be placed on the channel list page:

- a drop-down menu that allows you to select sorting;
- a button "Sort", which allows you to sort;
- a search panel is a search for a channel by its name and category (when searching, a hint appears with possible hints);
- a "BUY" button, which allows you to make purchases, when you click, a page with a form appears;
- an element "breadcrumbs", allowing you to go to the previous page;
- a Telegram channel logo;
- a logo of the online store, when users click on it, they are redirected to the home page of the site;
- a price of the Telegram channel.

On the Telegram-bot page, all standard elements of the Telegram messenger will be placed.

As can be seen from the above, the presented page templates demonstrate the process of developing the basic functionalities of this web resource. An online channel store will not only be able to replace the search for channels on questionable online forums or websites, but also provide a transparent and secure purchase.

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DESIGNING THE STEGOSYSTEM, BASED ON HIDING TEXT DATA IN IMAGES BY USING DISCRETE TRANSFORMATIONS

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The article presents a practical way of creating a reliable stegosystem with an unconventional way of hiding information. The purpose of this work is to build a system based on hiding text messages in images, as well as to study the attacks and to find out, whether such a system is suitable for practical usage.

Introduction. This article is about hiding data in images using one of the methods of steganography. Digital steganography refers to the concealment of one information in another. Moreover, concealment must be implemented in such a way that, first, the properties and some value of the hidden information are not lost, and secondly, the inevitable modification of the information carrier not only does not destroy the semantic functions, but also at a certain level of abstraction does not even change them. Thus, the transmission of one message within another is not detected by traditional methods.

Both spatial and frequency parameters of the image container can be subjected to steganographic modification. All these parameters are suitable for steganographic modification, but before the embedding procedure, it is necessary to evaluate the limits of modification of parameters of a container, as well as the distortions introduced in this case. The throughput, reliability, and stability of the steganographic system will largely be determined by the degree of modification of the image container [1].

The principle of a steganographic system designing and the description of the data hiding algorithm. The standard steganographic scheme is maintained regardless of the technology that implements it. The stegosystem performs the task of embedding and selecting messages from other information. The stegosystem consists of the following main elements (fig. 1).

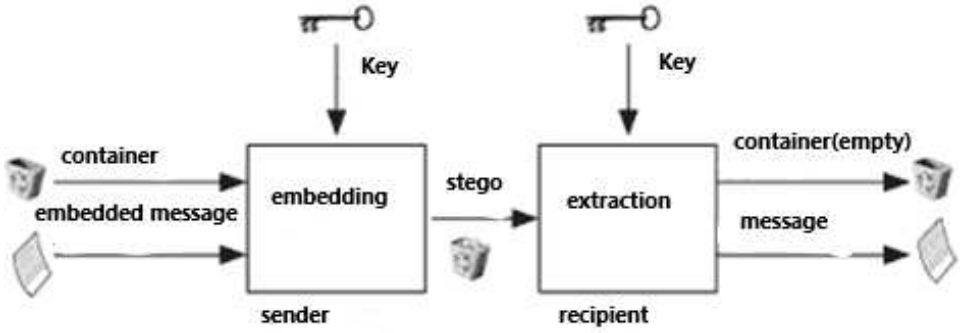


Figure 1. – Block diagram of a typical stegosystem

As the data may be any information: text, message, image, etc., Container any information that is intended to conceal secret messages. Empty container - a container without an embedded message; a filled container or stegocontainer containing embedded information. Embedded (hidden) message - a message that is embedded in a container. Steganographic channel - stego transmission channel. Stegokey or just the key - the secret key is needed for hiding information. Depending on the number of security levels (for example, embedding a pre-encrypted message), the stegosystem may have one or more keys.

Data containing a hidden message may be subject to deliberate attacks or accidental interference. As shown in figure 1, the stegosystem combines two types of information so that they can be distinguished by two fundamentally different detectors. One of the detectors is a digital watermark selection system, and the other is a human [5].

Steganographic replacement methods are unstable to any distortion, and the use of lossy compression operation leads to the complete destruction of all secret information hidden by the method of the Least Significant Bit of the image. More resistant to various distortions, including compression, are methods that use a frequency domain rather than a time domain to hide data [2].

The vast majority of computer steganography methods are based on two key principles:

– files that do not require absolute accuracy (in this case, image files) can be modified without losing their functionality;

– the human senses are unable to reliably distinguish minor changes in files modified in this way, and / or there is no special tool that would be able to perform this task.

The basic approaches to implementing computer steganography methods within an information environment are based on selecting insignificant fragments of this environment and replacing existing information with information that needs to be hidden.

Considered in this paper, the Koch-Zhao algorithm for embedding information uses the frequency domain of the container and consists in the relative replacement of the values of the coefficients of the discrete cosine transformation (DCT) [3].

The image is divided into 8×8 blocks (in our case, 2×2, 3×3, and 4×4 blocks) of pixels, and a Discrete Cosine Transform is applied to each block. Each block is suitable for recording one bit of information.

The hiding algorithm will be as follows:

- iterate the image with a double array in 8 steps;
- at each iteration, we create a temporary array of 8×8 pixels, each element of which will be a set of three pixel colors;
- we apply a DCT to this array, and get an array of coefficients of size 8×8;
- select 2 coefficients and calculate their difference modulo;
- if the difference is less than or equal to 25, then assign the first coefficient a positive value of the second + constant, or the same, but with a minus sign (this is called bit transfer);
- if the difference is less than or equal to -25, then we perform the same actions only for the second coefficient;
- then the reverse DCT is applied to translate our coefficients back into the spatial domain;
- then copy the color values to the image.

Advantages of the method:

- resistance to JPEG compression with a low compression ratio.

Disadvantages:

- noticeable visual distortion of the container image with a large threshold value of the difference between the DCT coefficients of the blocks;
- small message size than can be embedded.

Estimation of the implemented system stability. Each image has unique properties that can be used as a basis for dividing them into classes.

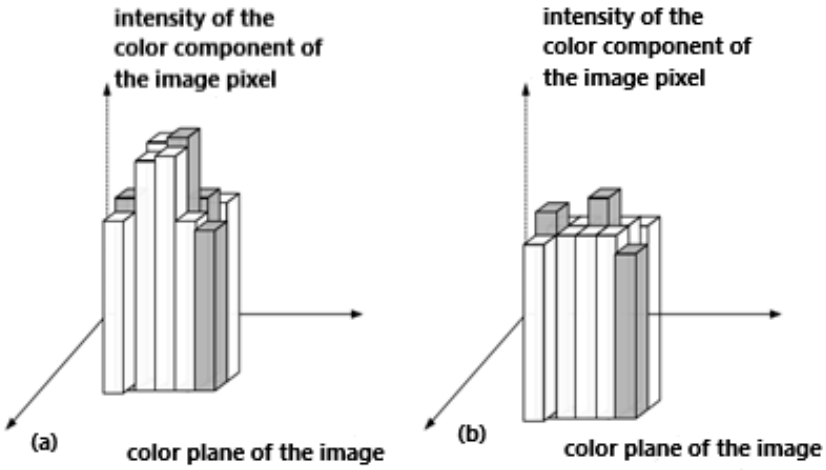
1. Images with a small number of colors (4-16) and large areas filled with a single color.
2. Computer-generated images with smooth color transitions.
3. Photorealistic images.
4. Photorealistic images with business graphics overlay.
5. Map images.
6. Space images.

To ensure that data is hidden in image containers, you must select images that contain areas with sharp color transitions and object borders, since they can hide small changes in the intensity of the color components of the container pixel in relation to neighboring pixels (fig. 2). Modified pixels in the drawing are grayed out. You can see that even a slight change in the intensity of some color component of individual pixels, in areas filled with a single color (fig. 2B), increases the possibility of visual or computer detection of the fact of steganographic data hiding.

It is advisable to analyze the contents of image containers using a mathematical transformation that allows you to select its frequency parameters and evaluate the contribution of individual frequencies to the image composition. One of these transformations is the discrete cosine transform [3], which is applied to images by means of n×n pixel windows. Discrete cosine transformation allows you to get information about sharp and smooth borders of image colors, areas filled with a single color or with a gradient color change, etc.

It is advisable to assess the suitability of the image for steganographic modification in two stages.

At the first stage, images are divided into classes according to the relative weight of their spatial frequencies. Positive results were obtained using spectral classification of images, which allows them to be divided into 8 classes [4]. Classes 1 through 3 describe images with the highest relative weight of low frequencies; classes 4 through 7 differentiate images by spectral components concentrated in areas close to the low-frequency and / or high-frequency ranges; the eighth class separates images that have a uniform spectrum within the entire considered range.



(a) the region of sharp transition of colors,
(b) area filled with a single color

Figure 2. – Color planes of modified image areas

In the second stage, the throughput of the container image is evaluated by excluding areas that are not suitable for modification, such as those filled with a single color or a gradient color change. It is possible to detect such regions in an image when analyzing its spectral composition (the presence of borders in the image leads to an increase in the contribution of medium and high frequencies), and when evaluating changes in the intensity of a pixel in relation to neighboring pixels.

In the Koch-Zhao method, it is undesirable to use images with a small number of colors and large areas filled with a single color (in particular, white) to ensure that data is hidden in image containers. Since in this case, after encryption, the image will clearly show the fact of hiding information.

The following types of attacks are distinguished for the Koch-Zhao method:

1. Attacks against the embedded message, directed to removal of or damage to the integrated information through the manipulation of the filled container. The attack methods included in this category are not aimed at evaluating and highlighting the message. Examples of such attacks in this paper are image compression.
2. The attack against the embedded message is directed to the use of filters. In this case, the message remains in the image, but the ability to receive it is lost. This category includes attacks such as attacks using effects in various photo editors.
3. The attack against the embedded message is directed to the use of geometric transformations. This category of attacks is related to truncation and changing the dimension of our image.
4. An attack aimed at changing the brightness and contrast of an image. This type of attack is associated with a significant change in the image.

Conclusion. Research in the field of steganography is a very promising area of information protection, since in the modern world the task of transmitting secret information is on a par with hidden communication, i.e. hiding the fact of transmitting messages. Therefore, it is necessary to continue research in this area to find new, effective, methods or improve existing ones. In this paper, we considered the method of embedding information in images. The most promising method, however, requires improvement in terms of bandwidth, and the probability of correct extraction of embedded bits of information. The efficiency of using the Discrete Cosine Transformation in this method for image compression is explained by the fact that it well models the image processing process in the human vision system (HVS), separates the "significant" details from the "insignificant" ones. This means that it is more appropriate to use it in the case of an active violator. The software product is implemented and ready for use with the possibility of further development.

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USING SAMSUNG SMART WATCHES AS AN NFC PASS

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This article talks about NFC technology and how to create a Samsung smart watch application to emulate an access card.

Introduction. Near field communication (NFC) is a form of contactless communication between devices or between a device and a chip/tag. Using NFC, a user can transfer/receive small amount information from a short distance (example, 10 cm).

Card-emulation mode, as the name suggests, makes the device behave like a contactless smart card. Using this mode, we can develop virtual credit cards, debit cards, transit cards, and access cards.

Near-Field Communication is a method that devices have for communicating with each other when in close proximity to one another.

The technology originated as an offshoot of RFID tech, or radio frequency identification, with the added rule that the devices had to be close to each other physically. Both techs rely on the physics of electromagnetic radio fields to transmit parcels of data. The term "radio wave" is used to denote a certain swath of wavelengths of light, and it's used in most modern technologies as a means of communication because it can easily go through walls and generally not be hampered by physical obstacles (as opposed to, say, visible light).

How do NFC readers work?

The door reader activates and transmits radio waves to induce electric current in the NFC card; passive devices do not actually need any power source, but instead are designed to activate and begin transmitting their NFC signal when exposed to a changing magnetic field. The active devices will have an electric current running through them and, when they are put in close proximity to a passive device, they will prompt it to begin transmitting—read the signal—then the passive device will stop transmitting when it's moved farther away. Here is a diagram explaining how the induced current works. The active device (right: "Reader") has its magnetic field interact with the passive device (left: "Smartphone") and creates a matching current to power it.

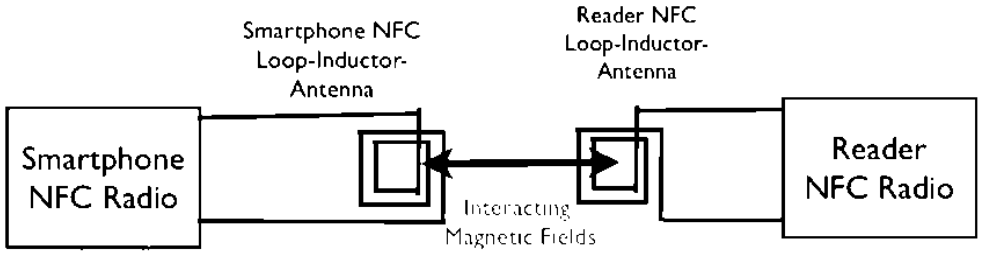

Figure 1. – NFC communication scheme

Different Types of NFC ID

The NFC reader induces a magnetic current in the token and, in turn, the token transmits the relevant string of characters. Depending on what type of token it is, the nature of this string will change: If it's a simple ID reader, then the string is a unique identifier for the user; if it's a transit card then it's an ID, but on the back end the reader needs to record the charge and update its server, and if it's a contactless payment card, then it's an ID with many added layers of encryption and security to protect the user's bank information (in this case, only a dedicated and approved reader could decrypt the information relevant to the bank details, any other reader would only be able to read a simple ID string).

Signal Relaying Back to the Server

After the reader reads the ID, based on the use case, the reader will then communicate this information back to the host server over local network or WiFi. Most readers only cache a small amount of information and have a method of communicating with the primary server—since storing all the relevant user info on a reader

would be impractical, insecure, and would result in too bulky a product. The server will then authenticate the request and prompt the reader to perform some relevant action, be it unlocking a door, communicating with a bank server, unlocking a subway turnstile, etc. This all happens behind-the-scenes and instantaneously (depending on the strength of the WiFi signal) guarantees the end user a seamless experience.

Main section. All current models of Samsung smart watches work on the Tizen operating system. Tizen is a user-interactive and service-oriented open source project that allows creating feature-rich applications for multiple device categories.

The Tizen Near Field Communication service enables information exchange between NFC-enabled devices (called "peers") or tags. The NFC-enabled devices can share contacts, photos, and videos, and can act as smart cards. You can use an NFC-enabled device to send NDEF messages to NFC tags to implement a variety of activities, such as paying the grocery bill or downloading a coupon. With application controls, you can launch NFC applications when NFC-related operations occur.

The main features of the NFC API include:

– NFC device management: you can manage NFC connectivity by enabling or disabling the NFC service.

– NFC tag and peer detection: you can receive notifications when an NFC tag or peer device has been detected.

– NDEF message manipulation: you can handle NDEF messages by first creating NDEF records, and then adding the records to an NDEF message.

– NDEF data exchange: you can exchange NDEF data between tags and peers.

– NFC card emulation: you can enable NFC card emulation and monitor the secure element transaction carried out by the device.

– NFC host-based card emulation (HCE): you can handle HCE events and transactions.

An NFC tag is a chip, which can securely store personal information, such as debit card numbers or contact details. The methods of the NFCTag interface (in mobile and wearable applications) are used to access an NFC tag for reading or writing information. Tizen supports the following NFC tag types: GENERIC_TARGET, ISO14443_A, ISO14443_4A, ISO14443_3A, MIFARE_MINI, MIFARE_1K, MIFARE_4K, MIFARE_ULTRA, MIFARE_DESFIRE, ISO14443_B, ISO14443_4B, ISO14443_BPRIME, FELICA, JEWEL and ISO15693.

The NFC forum defines the NFC data exchange format (NDEF) for encapsulating the data exchanged between two NFC-enabled devices or an NFC-enabled device and an NFC tag. An NDEF message can store data in various formats, such as text, Multipurpose Internet Mail Extension (MIME) type object, or ultra-short RagTime Document (RTD). The NFC tags use NDEF for exchanging messages. Tizen provides the NDEFMessage interface (in mobile and wearable applications) to define an NDEF message.

An NDEF message is composed of multiple records. An NDEF record is created using the NDEFRecord interface and is identified by record type, ID, and payload.

A record in an NDEF message can be created by using the following payload types:

– Text. The NDEF record content is created using text format. The *NDEFRecordText* interface is used to create the text format payload using the text, languageCode, and encoding attributes.

– URI. The NDEF record content is created using a URI. The *NDEFRecordURI* interface is used to create the URI type payload using the uri attribute.

– Media. The NDEF record content is created using a media format. The *NDEFRecordMedia* interface is used to create the media format payload using the mimeType attribute.

Managing NFC Connectivity

To use the Application and NFC APIs, the application has to request permission by adding the privileges to the config.xml file. To use NFC, retrieve the default NFC adapter using the *getDefaultAdapter*() method of the *NFCAdapter* interface.

To enable or disable the NFC service:

1. To get the default NFC adapter, use the *getDefaultAdapter*() method and prepare an *ApplicationControl* object to request the NFC switching operation.
2. Define the event listener for the *launchAppControl*() method.
3. Define the event handler for an application control, which implements the *ApplicationControlDataArrayReplyCallback* interface.
4. If necessary, request launching the NFC Settings with *nfcSwitchAppControl* as a parameter.

Using NFC Card Emulation

You can enable NFC card emulation and monitor the secure element transaction-taking place using the *NFCAdapter* interface. The device carries out the secure element transaction. The Tizen application can detect

the transaction, but does not take part in it. Interpreting the transaction data requires knowledge about the data protocol the transaction uses. With the required knowledge, the application can detect whether the transaction was successful.

To enable or disable the NFC card emulation and detect secure element transactions:

1. Declare the required variables and obtain the *NFCAdapter* object using the *getDefaultAdapter*() method of the *NFCManager* interface.

2. To enable NFC card emulation, change the value of the *cardEmulationMode* attribute to *'ALWAYS_ON'.*

3. To be notified when the type of an active NFC secure element changes, use the *addActiveSecureElementChangeListener*() method of the *NFCAdapter* interface.

4. To be notified when a NFC secure element transaction data is exchanged, use the *addTransactionEventListener*() method of the *NFCAdapter* interface.

5. Remove the registered listeners when they are no longer necessary and disable NFC card emulation

Using NFC Host-based Card Emulation

You can handle HCE (host-based card emulation) events and transactions taking place using the NFCAdapter interface. HCE is an on-device technology that permits a device to perform card emulation on an NFC-enabled device without relying on access to a secure element. The transaction data is routed to the host application directly, instead of routing to a secure element. The Tizen application can detect the transaction and can take part in it.

To detect NFC HCE events and manage AID (Application ID):

1. Specify an *AID* value for receiving HCE transaction events. To tell the platform which AID groups are requested by the application, a metadata element must be included in the *config.xml* file.

2. Declare the required variables and obtain the NFCAdapter object using the *getDefaultAdapter*() method of the *NFCManager.*

3. To detect the HCE event, use the *addHCEEventListener*() method of the *NFCAdapter* interface to register a listener. Use the *sendHostAPDUResponse*() method of the *NFCAdapter* interface to send a host APDU response to a contactless front-end. (APDU - Application Protocol Data Unit - is defined in the ISO/IEC 7816-4 specification.)

4. To register an AID for a specific category and secure element type, use the *registerAID*() method of the *NFCAdapter* interface.

5. To retrieve the registered AIDs for a specific category and secure element type, use the *getAIDsForCategory*() method of the *NFCAdapter* interface.

6. Remove the registered listeners when they are no longer necessary, and disable NFC card emulation

Conclusion. Using a smart watch as a pass can be very convenient. Implementing an application that allows you to emulate an access card is not so difficult if the pass used only works on ID transfer. If the pass uses a secure transaction, then for its emulation it is necessary to know the data transfer protocol.

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UDC 004.055

DESIGNING INTERFACES OF THE SPORT CLUB SITE

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The article presents a practical way to create an interface for a sports club website. The main goals of the site, the tasks of the web service, and the basics of building an interactive interface prototype were set.

Introduction. Website should represent sports club on the Internet, maintain its positive and modern reputation, introduce visitors to the services of the club, provide convenient and user-friendly interface to facilitate the process of familiarizing with the services and further interaction with the site.

The purpose of the site is to introduce visitors to the club, its activities, services, prices, as well as to help make the first steps towards a healthy lifestyle in general, to provide information on training methods and nutrition. Also, the main goals include:

– attracting an audience to the club;
– saving the club's clients and administration time;
– providing current information on training and nutrition.

The objectives of the web site should be oriented towards achieving the set goals. The objectives of this project are:

1. registration for training online;
2. filling in the data using forms;
3. communication with the user via a feedback form;
4. publication of current information on training and nutrition;
5. correct and fast search for necessary information;
6. convenient functionality and visually appealing content.

Creation of an interactive interface prototype. The prototype is a visual structure of the site, which gives an idea of what a web resource will look like [1]. It represents the structure of the future site as well as its individual pages outside the design elements, colors, images and branding. The site prototype is made with the help of modular grid and Axure RP 8 program, which allows you to create interactive prototypes with the ability to view the result in a browser for visualization [2].

At the top of each prototype page is a static unit with a logo and a menu. At the bottom of the site is a block with information about the club, contact details, club addresses and links to social networks.

On the screen shown on picture 1, at the top there is a site menu with links to the home page and registration, or a link to sign in to your personal account, which is accompanied by an icon.

Below is a block with information about the goals of the site. This location will help to ensure that the user who came to the site, will immediately pay attention to this block. In order to attract attention, it contains pictures of medium size, which fit into the overall design. Below is a block with the features of training, also accompanied by images.

Right after them you can see a list of what our club specializes in and what services it provides, all this information is presented in large text with icons explaining it.

Further, you can find information about prices for the services of the club, a block with the type of subscription, below which you can see all the options provided to the owner of the subscription for the specified price in the block.

Then, the user has the opportunity to get acquainted with the information about the coaching staff, their images, service record, achievements, methods on which they train, personal information.

As a conclusion, there is a photo gallery, each image illustrates a certain service of the club, all images have the same stylistics and interactivity, which activates after cursor pointing.

At the end of the page there is a block with information about the site, contact form, working hours and links to social networks.

You can see the main page on figure 1. The page represents the location of the blocks presented on the web site.

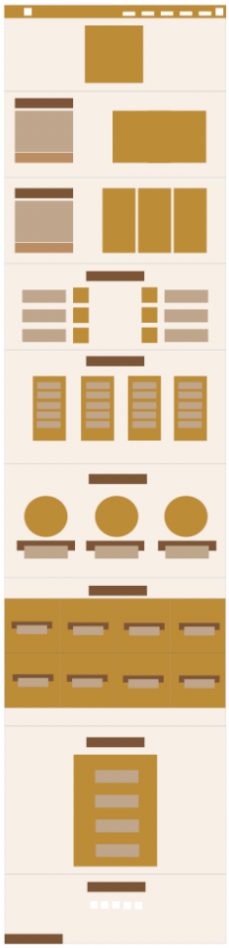

Figure 1. – Main page prototype

Figure 2 shows the prototype of the "Personal Cabinet" page. The page represents two blocks, one - the menu of the personal cabinet, and the second shows the information of the menu item. Each of the blocks contains unique information about training plans, their schedule, as well as nutrition. You can choose the desired date and time, and then make an appointment for a training session. After confirming the appointment, a training reminder will appear in your personal cabinet.

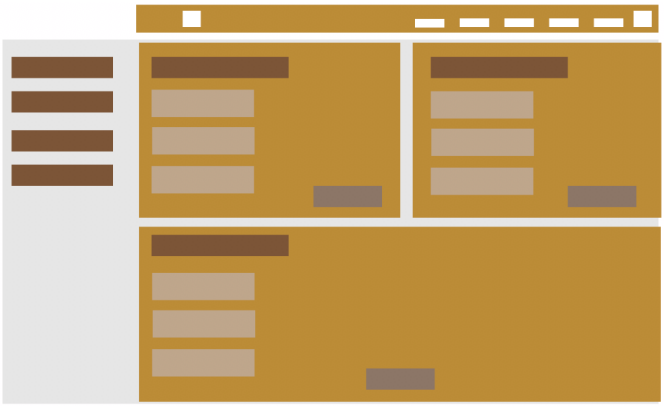

Figure 2. – Personal Cabinet page prototype

On the screen with the registration form, the prototype of which is shown on figure 3, the user must enter contact details and send, then he will be registered and will be able to use the functions of a personal cabinet.

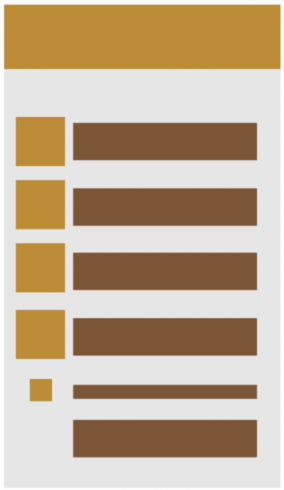

Figure 3. – Part of the registration prototype

On the screen of the personal cabinet the user can see the tabs with the recording of training, meals and the training itself. On the screen of entering contact information there is a verification of the correctness of entered data. In case the user enters the data incorrectly, the resource will not let it pass on.

Conclusion. Basic interface constructions are described in this article. The necessary sections of the software were formulated, for each of them was designed a prototype on the basis of which you can create a graphical image of the site screen, and then the web site itself.

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UDC 004.021

POSTMAN PLATFORM FOR API DEVELOPMENT IN THE MOBILE APPLICATION "MUSICIANS OF RUSSIA"

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This article describes a modern way of testing software, in particular the server part of the application (API - application programming interface). There you can find an example of usage Postman in the development process of the server part of the mobile application "Musicians of Russia".

Introduction. Testing process is an essential part of creation software product. The main purpose of testing process is an investigation conducted to provide stakeholders with information about the quality of the software product under test. The following type of the software errors can be distinguished:

functional errors (adding goods to the basket order doesn't work, it's impossible to leave a comment on the user's post, the search by keywords doesn't work);

user interface errors (the text doesn't fit within the boundaries of the designated area, the image isn't displayed, the wrong size or font of the text);

logical errors (it's possible to select the date of birth in the future during the registration process, make an order without leaving contact details for communication);

content errors (spelling and punctuation errors);

usability errors (clearing the filled form fields during validation data process, it's impossible to save your current progress, not user friendly interface);

security errors (sql-injections, public access to the private data) [1].

There are a lot of different tools for the software testing. In more details we will consider the testing process of the API with usage of Postman tools. Thanks to the Postman we are able to find and prevent functional, logical and security errors, and on the next step we will figure out how to do it.

Main Postman features. Postman is one of the most popular tool which is used in API testing. The application allows developers easily create, share, test and document API. In fact it's very useful, because developers can create and save HTTP requests, as well as read their responses. Also we are able to create different test scenarios, which allow us to increase the coverage of the application source code. There are some advantages of the Postman:

always around - in order to use Postman it's enough to login with your account, what simplify access to the files anytime, anywhere;

collections usage - the Postman allows users to create collections for the API calls. Each collection may contains several queries. It helps you better to organize your test instructions;

collaboration - collections can be imported and exported. A direct link is also can be used to exchange collections;

creation of environments - you are able to use the same collections for different test environments, what allow to prevent test duplications;

tests creation - for every API call you are able to add control points, such as checking for a successful HTTP response status, which helps ensure test coverage;

automated testing - using Collection Runner or Newman, tests can be run in several iterations, saving your time fore repeated test cases;

debugging - the Postman console helps you verify what data what received during the API call, what makes debugging tests easier [2].

The most powerful features are collections and automated testing, we are during the development process.

There are several steps, which you need to do to make HTTP request with Postman:

1) select a GET request from the list of suggested request types;
2) in the address bar you need to insert the API url address that we are going to call;
3) click button Send;
4) after request submission we should see successful execution result, HTTP status 200 tells us about it;
5) in the result section you are able to see the array of users in the JSON format.

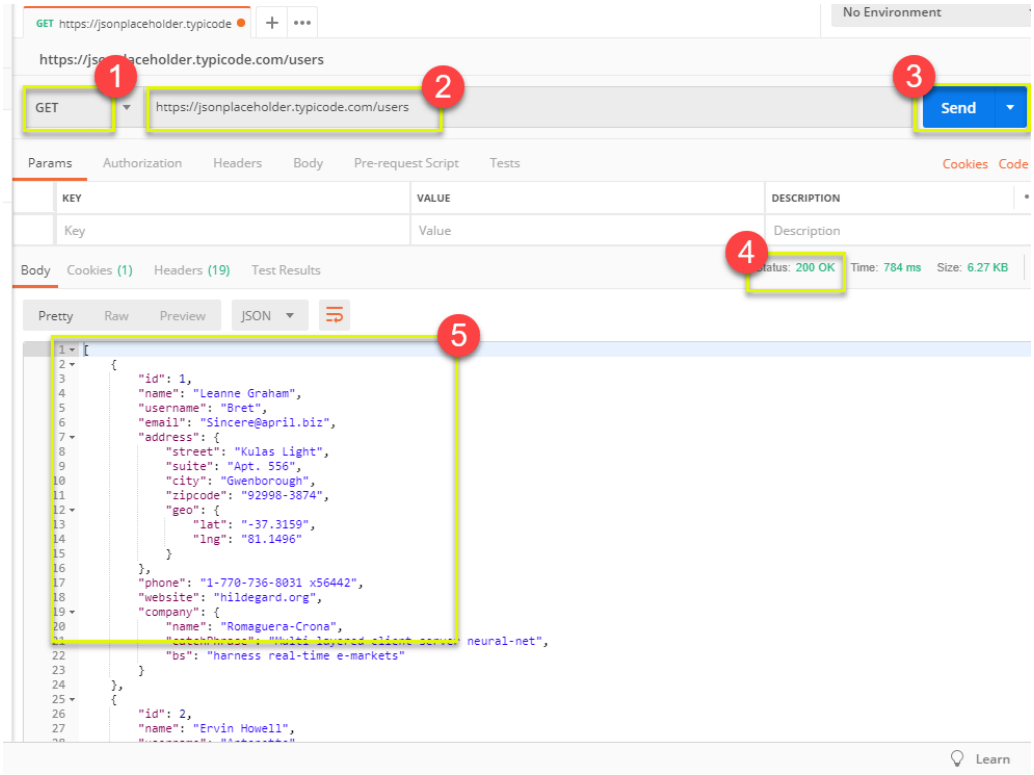

Figure 1. – Example of GET request execution with Postman

How do we use Postman in the "Musicians of Russia"?

The REST API (Representational State Transfer) model was chosen as the architectural solution for creation server part of the mobile application - there are the principles of building distributed hypermedia systems including universal methods for processing and transferring resource states via HTTP protocol [3]. Resource information management is entirely based on the data transfer protocol. The most common protocol is HTTP. We have next methods for the HTTP protocol to proceed data: GET (receive), PUT (add, replace), POST (add, change), DELETE (delete) [3]. All methods combined into the CRUD (Create-Read-Update-Delete) actions.

During the development process User entity was created. There you can find API methods, which are presented in the Table 1.

Table 1. – HTTP methods for the User entity

HTTP method	URL	Description
GET	/users	Get list of all users
GET	/users/:userId	Get user by id
POST	/users	Create a new user
PATCH	/users	Update user profile
DELETE	/users/:userId	Remove user by id

Next consider an example of execution HTTP request for the Users entity using Postman tools. In order to create a new user, we need to perform a POST request with next URL address /api/v1/user/1, where 1 is a unique identifier, which we assign to each user during the creation step. In the body request we pass all necessary parameters, in our case we need to pass the user's name. Figure 2 show us the result of successful execution POST request.

In case the query was executed with an error, for example validation error, we are able to see the error message in the output window. Figure 3 shows us the result of the POST request with an error message.

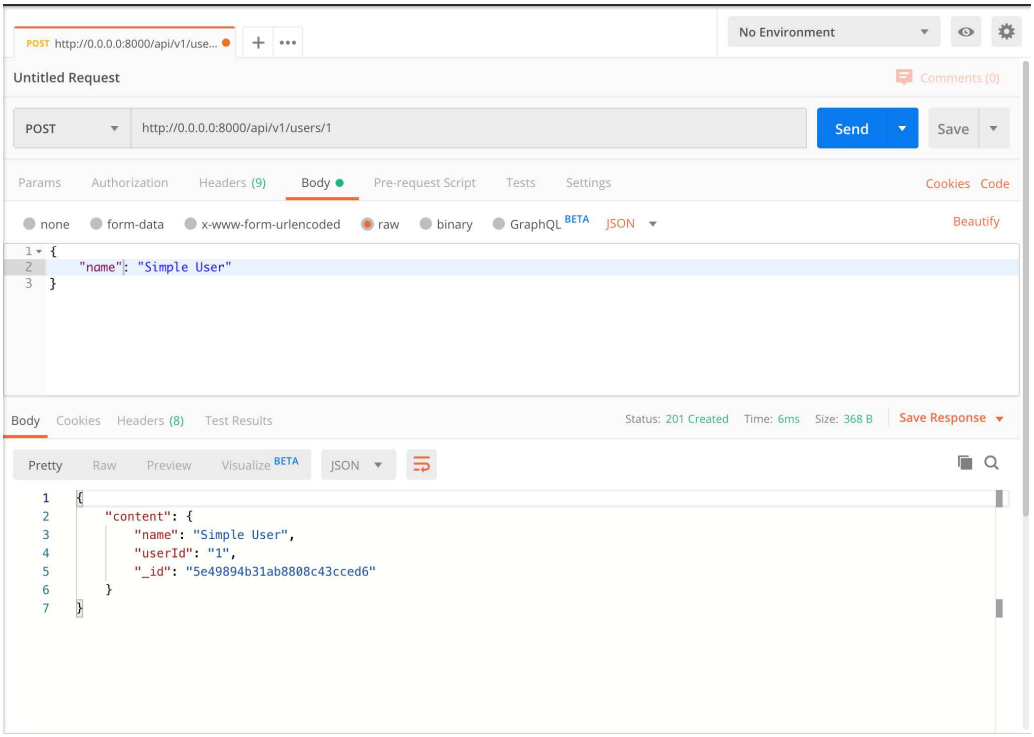

Figure 2. – Example of POST request execution with Postman

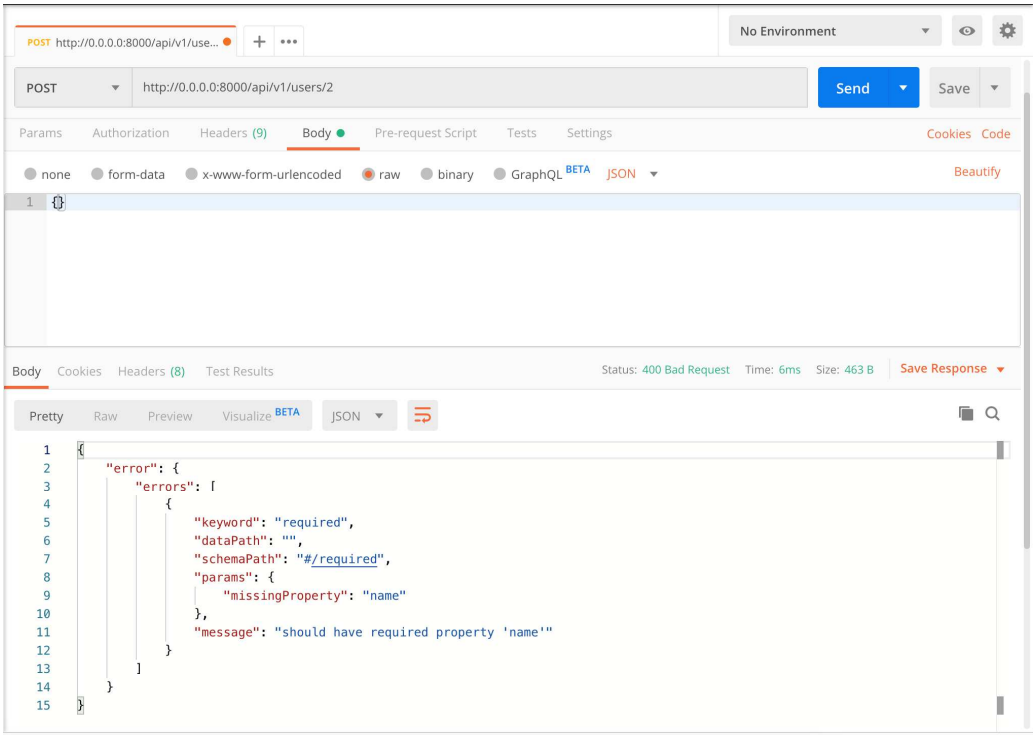

Figure 3. – Example of POST request execution with validation error

Conclusion. In the article was presented Postman application, the advantages of using the tool to test the API. Also the way of usage Postman was described during the development of the server part of the real mobile application "Musicians of Russia".

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UDC 004.5; 004.921

GRADUATES WEBSITE IN EDUCATION

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This article discusses the creation of a website for work at the university on the example of the resource of St. Petersburg State University "Alumni Association of St. Petersburg State University".

Nowadays we live in the century of information technology and most people communicate with each other through the Internet. Previously, after graduating from university, many classmates tried to keep in touch with each other, but contact information or addresses could easily be lost, after which, communication could stop. People talked through letters, rarely could talk on the phone. Currently, letters in envelopes, as well as minute calls have been replaced by various instant messengers, online chats, social networks, as well as the opportunity to talk with anyone around the clock on the phone.

For graduates, it is necessary to create a site on which they can find their classmates, people with whom they were friends while studying at the university, contact them according to the information provided on the site, and invite everyone to come together, as in the good old days.

When creating the site, it was possible to find very few such resources that will help graduates to get together, or to find their friends. On the basis of analogues, the website "Graduates" was created.

In order for it to function well, it was necessary to raise all the archives from the beginning of the opening of the educational institution and get all the data, at least from the very first issue. All the collected information about the graduate is uploaded to the site on which he can register with his name, valid at the time of training, diploma number, as well as e-mail, which, upon registration, will receive a password to enter. After registration, in his personal account, the user will see information about himself that was stored at the university, but he can enter his personal data. In addition, each user can upload photos to the site, as this will help facilitate the search for their friends on the site.

Another feature of this site is that not only site administrators, but also registered users can post ads. The user, in his personal account, can create an advertisement of whatever he wants and send for publication on the main page of the site, but it will not be published, since immediately it is sent for review and editing to the administrator to prevent the possibility of publishing ads off-topic.

Why is the site universal? The site has an admin panel where the administrator can configure everything as he needs, so the site can be embedded in various universities, and even in schools. Using such a resource, you can not do without a database. Since the project was done in PHP (Hypertext Preprocessor), a decision was made to use the MySQL database management system (8.0) to organize data storage. It is also convenient, it is possible to convert data and the administrator does not need to fill it in manually, he just needs to click a button, select an Excel file and all information about university graduates will be uploaded to the database and displayed on the site. But there is a small nuance for the data to load correctly, you need to enter them in the correct order into the Excel file. In addition to entering information through an Excel file, you can manually enter one record, as well as edit or delete it.

If the user is interested in any question, he can contact technical support at any time, where they can help him solve it.

Another of the main features of this site is the ability to search for graduates in the following input fields:

1. Last name.
2. Name.
3. Patronymic.
4. The group.
5. Year of release.
6. Faculty.
7. Specialty.
8. The form of training.

All specified fields are optional. If the user does not enter anything, then all university graduates will be displayed. An example of a graduate search page is shown in picture 2. The data is filtered by the fields of the faculty, specialty, and the user's training form can be obtained from the list, which is also loaded from the database.

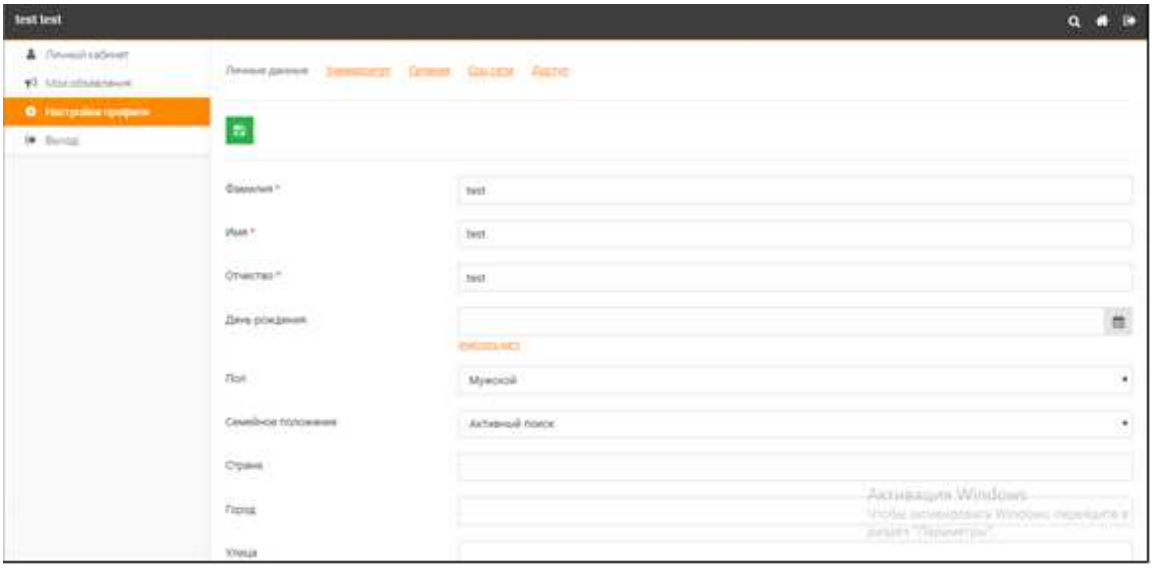

Figure 1. – Personal Information Editing Page

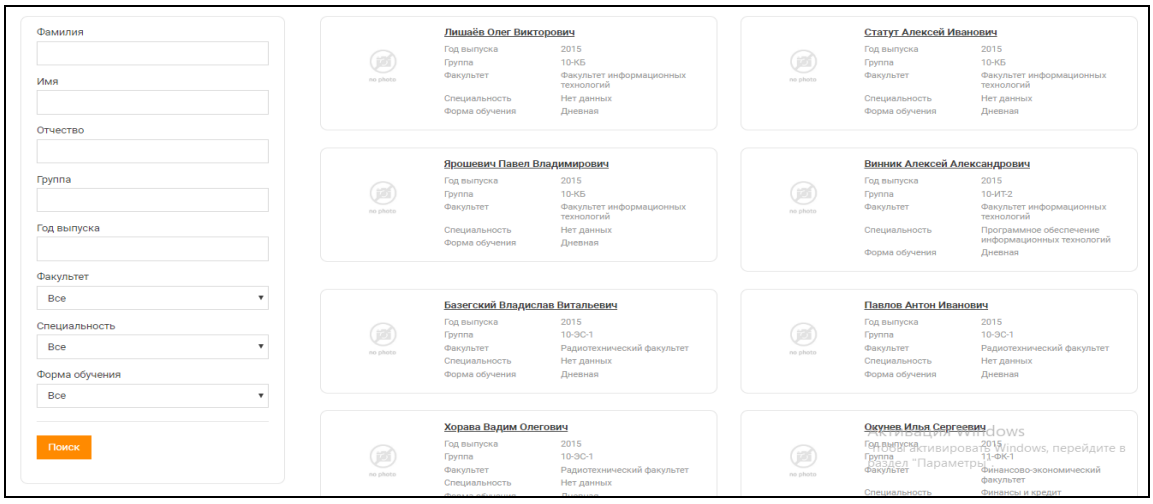

Figure 2. – Graduate Search Page

In their personal accounts, graduates can create ads that appear on the main page. I think that this function is very convenient, it's easier to gather your classmates for some kind of meeting, because you don't need to call everyone and invite them, especially since some may not have information about contact numbers. To make sure that the graduate has created an ad with acceptable content, it is moderated, and as soon as the administrator makes sure that the content of the advertisement really meets the requirements, he makes it visible to all graduates, however, if the announcement has obscene content, the administrator has the option to edit it.

In the process of developing a software product, all the restrictions imposed on the database by the subject area were observed, thus maintaining the integrity of the system. The integrity constraint lies in the absence in the relations of records with the same primary key values, as well as in the absence of records in which the primary key value is not specified. This restriction works due to compliance with the basic properties of the primary key.

An important feature of modern DBMSs is the standard means of maintaining the integrity of databases when changing and deleting records in relationships.

For foreign keys, the integrity constraint is that the value of the primary key must be equal to the value of the foreign key, i.e. each attribute value must be undefined.

Storage of the necessary data is implemented in the free relational database management system MySQL 8.0, which has advantages over analogues:

1. A large number of plug-ins and auxiliary applications that help simplify the work with databases;
2. A wide selection of tools that allows you to implement almost any project;
3. There are many built-in security features that work by default;
4. equally easily can be used to work with small and large volumes of data;
5. Due to some standards used, there is a high system performance.

The university consists of several faculties. Each faculty has several departments, and several specialties and forms of training may also be present. Thus, each student is listed in the faculty, in a particular department, specialty and form of training and has unique personal data. Thus, including all options for combining a graduate with a university, the following scheme was developed, shown in picture 3.

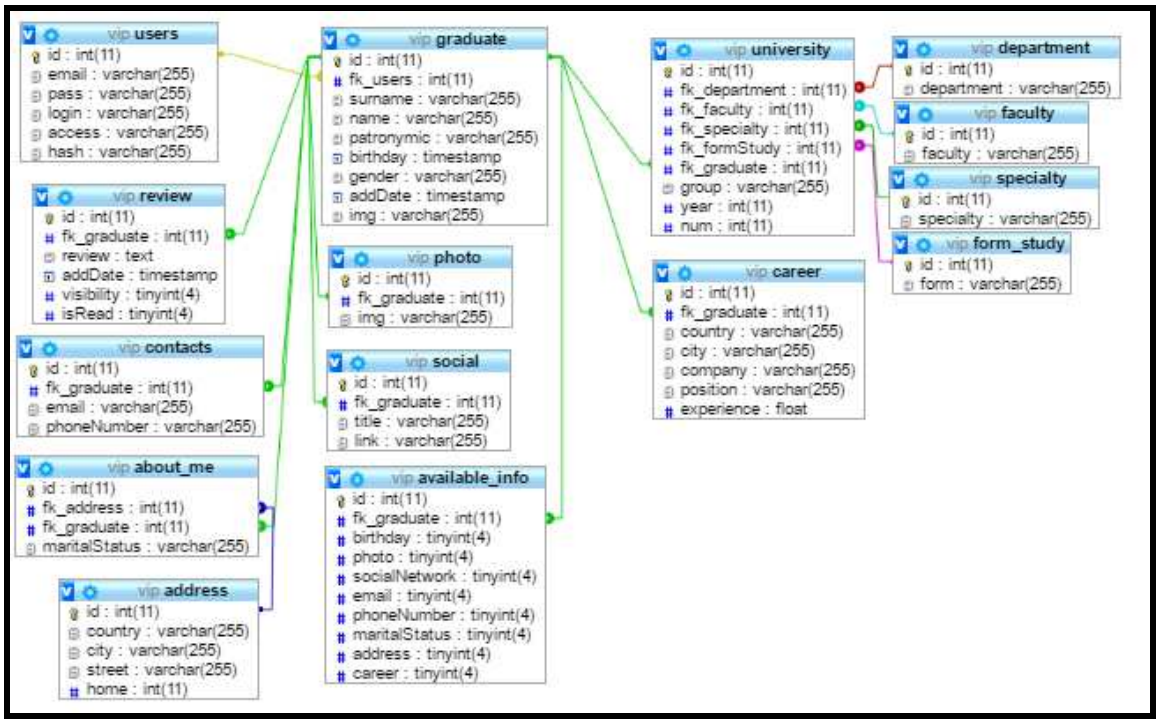

Figure 3. – Relational database schema

When implementing this relational database schema, the SQL language features were used to the maximum. SQL (Structured Query Language - Structured Query Language) is a universal computer language used to create, modify and manage data in relational databases.

Thanks to the developed database, as well as the user interface, a software product was implemented that can be used in any educational institution.

Thus, the developed software product contributes to the education among students of pride in their native university, their involvement in one of the best universities in the country and the world, in the elite of a modern intellectual society, and will also allow the promotion of the outstanding achievements of its graduates.

Conclusion. This site is already at the stage of implementation in the educational institution "Polotsk State University". The developed product will facilitate the work of university employees. With ease it will be possible to inform all graduates about a planned event in honor of them. In addition, graduates have the opportunity to find their classmates by search provided on the site, enter information about themselves in their personal account.

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UDC 338.46

MOBILE APPLICATION FOR PERSONAL FITNESS TRAINING

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Personal training is best-done face-to-face, but technologies assist to offer better results.

Is your business maximizing profit? Are you utilizing digital-based business solutions to get success? Digital tools are set to amend training for the better in the future. Here are five points where these tools will be helpful.

1. VIRTUAL PERSONAL TRAINING

The investment in personal training of club members is near 10 percent, a lot of them choose to get support from the growing numbers of applications. Nowadays if club owners want to increase market coverage and receive new revenue, they should be in trend and offer online personal training. Clubs can enlarge personal training with clients using centralized digital programming —and not just those who are regularly in the club but also those who is at home, or travel on business or on holiday. Consuming online programming allows clubs to analyze which programs and virtual workouts are most demanded. That, in turn, can unlock new revenue stream opportunities.

2. DIGITAL PROGRAMMING

Access to a digital library of fitness exercises allows clubs to provide template workouts, advice on exercise techniques and software development innovation, all available to personal trainers and clients at the click of a button on their devices. This improves the personal training and member experience, also it is much more productive than paper-based systems, saving much time for gym floor staff to deliver other areas of the business.

3. ONLINE ORDERS AND PAYMENTS

Keeping track of payments, credits, sessions, subscriptions, and cancellations manually are hugely time-consuming actions. Nowadays digital systems are able to cover and automate personal training bookings and payments, including handling auto-renewals, multiple subscriptions, personal training approaches and push notifications to keep clients posted and motivated. It saves a lot of time for personal trainers, allowing them to spend it interacting with clients rather than working on papers. The solutions for online bookings create operational transparency and speed up internal processes. Centralized reporting tools also allow observer real-time performance analysis. It enables fitness club owners to make programming and operational decisions based on evidence rather than feeling. Simplifying the payment process provides studio owners more time to focus on delivery while clients have the convenient and quite fast option of purchasing packages without the necessity to stand in line. Also, it allows keeping track of bookings and viewing training programs.

4. PERSONAL TRAINING MARKETING AND EDUCATION

Retention of talented personal trainers is a challenge for many operators. To create successful, financially viable businesses to keep and support personal trainers it's needed to be done more. A successful personal trainer will not have a good reason to look for an alternative workplace. At the same time, there are not so many opportunities in terms of business training, marketing, and further education, either at the point of qualification or during employment.

5. TRAINER PERFORMANCE

To get the ability to anticipate potential pitfalls before they appear digital solutions can offer monitoring and assessing the result of the club and individual staff in real-time. To avoid issues there is a possibility to set up performance parameters via the online application and track them weekly, it gives to clubs the best chance of anticipating challenges. Digital technologies and programming advancements are a brilliant tool for clubs and studios to integrate in order to support staff in delivery and time efficiency and in the enhancement of member experience.

CONCLUSION. The advantage of mobile application for personal training consists of enhancing business efficiency and member service through a butch of online business and member management solutions. Staff and client management apps are becoming more and more popular in the fitness industry. With the help of these mobile applications, you can streamline your business and give your clients a more convenient method to

interact with your facility. Such technology has become the biggest software market in the world as it truly helps optimize your business in every way. All data is now in one place, saving you time and energy.The days when you had to keep track of different documents in various places are gone [1].

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UDC 004.05

HOW TO SELECT CORRECT TEST CASES FOR AUTOMATED TESTING

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I am planning to cite down a few important points based on my experience how to select the correct test cases for automation and determine various other factors that will produce better test results and benefits.

Automated testing is a Software testing technique to test and compare the actual outcome with the expected outcome. It can be achieved by writing test scripts or using automation testing tools.Automated testing is used to automate repetitive tasks and other testing tasks which is difficult to perform manually.

Automated testing can be defined as a way to run a set of tests over and over again without having to execute them manually. Introducing automation tests in your test strategy is a way to save money and time.

One of the most commonly automated test suites is the regression test suite. Regression, as you may already know, is the test that is done at the end of testing a new module to ensure that none of the existing modules have been affected by it.

It is repeated after each new iteration of testing and the main test cases stay fixed with usually a few new additions after a new iteration. As it is frequently run almost all the test teams try to automate this pack.

The smoke testing is a famous test performed in the test life cycle. These are post-build tests, they are executed immediately after some structure is given out of the application to ensure that the application is still functioning after the structure is done.

This is a small test suite and is something that will be executed many times and thereby it makes sense to automate it. These tests will usually be of a functional nature and depending on the type of application a tool picked for them.

Most of the testing projects are trying to translate their manual test cases to automated ones to improve productivity and coverage.

One of the key steps to commence Automation Testing is – selecting the appropriate test cases.

Automation does not overpower or replaces Manual Testing but it compliments it. Like Manual, Automation needs a strategy with proper planning, monitoring & control. Automation, when implemented correctly, can become an asset to the team, project and ultimately to the organization.

There are many advantages of Automation. Here are a few important to mention:

1. Useful to execute routine tasks like Smoke tests and Regression tests.
2. Useful in preparing the Test data.
3. Helps to execute the Test cases which involve complex business logic.
4. Good to execute the cross-platform test cases (like different OS, browsers, etc.)
5. Great to execute the test cases which are a bit difficult to execute manually.
6. When the number of iterations of the test case executions is not known.

Stakeholders often feel that automated tests act as a support tool for Manual Testing, so it's vital to understand that automation is the best way to increase the effectiveness, efficiency, and coverage of testing. It not only saves time but also improves accuracy as repetitive tasks through the manual approach pronged to human errors and which can be time-consuming.

One of the most basic mistakes which testers make is NOT Selecting the correct test cases for automation.

There is no standard procedure for determining the correct test cases for automation. It all depends on the application you are testing.

Step 1: Identify the parameters on which you will base your test case as a candidate for automation.

As of now, I am identifying the following parameters, you can have your own parameters depending on your application.

1. Test case executed with different sets of data.
2. Test case executed with different browsers.
3. Test case executed with different environments.
4. Test case executed with complex business logic
5. Test case executed with a different set of users

6. Test case involves a large amount of data
7. Test case has any dependency
8. Test case requires Special data

Step 2: Break each application into modules. For each module, analyze and try to identify the test cases which should be automated based on the parameters.

Step 3: Consolidate and group the number of test cases for each module.

Step 4: We should also take into account the following attributes:

1. Purchasing and licensing cost of the tool
2. Time to develop the scripts
3. Time to maintain the scripts.
4. Time to analyze the results manually and automatically
5. Time and cost to train the resources.
6. Management overheads

Automating a 100% application is a big task. Not that it is impossible, but it requires proper planning and monitoring and of course; some time. There are lots of permutations and combinations of data, n number of environments with n number of authentication and authorization attributes that need to be validated and hence require a strategy to automate.

In most cases, we prefer to Automate the Regression suite (here are some challenges in automating regression suite in an agile environment) as it contains a larger number of test cases. In that case, we can break down the regression suits into smaller suits and decide to run the appropriate suite as per the release requirement.

Let's suppose that a regression suite contains 1500 test cases, you can break it to 3 suits of 500 test cases per suit and automate it.

Instead of automating the entire suite, you can opt for phase-wise automation. In other words, you can follow the prototype model for developing the automation suite. Create a structure or framework with the implementation of fewer numbers of test cases and start using that and gradually enhance it by adding more test cases to it.

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WIRELESS TRANSMISSION OF TELEMETRY DATA TO LONG DISTANCE

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The article presents a practical experiment of the developed module which uses one of the varieties of LPWAN (Low-power Wide-area Network) technology. The system is based on UBN (Ultra NarrowBand).

Technical characteristics. An ultra narrowband receiver is highly selective and it can reject noise and interference. It enters the receiver outside its narrow bandwidth, enabling an acceptable signal-to-noise ratio to be achieved with a relatively weak received signal. Consequently, transmitter power levels can be low and the effective range of transmissions may be greater than would typically be the case for technologies which do not provide such selectivity. Some other radio technologies, such as direct sequence spread spectrum and chirp spread spectrum[1], employ alternative approaches to selectively extract signals from interference and noise. Typical UNB systems operate with a bandwidth of a few 10s to a few 100s Hz[2] and are used for the transmission and reception of digital signals [3].

The use of highly selective filters in UNB receivers can provide very effective rejection of UNB signals from other UNB devices on adjacent carrier frequencies, permitting the operation of many devices in a limited geographical area.

UNB technology is often used where links from very high numbers of devices are needed, with relatively small amounts of data being exchanged on each link. Some such applications can be found in the Internet of things, with UNB being one of the technologies that have been used to implement Low-Power Wide Area Networks. [4]. Short infrequent transmissions with low transmit power can enable long-life, battery-powered operation of UNB devices connected in a LPWAN.

Typical properties of UNB devices operating in the UHF spectrum below 1 GHz have been described by ETSI; whilst specific UNB-based protocols for the implementation of LPWAN have also been standardised (alongside others) by ETSI.

System characteristics. The distance test in urban development was carried out using the developed module based on the AX8052F143 chip with the installed TCXO thermally compensated generator. We used software settings optimized for data transmission over long distances - 1200 bit / s, deviation ± 1.75 kHz, BW filter Rx 10 kHz. Frequency offset compensation was performed for each packet:

- output power: 15 dBm;
- frequency: 868 MHz;
- Location: Vitebsk, Belarus.

In the calculations, a Friis formula and a two-beam propagation model were used to obtain a realistic estimate of the communication range. The two-beam model takes into account the earth's surface, the influence of which will always reduce the attainable distance. The model takes into account various building materials, which are used to estimate the distance inside buildings more accurately.

The reviewed field test examples demonstrate the importance of considering antenna height and line of sight limitations in order to achieve greater distance for both direct visibility scenarios and indoor communications.

Results. The results obtained during transmission inside the building with the receiver located on the staircase of the 9th floor and the transmitter located on the 1st floor of the staircase: signal level at the receiver input: -95 dBm, 5% of the packets are lost.

The results obtained during data transmission in urban areas, when the receiver was placed on the balcony of the 7th floor, amounted to: distance 740m, signal level at the receiver input -110dBm.

Conclusions. The developed system meets the expected characteristics (range, power consumption, signal level) and allows you to implement a cost-effective product for the Internet of things.

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UDC 003.26

DIGITAL WATERMARKING AS AN IMAGE PROTECTION METHOD

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This article presents the classification of digital watermarks. The types of embedding algorithms are analyzed, their main advantages and disadvantages are highlighted.

Introduction. In the era of computers, the most common violations of intellectual property are: plagiarism, "piracy", changing information, faking information, unfair competition.

When storing, distributing and transferring intellectual property, digital watermarks are often used as protection. Digital watermark is a special tag embedded in the digital segment, in order to monitor the dissemination of information over communication networks, to provide information search in multimedia databases. Usually, we don't see a digital watermark on image, the original image, and the image with the integrated digital watermark, are visually indistinguishable by the human eyes.

Digital Watermarks Classification. The term "Digital watermarking" got its name from a method of protection against counterfeiting securities. Currently, various methods for applying watermarks have been developed:
1) According to the degree of perception: visible and invisible. Invisible are divided into: fragile, semi-fragile, resistant.

2) By degree of reversibility: reversible and irreversible.

3) By embedding method: linear, non-linear, fractal coding.

4) By embedment area: spatial and using container conversion. Container conversions are divided into frequency based and moment based.

An embedded watermark can be either visible to the eye or invisible. The second option is more common and is divided into fragile, resistant (robust) and semi-fragile watermarks. In the case of a fragile watermark system, the watermark is destroyed after any minor changes to the container. Such marks are necessary for signal authentication (digital fingerprints). Robust signs, on the contrary, must protect from many types of attacks: affine transformations (turns, cropping), compression, and others. Only such marks are used to determine authorship, since they are difficult to destroy. Semi-fragile watermark is a mark with selective complexity. Such a sign may allow certain transformations of the container, collapsing from others [3].

Embedding algorithms are divided into reversible and irreversible. Reversible algorithms allow you to extract the watermark and completely restore the container for further work. Such algorithms are used for medical and military purposes, where any distortion of images is strictly prohibited. Irreversible algorithms, when removing the watermarks, make changes to the original container, so when developing such algorithms, the developer's goal is to reduce the level of distortion to the minimum.

More complex reversible methods are algorithms based on modifications of the image histograms and on the intentional adjustment of the difference between adjacent pairs of pixels. The first group is simple to implement and uses a minimum of information for decoders, but the disadvantages are the limitation of the embedding size, which depends on the number of occurrences of the maximum brightness points. The second group of algorithms allows you to embed large amounts of information in the message, but the quality of the marked image is worse.

There are linear and nonlinear methods of applying watermarks and methods using fractal coding, based on the assumption that the image is self-similar [2]. Linear algorithms are divided into embedding algorithms (additive) when a digital image is added to a digital message, and fusion algorithms when one image is embedded into another image, for example a logo.

Also, many developers have proposed the use of correlation algorithms. But the use of such algorithms is justified if the user needs to retrieve a hidden message, and the main container is perceived as noise (an irreversible method). The main advantage of merging algorithms over embedding algorithms is the assumption of a slight distortion of the watermark during extraction.

Spatial domain algorithms embed watermark into the original image. Their advantage is that there is no need to perform image conversions. Watermark in such methods is usually implemented due to the manipulation of brightness or color components. The disadvantage of such algorithms is the rather weak resistance to various image processing operations.

Frequency-based algorithms based on image transformations are more complicated, because before implementing watermark, it is necessary to "redistribute the energy" of the container in order to embed the message in special spectral regions. Due to this decomposition of the image, the watermark becomes robust to attacks.

The greatest difficulty is the introduction of the watermark into the low-frequency region, containing most of the image energy, because non-optimal implementation can lead to significant distortion of the container. This complexity is also an advantage, since any attempt by an attacker to extract the watermark from the low-frequency region will also lead to significant image distortion. Thus, when embedding the watermark into the frequency area of the image, it is necessary to observe a compromise between the size of the embedded watermark and the quality of the stegano container [4].

Methods based on the moments of images are used to protect the watermark from the geometric transformations of the container. However, they have a narrow focus, and their main disadvantage is the low level of security from other types of attacks.

Conclusion. Digital watermarks are currently the most effective means of protecting the copyright of multimedia works. This is one of the main ways to prevent copyright infringement on the Internet. This area is developing rapidly, so there are many different types of embedding. Today, there are a large number of methods for implementing the watermark, each of which has its own advantages and disadvantages, which must be taken into account when using one or another method to protect multimedia data from illegal distribution and modification.

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DEVELOPMENT OF A TRAINING PLATFORM FOR JUNIOR SPECIALISTS IN THE FIELD OF TESTING SOFTWARE

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This article describes the concept of developing a training platform for testing software and the most suitable tools for the development of lodging. The key points in the program are described.

Recently, the popularity of the information technology industry has been growing. The number of companies engaged in information technology services is becoming more and more. The demand for developers and testing specialists is also increasing.

Many IT companies organize their own laboratories in which they train future specialists from scratch. However, not everyone who wants to get a well-paid position is worthy to study at the expense of the company in such laboratories.

Inexperienced junior developers fill the labour market in the field of information technology. For many beginner testers and developers, it is not so easy to find their first job, even after successful graduation from higher or secondary special educational institutions, as well as specialized courses.

Employers, as a rule, are not ready to hire employees without commercial sky experience. Thus, there was a need to help beginners and young professionals get the experience necessary for their future work.

One of the most popular and most sought-after professions in the information industry nowadays is a software tester. Therefore, the subject of work on the training platform is a set of services that will allow future specialists to improve their professional skills.

Testing is a process that contains all the activities of the life cycle, both dynamic and static, related to the planning, preparation and evaluation of a software product and connected with work in order to determine that they meet the described requirements, show that they are suitable for the stated purposes and for identifying defects [1].

A software tester is an experienced professional who takes part in testing a component or a system [1].

Figuratively expressed, the main goal of a tester is "to understand what the project currently needs, whether the project receives what is necessary or appropriate and, if it does not, how to change the situation for the better " [2].

It is the responsibility of a testing specialist to search for probable errors and failures in its function, positioning the test object (system, component, etc.). A tester models different situations that may arise in the process of using the subject of testing so that developers were able to correct the detected errors before the product goes into implementation to real users.

In this article we would like to describe the development of a platform for testing. This board is the form with private links to resources, which will contain both theoretical information on the topic and cases from the developers' and testers' practice. As in any sphere of information services, about 70% of testing is practice, then there is an ability of testers to find errors in applications. Thus, a platform will be developed in the game, where within a limited time it will be necessary to find the maximum number of defects.

This is a kind of a training base for future experts in the field of testing. To provide structured learning, the training platform will be divided into three modules: "Testing Web applications", "Testing mobile applications", "Testing Desktop applications. " There will be an opportunity to train their skills separately depending on the chosen specialization.

To ensure that the tasks are completed correctly, there are modal windows in which the user will indicate the following data:

- the component in which the error was detected;
- type of testing;
- criticality of error.

In addition to the practical tasks faced by a specialist in testing, there is a large amount of work connected with writing test documentation (check lists, test cases, defect reports, test reports, test plans, etc.). A defect report is a document containing a report of any deficiency in a component or a system, which can lead a component or a system to the inability to perform the required function [1]. This document should contain correct, uniform terminology describing the elements of the user interface and event data elements that cause errors.

In general, it consists of the following fields:

- header (brief description of the problem, project, application component, version, severity, priority, status, author, appointment);
- environment;
- description (reproduction steps, actual result, expected result);
- additions (attached file) [3].

As a part of the development of this service, it will be possible to describe, as a tester believes, identified errors and save them in your account.

The prototype is the popular paid Atlassian Jira system used in commercial projects that allows you to describe and create reports on errors found in the system or component [4].

The platform will be developed using the popular Vue.js front-end framework, the base MySQL data and Node.js. Vue.js – an open source JavaScript framework for creating custom tools.

It easily integrates into projects using other JavaScript libraries. It may be fun Design as a web framework for developing single-page reactive-style applications [5].

The necessary qualities of a tester are logical thinking, attentiveness, quick-wittedness, good memory, the ability to learn and adapt to existing tasks, quickly switch from one type of task to another. Patience, perseverance, creativity and ability to work in a team are also important. Moreover, a tester acts simultaneously as a user, and as an expert, and therefore must have a certain way of thinking: be able to reproduce behaviour of the user of the product and analyze the behaviour of the system, the input parameters and the results obtained from the point of view of the engineer. Thus, after using the training platform, future testing experts will also be able to improve the qualities necessary for the work. In conclusion, we would like to mention that this platform will be further developed and not only testers can become highly qualified specialists, but also software drivers.

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COMPUTATIONAL COMPLEXITY OF ALGORITHMS FOR FORMATION OF RADAR IMAGES

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In this paper the basic algorithms for spaceborne Synthetic Aperture Radar data-focusing are considered. The comparative analysis of computational complexity for them is presented.

Introduction. The process of forming a radar image is called focusing of a radio hologram and is performed at the stage of primary processing of radar data. It includes irradiation of the Earth's surface with a probing signal, reception and processing of echo signals (responses) reflected from points on the Earth's surface, and the actual formation of radar images.

Currently, to get high spatial resolution of the obtained radar images, radars with a synthetic antenna aperture (SAR) are used. When moving in orbit, the SAR antenna emits short frequency or phase modulated pulses with a given repetition rate. The synthesis of the aperture is the result of successive reception of the responses of the probing signals by the antenna at a different position relative to the source of these responses. For each radiation of the probing signal, one line of the radio hologram is recorded. The number of radio hologram lines depends on the frequency of the probing signals and the flight time of the radar.

Types of computational complexity of algorithms. By computational complexity we understand the function of work volume dependence that is performed by some algorithm on the size of the input data. The volume of work is usually measured by abstract concepts of time and space, called computing resources. The theory of computational complexity arose from the need to compare the performance of algorithms, clearly describe their behavior (runtime and amount of required memory) depending on the size of the input data. The time complexity of an algorithm is a function of the size of the input data, equal to the maximum number of elementary operations performed by the algorithm to solve an instance of a task of a specified size. By analogy with time complexity, the spatial complexity of the algorithm is determined, only here they show not only the number of elementary operations, but the amount of memory used. Despite the fact that the function of the time complexity of the algorithm in some cases can be determined exactly, in most cases it is meaningless to look for its exact value, because, firstly, the exact value of the time complexity depends on the definition of elementary operations, and secondly, with increasing the size of the input data, the contribution of constant factors and lower order terms appearing in the expression for the exact time of operation becomes extremely insignificant.

Consideration of large input data and estimation of the operating time of order growth, the algorithm leads to the concept of asymptotic complexity of the algorithm. Moreover, an algorithm with less asymptotic complexity is more efficient for all input data, with the possible exception of, possibly, small data. Currently, the asymptotic complexity of most mathematical operations, functions, and transformations is calculated.

Analysis of the computational complexity of focusing algorithms. For primary processing of PCA data, the following algorithms are used: Range Doppler (RD), Chirp Scaling Algorithm (CSA), Range Migration Algorithm (RMA), as well as their modifications: Range Doppler Algorithm (RDA), Extended Nonlinear Chirp Scaling Algorithm (ECS).

The essence of the RD and RDA algorithms is as follows: using the fast Fourier transform (FFT) method, the spectrum of the input signal is obtained, the resulting spectrum is multiplied by the spectrum of the reference function (range compression), and the inverse Fourier transform (IFFT)) is performed. For azimuth compression, matched filtering in the frequency domain in azimuth is used. The change in the Doppler frequency depends on the range, therefore, a separate filter is used for each column of the RGG. To compensate for range migration, an array of range-compressed data is converted into range / Doppler frequency coordinates and each column of the data array is added with the corresponding frequency offset (RCMC – Range Cell Migration Correction) [1].

The CSA and ECS algorithms are designed based on alignment of curvature (range migration) in the two-dimensional frequency domain so as to have congruent range migration paths. This is achieved by the successive use of FFT in azimuth, multiplying the obtained spectrum by the LFM support (LFM scaling), FFT in range, multiplying by the phase function (correction of average range migration) and subsequent IFFs in range with phase correction distorted during LFM scaling and IFFT in azimuth [2].

The RMA algorithm involves the initial conversion of signal data into a two-dimensional frequency domain. The second focusing step is multiplying by the reference function calculated for the selected range. This operation can be considered as "volume compression". The third stage of focusing is Stolt interpolation (transformation), which completes the focusing of targets outside the control range. Finally, two-dimensional IFFT is performed to convert the data back to the time domain, that is, to the image region [3].

To compare the computational complexity of the considered algorithms, the amount of input data should be the same for each algorithm and have a size of Na × Nr (azimuth × range). As a result of focusing, the obtained radar image must also have proportional characteristics. In this case, the temporal complexity of the algorithm will be the characteristic that determines the best algorithm from the point of view of computational complexity.

The complexity of the focusing algorithms at each stage is studied in terms of the number of floating point operations (FLOP). Each FLOP can be either real multiplication or real addition. Complex multiplication of floating point numbers requires 6NrNa operations. FFT or IFFT can be calculated as 5NrNalog2Nr/a operations (depending on range or azimuth conversion). Interpolations of various types (sinc, Lagrange, Stolt) have complexity 2 (Mken - 1) NaNr, where Mken is the length of the interpolation core [4].

Table shows the results of determining the computational complexity of the algorithms.

Table. – Results of determining the computational complexity of algorithms

The main steps of the algorithm	Computational complexity, FLOP				
	RD	RDA	CSA	ECS	RMA
Range FFT	$5NaNr\log_2 Nr$	$5NaNr\log_2 Nr$	$5NaNr\log_2 Nr$	$5NaNr\log_2 Nr$	–
Range IFFT	$5NaNr\log_2 Nr$	$5NaNr\log_2 Nr$	$5NaNr\log_2 Nr$	$5NaNr\log_2 Nr$	–
Azimuth FFT	$5NaNr\log_2 Na$	$5NaNr\log_2 Na$	$5NaNr\log_2 Na$	$5NaNr\log_2 Na$	–
Azimuth IFFT	$5NaNr\log_2 Na$	$5NaNr\log_2 Na$	$5NaNr\log_2 Na$	$5NaNr\log_2 Na$	–
Two-dimensional FFT	–	–	–	–	$5NaNr\log_2 Na+$ $+5NaNr\log_2 Nr$
Two-dimensional IFFT	–	–	–	–	$5NaNr\log_2 Na+$ $+5NaNr\log_2 Nr$
Azimuth Average Compression	–	–	–	–	24NaNr+ +2(Mken_l – 1)* *NaNr
Range Compression	6NaNr	6NaNr	6NaNr	6NaNr	
Medium Migration Correction	–	–			
Secondary compression	–	6NaNr			–
Range Migration Correction	18NaNr+ +2(Mken_l – 1)* *NaNr	18NaNr+ +2(Mken_l – 1)* *NaNr	–	–	–
Resolving Range Migration Differences	–	–	6NaNr	6NaNr	(Mken_s – 1)* *NaNr
Azimuth compression	6NaNr	6NaNr	6NaNr	6NaNr	–
Phase correction	–	–		6NaNr	–
Elimination of differences in the rate of change of the Doppler frequency	–	–	–		–
Total computational complexity	$10NaNr\log_2 Na+$ $+10NaNr\log_2 Nr+$ 30NaNr+ +2(Mken_l – 1)* *NaNr	$10NaNr\log_2 Na+$ $+10NaNr\log_2 Nr+$ +36NaNr+ 2(Mken_l – 1)* *NaNr	$10NaNr\log_2 Na+$ $+10NaNr\log_2 Nr+$ +18NaNr	$10NaNr\log_2 Na+$ $+10NaNr\log_2 Nr+$ +24NaNr	$10NaNr\log_2 Na+$ $+10NaNr\log_2 Nr+$ +24NaNr+ +2(Mken_l – 1)* NaNr+2(Mken_s – 1)* *NaNr

As can be seen from the table, the CSA algorithm has the lowest computational complexity, while it provides high quality primary processing of SAR data in conditions when the deviations from the strictly side view (at which the Doppler centroid is zero) are small. If these conditions are not satisfied, then deviations of the law of

change of the Doppler frequency from the linear one and the dependence of the Doppler centroid on the distance arise. In the CSA and ECS algorithms, these facts are not taken into account, which leads to a decrease in the quality of the synthesized radar images.

The RD and RDA algorithms have the greatest flexibility and allow to obtain high-quality radar images even with sufficiently large deviations from strictly lateral viewing. But at the same time they require more floating-point operations than CSA and ECS algorithms.

The RMA algorithm is accurate even if the aperture is very wide or there is a significant deviation of the radar from a strictly side view, however, Stolt interpolation requires a significant amount of mathematical operations. The RMA algorithm is not used to focus radar data from space SAR, because it is based on the Stolt transform.

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UDC 004.021

COMPARATIVE ANALYSIS OF ALGORITHMS FOR DETECTING COVERAGE DEFECTS

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This article discusses possible algorithms for assessing the quality of pavement, as well as a comparative analysis of existing approaches.

The importance of road infrastructure for the development of society can be compared with the importance of blood vessels for people. To ensure the quality of the road surface, it is necessary to continuously monitor and repair, as necessary, all defects. An optimal allocation of resources for road repairs is possible provided that comprehensive and objective real-time data on road conditions are available. Joint monitoring is a promising approach for road quality control.

Hazardous road conditions are the main distractions for safe and comfortable transportation. Both drivers and road repairmen are interested in fixing them as soon as possible. However, these conditions must be determined first. One of the approaches to detect damage on the roads and monitor them is to use a device that is affordable, having communication modules like GPS, an accelerometer.

To simplify the monitoring system of the condition of the road surface, it is advisable to use mobile devices (smartphones, tablets), because most modern mobile devices contain many different sensors, including an accelerometer, GPS controller, gyroscope, magnetometer and others. The optimal choice goes to mobile devices because of the relatively low cost, ease of use, lack of difficulty in installing a vehicle in the cab for data collection, and also because almost every person has such a device.

To determine the quality of the road surface using a mobile device, you can use the built-in accelerometer module [1].

The following algorithms for detecting pavement defects are considered:

The simplest and most convenient algorithm for detecting pavement defects is Z-TRESH (Figure 1), based on the Z-axis of the accelerometer. The function classifies the Z-axis of the accelerometer and values that exceed specific thresholds are defined as various types of defects, for example, pit, accumulation pits. This algorithm requires that the information on the Z axis be known in advance [2,3]

Figure 1. – Example of the Z-THRESH pavement defect detection algorithm

And the second algorithm under consideration is Z-DIFF (Figure 2).

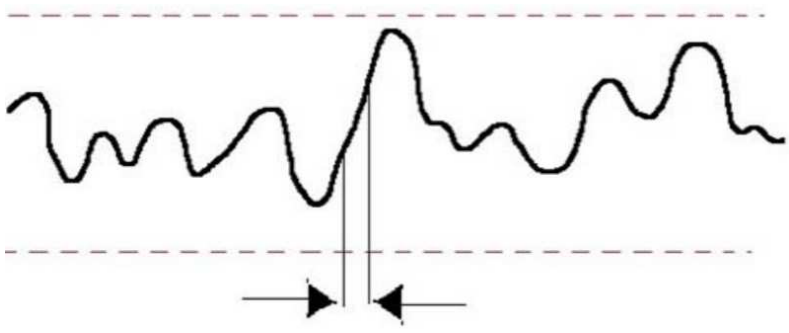

Figure 2. – An example of the Z-DIFF pavement defect detection algorithm

The Z-DIFF algorithm is based on the accelerometer readings along the Z axis. Unlike the Z-TRESH algorithm, the Z-DIFF algorithm searches for two consecutive values, the difference of which is above a certain threshold level. The algorithm detects rapid changes in vertical acceleration, according to which it is possible to classify the type of road surface defect. As for the previous algorithm, it is necessary that information about the position of the Z axis be known.

In the article, the test results of the used Z-THRESH and Z-DIFF algorithms are presented in Table 1.

Table 1. – The results of the applied algorithms Z-THRESH and Z-DIFF.

Class	Z-TRESH	Z-DIFF
Large pits	3(100%)	3(100%)
Small pits	15(83%)	16(89%)
Cracks	31(78%)	36(90%)
Hatches	10(59%)	17(100%)
Pit accumulation	25(83%)	27(90%)
Average	84(78%)	99(92%)

Based on the results of Table 1, in order to develop a system for monitoring the quality of pavement, it is concluded that the Z-DIFF algorithm is an accurate algorithm.

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UDC 004.021; 004.514; 004.55

ELECTRONIC GUIDE FOR PEOPLE WITH DISABILITIES IN NOVOPOLOTSK

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The paper presents the development of a web resource with a map and useful information about objects of urban infrastructure for people with disabilities on it. The article discusses the importance of the problem. The analysis of technologies and approaches used for development is provided.

People with disabilities need constant support from other members of society and the state. In the Republic of Belarus today, there are more than half a million disabled people [1]. Modern information technologies can make life easier for such people. The availability of portable, high-performance mobile devices and the reduction in the cost of communication services and Internet access, which is necessary to keep the information up to date, also help make it available to them.

More than two hundred wheelchair users live in Novopolotsk, many of whom cannot lead an active lifestyle due to the lack of information about unhindered access to the city's social infrastructure. Therefore, the development of an electronic guide for people with disabilities in the city of Novopolotsk is an urgent and important task.

Designing a software product of this kind can be divided into several stages. It is necessary to develop a subsystem for storing information about city objects, an administrative interface for managing this information, a user interface for displaying this information to end users in a convenient form, as well as an intermediate infrastructure that allows all components of the system to cooperate.

The relational database management system (DBMS) MySQL 8.0 was chosen as the data warehouse. This DBMS is perfect for working with not very large amounts of data that do not have a complex structure (for example, the structure of the developed database, see Figure 1), providing high performance combined with acceptable resource consumption, sufficient reliability and flexibility. An important fact is its maturity (development has been under way for more than 20 years) and free distribution (distributed under the GNU Public License).

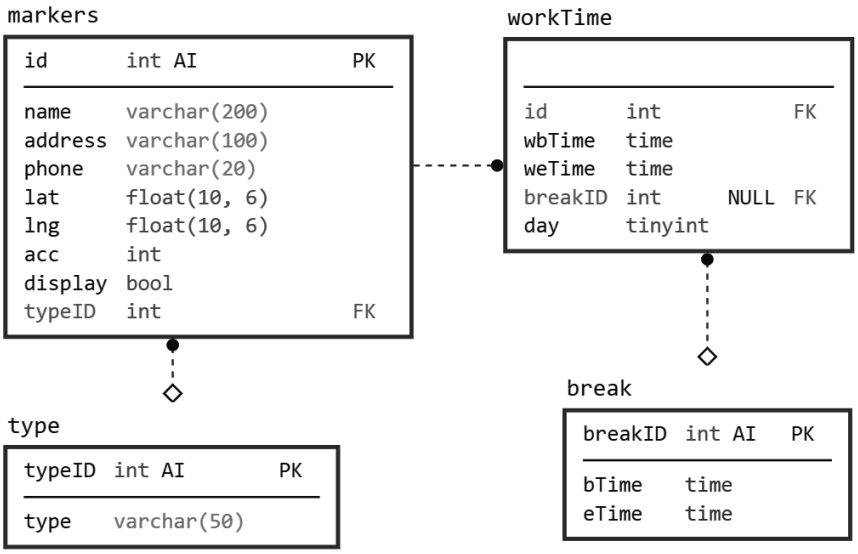

Figure 1. – Database structure

Another open technology which interacts perfectly with MySQL is PHP (PHP: Hypertext Preprocessor). This language was chosen to perform the connecting functions: providing a secure interface for updating information in the database and generating an intermediate representation of data. PHP is very handy for quick and efficient solving problems in web development.

The REST approach (short for Representational State Transfer) was chosen for the overall application architecture. This style of interaction between application components imposes some restrictions on the system, which provide increased productivity, reliability, transparency of interactions, simplification of architecture and ensuring ease of changes and evolution, such as:

– client-server model, including the separation of the database from the client and independent determination by the client how to present data received from the server;

– no client context kept on the server – all the data necessary for an accurate response to the client's request is provided by them;

– caching, which allows in many cases not to process the same request again and again, even if it was received from another client, and immediately return the response;

– uniform interface, which allows independent upgrade the internal implementation and design of components; and also a system of client-server interaction layers to simplify caching and distribution of requests [2].

As a result, the system consists of four components. The administration subsystem is responsible for operations on markers. It interacts with the database and also generates an intermediate JSON file, accessible to any Internet user. In this case, it can be considered as a kind of cache. Using the data from this file, the user subsystem displays markers on the map and information about them and allows filtering. As an important feature, after receiving this information, there is no need to interact with the server, and after the map is loaded, access to the Internet is not needed at all. The page can work completely autonomously, saving user traffic and server resources.

Nginx or Apache HTTP Server can be used as a web server, but the second is preferable, since it does not require an additional layer to generate dynamic content, and the target audience of the developed application is not so extensive as to necessitate the separation of the server system into independent modules provided by the first application.

Thus, all the technologies mentioned are widespread, time-tested and well-described, which simplifies the deployment of the system in any environment. If necessary, adaptation or scaling of the system can be carried out in a short time.

JetBrains PhpStorm was used to develop the application. This is due to the support of all the technologies used: SQL, PHP, HTML, CSS, JavaScript for the development of the user part; the presence of powerful tools for auto-generation, refactoring and auto-completion; deep integration with version control systems in one appication.

The development of the interface of such a system is also a non-trivial task. It is necessary that the content is correctly displayed on various devices. This includes not only the configuration of the blocks on the screen, but also the adjustment of the text size, the location and size of the images, and sometimes the color scheme. In this case, it is desirable to obtain a high-quality and easy-to-support product in the shortest possible time. In this regard, adaptive layout is an effective approach that solves many problems at once.

Responsive web design is an approach to page layout development in which the interface is correctly displayed on devices with different orientations, screen size and clarity, browser window size and, usually, is able to dynamically adjust in case of changes.

The current approach to adaptive interface development has emerged as a result of the interaction of several development strategies:

– Progressive improvement. The strategy provides for the gradual improvement and expansion of the user interface through increasingly sophisticated and modern CSS styles and JavaScript scripts for devices that support them, but continue to provide basic functionality to less modern customers. It was represented by Stephen Champion at the SXSW conference in 2003.

– Responsive design. This includes rubber blocks, stretched images, and the widespread use of CSS media queries. The concept was first introduced by Ethan Marcott in 2010 [3]. Later on, Jeffrey Zeldman proposed to expand this concept for any techniques that allow to achieve the correct display of interfaces regardless of the characteristics of the screen [4].

– Mobile First. A strategy that requires first developing a mobile version of a resource with subsequent adaptation to other devices. Described by Luke Wroblewski in 2011 [5].

It is also important to note Aaron Gustavson, who described a strategy for the simultaneous use of the approaches described above [6].

There are various adaptation methods. It is possible to divide devices into subgroups and develop layout for each separately, from scratch. However, this significantly increases the complexity of developing with a single style, very time-consuming, and is also negatively perceived by search engines in case of placing different versions on different subdomains.

Implementation according to the original plan of Ethan Marcott also has its drawbacks. Often there are difficulties with images and there is free space in the area of the side panels as you scroll the page.

Techniques to load different resource sets depending on the characteristics of the client have been developed (for example, Responsive-Images by filamentgroup or using User-Agent to determine the type of device), but this cannot be considered as a standalone solution.

Rubber layout is implemented by changing the layout of the markup tapes (for example, the Bootstrap framework). Block transfer involves changing the layout structure when changing the screen width. Hiding and panels provides the ability to display only part of the default interface for some devices, but with access to them, for example, by pressing buttons.

In addition to the already mentioned option with the generation of HTML markup on the server, taking into account the characteristics of the user's device, it is possible to use additional files of CSS styles and media queries, as well as JavaScript.

Media queries (@media), as well as support checks (@supports), allow you to apply styles only for types of devices with certain characteristics and support for these specific styles. For example, you can easily develop a printable version of a page or with some aspect ratio (see Figure 2).

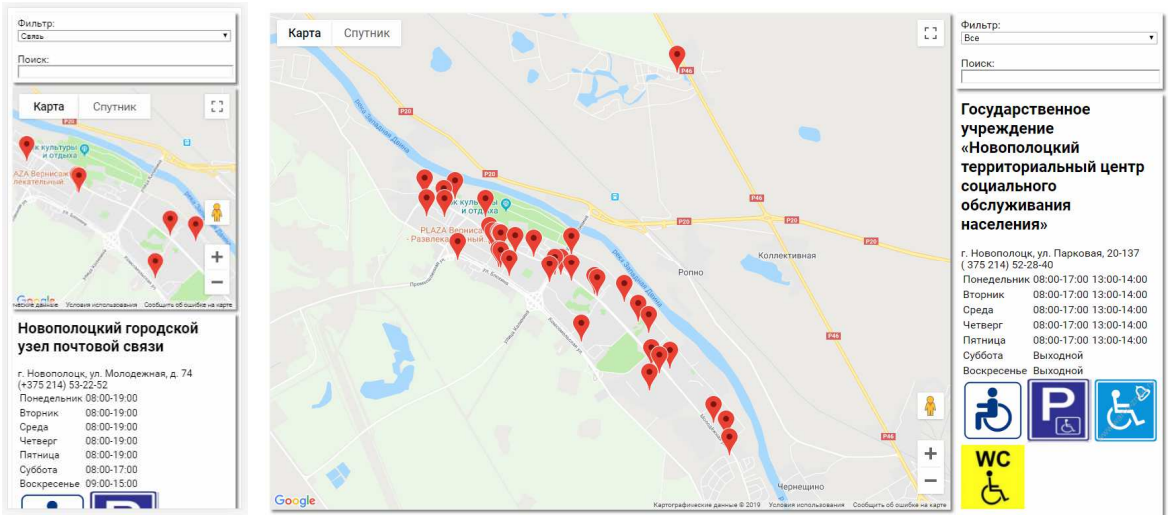

Figure 2. – Adaptive interface of the same page on a mobile device and a personal computer

It is possible to change and create various layout schemes using tables, blocks and more modern flexbox and grids. The last two approaches allow you to create quite complex one- and two-dimensional structures, respectively, using a wide range of restrictions and settings of different types at the same time.

JavaScript provides complete control over the page through the document object model. This allows you to load additional style files, apply styles to elements directly, implement complex reactions that are not provided by HTML and CSS by default, for example, clicking on objects. With its help, it is also possible to realize reactivity, for example, on gradual input or scrolling of a page, various related interactions.

An important parameter in the implementation of adaptability, including for people with disabilities, is the ability of the page to work with a non-standard font size, which can be set through the browser settings. To achieve this, it is important that the vast majority of page element sizes are set not in absolute units (pixels and their derivatives), but in relative: percentages and percentages relative to window size, em and rem (based on font size). Also, the last units allow you to easily and in one place change the size of some nested elements directly on the page, changing the font size of the root element.

The combination of JavaScript and CSS may allow different color schemes for people with visual impairments. It is also important to specify the alt attribute on images, providing a textual description for them. It can also be useful for users with low access speeds or with disabled images. The description should be meaningful, clear, capacious, in the presence of the result of a click - describe it. It's important to use valid HTML tags, such as a hierarchy of headings, as programs for blind rely heavily on them and this speeds up page navigation.

Optimization for mobile devices also includes setting the correct types of input fields, disabling autocorrection for some of them, increasing the size of active interface elements and supporting interaction with

them through touches, the widespread use of autocomplete, refusal to track guidance (replacing it with touches).

The developed application meets all the requirements of the subject area, the tables of the created database meet the requirements of normalization, which ensures the integrity and consistency of information. The most suitable and modern programming languages and development environments, key technologies and approaches for creating adaptive interfaces, including those adapted for use by people with disabilities, were used to create the application.

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THE INSIDE OF HEADLESS CHROME

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In this paper, we define headless web browsers and how to use them. The main components of the Headless Chrome web browser and the interaction protocol are considered.

Introduction. A headless browser is a great tool for automated testing and server environments where you don't need a visible UI shell. For example, you may want to run some tests against a real web page, create a PDF of it, or just inspect how the browser renders an URL.

Headless browsers provide automated web page management in an environment with all modern web platform features. They provide special programming interfaces for interacting with the runtime and allow you to control the web browser, execute code in its environment and receive any available information from the context of the web browser.

Chromium is an open browser implementation based on WebKit. Google Chrome is a branded version of Chromium, which has proprietary codecs, integrations with Google services, etc. Headless Chrome is a headless version of the Google Chrome browser. And that is we gonna explore.

Blink is a browser engine. Blink is a fork of the WebCore component of WebKit, which was originally a fork of the KHTML and KJS libraries from KDE. It is used in Chrome starting at version 28, Microsoft Edge starting at version 79, Opera (15+), Vivaldi, Amazon Silk and other Chromium-based browsers and frameworks.

The Chrome DevTools protocol is used as the management interface (API). Chrome DevTools is a set of tools for web developers, built directly into the Google Chrome browser.

Chromium Components. The lowest level is a Platform layer.

1. Ozone, the abstract window manager in Chrome, is what the window manager of the operating system interacts with. On Linux, it is either an X-server or Wayland. On Windows, it is a Windows window manager.

2. Scheduler - the same scheduler that deals with the synchronization of threads and processes, because Chrome is a multi-process application.

3. Net - a network component that parses HTTP, creates headers, etc.

The Content layer is the largest component Chrome has.

1. Blink - a WebCore-based web engine from WebKit for working with HTML and CSS; V8 (JavaScript engine); API for all extensions we use in Chrome. It also includes the DevTools protocol.

2. The Content API is an interface with which you can very easily use all the features of the web engine. Since there are a lot of things inside Blink (several hundred thousand interfaces), in order not to get lost in all these methods and functions, you need a Content API.

Headless layer level.

1. Headless library.

2. Embedder API interface for embedding Headless library in the application.

3. Client API is an interface that Puppeteer uses.

Application Layer

1. Your application (Embedding app).

2. Gadgets, for example, Headless shell.

Chrome DevTools protocol. All front-end developers (and not only they) came across the Chrome DevTools protocol, because they used the Chrome developer panel or the remote debugger, or Chrome development tools. If you run the developer tools remotely, communication with the browser occurs using the DevTools protocol. When you install debugger, see code coverage, use geolocation or something else - all this is controlled using DevTools.

The protocol has 2 components:

1. DevTools target - the tab that you inspect.

2. DevTools client - for example, this is a developer panel that is launched remotely.

They communicate using simple JSON:

1. There is an identifier for the command, the name of the method to be executed, and some parameters.

2. The answer also looks very simple: an identifier that is needed because all the commands that are executed using the protocol are asynchronous. In order for us to always be able to compare which response to which team we received, we need an identifier.

3. Result.

Puppeteer. This is a library developed by the Chrome team (available for several programming languages) that provides a high-level API for controlling Chrome or Chromium using the DevTools protocol.

It provides a high-level API to control headless (or full) Chrome. And hides away the complexities of the DevTools protocol and takes care of redundant tasks like launching a debug instance of Chrome. It's similar to other automated testing libraries like Phantom and NightmareJS, but it only works with the latest versions of Chrome.

Among other things, Puppeteer can be used to easily take screenshots, create PDFs, navigate pages, and fetch information about those pages, measure and diagnose performance indicators, intercept of network requests / responses, test Chrome extensions, automate form submission, user interface testing, keyboard input, etc.

Playwright. Playwright is a Node library to automate the Chromium, WebKit and Firefox browsers with a single API. It enables cross-browser web automation that is ever-green, capable, reliable and fast.

Headless is supported for all the browsers on all platforms. This solution has all abilities that Puppeteer has, but also supports WebKit and Firefox browsers. Playwright also has really similar to Puppeteer programming API.

Conclusion. Headless Chrome is a tool that allows you test our web applications and automate interactions with them. DevTools protocol has a rich set of features that allows you to develop complete and independent software solutions for a wide range of tasks (monitoring web applications, development environment VS Code). The ability to receive information, execute code, and automate browser actions opens up many possibilities.

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UDC 512.7

ON QUESTION ABOUT THE INTERPOLATION POLYNOMIAL OF THE FUNCTION f(λ)

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Let different argument values be given λ_1, λ_2, …, λ_s and function values $f(\lambda_k)$, $f'(\lambda_k)$, …, $f^{(m_k-1)}(\lambda_k)$ real or complex variable functions and its derivatives up to and including order (m_k-1) with the specified argument values, where $k=1$, 2, …, *s*.

There is a polynomial $p(\lambda)$ of degree $(n-1)$, where $n=m_1+m_2+\ldots+m_s$. This polynomial satisfies the conditions:

$$\begin{aligned} p(\lambda_k) &= f(\lambda_k), \\ p'(\lambda_k) &= f'(\lambda_k), \\ p^{(m_k-1)}(\lambda_k) &= f^{(m_k-1)}(\lambda_k). \end{aligned} \tag{1}$$

The polynomial $p(\lambda)$ is called the Lagrange-Sylvester interpolation polynomial of a function $f(\lambda)$ under interpolation conditions (1).

To solve the problem of interpolating a function $f(\lambda)$ by a polynomial $p(\lambda)$ we find the defining polynomial

$$\psi(\lambda)=(\lambda-\lambda_1)^{m_1}\cdot(\lambda-\lambda_2)^{m_2}\cdot\ldots\cdot(\lambda-\lambda_s)^{m_s}, \text{ where } n=m_1+m_2+\ldots+m_s. \tag{2}$$

Next, we build the right rational fraction

$$\frac{p(\lambda)}{\psi(\lambda)}=\frac{p(\lambda)}{(\lambda-\lambda_1)^{m_1}\cdot(\lambda-\lambda_2)^{m_2}\cdot\ldots\cdot(\lambda-\lambda_s)^{m_s}},$$

which decomposes into a sum of elementary fractions

$$\frac{p(\lambda)}{\psi(\lambda)}=\sum_{k=1}^{s}\left[\frac{\alpha_{k1}}{(\lambda-\lambda_k)^{m_k}}+\frac{\alpha_{k2}}{(\lambda-\lambda_k)^{m_{k-1}}}+\ldots+\frac{\alpha_{km_k}}{(\lambda-\lambda_k)}\right]. \tag{3}$$

To determine the coefficients α_{ij} of the presented decomposition multiply both parts by $(\lambda-\lambda_k)^{m_k}$, then we get

$$\frac{p(\lambda)}{\psi_k(\lambda)}, \text{ where } \psi_k(\lambda)=\frac{\psi(\lambda)}{(\lambda-\lambda_k)^{m_k}}. \tag{4}$$

Substituting $\lambda=\lambda_k$ into a $\frac{p(\lambda)}{\psi_k(\lambda)}$ and into a $\left[\frac{p(\lambda)}{\psi_k(\lambda)}\right]^{(j-1)}$, where $j=1$, 2, …, m_k,

we find

$$\alpha_{kj}=\frac{1}{(j-1)!}\left[\frac{f(\lambda)}{\psi_k(\lambda)}\right]^{(j-1)}_{\lambda=\lambda_k}. \tag{5}$$

From equality (3) multiplying both parts by $\psi(\lambda)$, we uniquely define a polynomial $p(\lambda)$:

$$p(\lambda)=\sum_{k=1}^{s}\left[\alpha_{k1}+\alpha_{k2}(\lambda-\lambda_k)+\ldots+\alpha_{km_k}(\lambda-\lambda_k)^{m_{k-1}}\right]\cdot\psi_k(\lambda). \tag{6}$$

The expression in square brackets is the sum of the first members m_k of the Taylor series.

Consider a special case of a function $f(\lambda)$: $f(\lambda)=e^{\lambda}$.

We construct an interpolation polynomial $p(\lambda)$ under the following conditions:

$\lambda_1=1$, $\lambda_2=2$, $\lambda_3=3$,

$p(1)=e$, $p(2)=e^2$, $p(3)=e^3$.

First of all, we compose the defining polynomial

$\psi(\lambda) = (\lambda-1)^{m_1} \cdot (\lambda-2)^{m_2} \cdot (\lambda-3)^{m_3}$,

and define

$m_1 = 2$, $m_2 = 1$, $m_3 = 1$.

Then

$n = m_1 + m_2 + m_3 = 2+1+1 = 4$.

Therefore, we seek a polynomial of degree

$n-1 = 4-1 = 3$.

$$p(\lambda) = \left(\frac{e}{2} + \frac{5e}{4}(\lambda-1)\right) \cdot (\lambda-2) \cdot (\lambda-3) - e^2(\lambda-1)^2 \cdot (\lambda-3) + \frac{e^3}{4}(\lambda-1)^2 \cdot (\lambda-2) =$$

$$= \left(\frac{e}{2} + \frac{5e}{4}(\lambda-1)\right)(\lambda^2 - 3\lambda - 2\lambda + 6) - e^2(\lambda^2 + 1 - 2\lambda) \cdot (\lambda-3) + \frac{e^3}{4}(\lambda^2 + 1 - 2\lambda) \cdot (\lambda-2) =$$

$$= \left(\frac{e}{2} + \frac{5e\lambda}{4} - \frac{5e}{4}\right)(\lambda^2 - 5\lambda + 6) - e^2(\lambda^3 - 3\lambda^2 + \lambda - 3 - 2\lambda^2 + 6\lambda) + \frac{e^3}{4}(\lambda^3 - 2\lambda^2 + \lambda - 2 - 2\lambda^2 + 4\lambda) =$$

$$= \left(\frac{5e}{4} - e^2 + \frac{e^3}{4}\right)\lambda^3 + (-7e + 5e^2 - e^3)\lambda^2 + \left(\frac{45e}{4} + \frac{5e^3}{4} - 7e^2\right)\lambda + \left(-\frac{9e}{2} + 3e^2 - \frac{e^3}{2}\right).$$

So, the interpolation polynomial $p(\lambda)$ for a function $f(\lambda) = e^{\lambda}$ for $\lambda_1 = 1$, $\lambda_2 = 2$, $\lambda_3 = 3$, $p(1) = e$, $p(2) = e^2$, $p(3) = e^3$, $p'(1) = e$, $p'(2) = e^2$, $p'(3) = e^3$ has the form:

$$p(\lambda) = \left(\frac{5e}{4} - e^2 + \frac{e^3}{4}\right)\lambda^3 + (-7e + 5e^2 - e^3)\lambda^2 + \left(\frac{45e}{4} + \frac{5e^3}{4} - 7e^2\right)\lambda + \left(-\frac{9e}{2} + 3e^2 - \frac{e^3}{2}\right).$$

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UDC 004.771

DESIGNING AN APPLICATION FOR REMOTE COMPUTER MANAGEMENT USING AN ANDROID DEVICE

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The article discusses the design of a system for working with a computer using an android device. The analysis of the most suitable technologies for the application development is performed. Research on the relevance of this application development has been carried out.

Keywords: information technology, android, network, computer management.

Introduction. Remote computer management programs allow you to distantly control another computer over the Internet or a local network. This is useful when you need to help a user who is not very experienced, such as a relative or a friend who is not well versed in the computer to do something on it. Such programs are also convenient to use for remote work, for example, to connect to the office from home and, conversely – to access your home PC, for system administration of a whole fleet of computers and servers.

Remote computer control allows you to get full control of the remote machine, as well as applications and files. The most common functions for many remote PC management programs are file Manager, voice or text chat, and, directly, remote computer management.

The remote PC connection technology opens up a wide range of opportunities for both corporate and private users who want to stay active and mobile and at the same time have a quick access to their work and home computers from anywhere in the world.

These days, remote access to a computer and the benefits it provides have long gone beyond simple convenience. Now it is a necessity, and the business of more and more companies depends on remote connection technologies. Remote technical support, system administration, online business conferences, and distance learning are the broadest applications of this technology.

While developing the application, image broadcasting from the computer monitor to the phone screen and control of the cursor and mouse buttons from the phone were implemented.

Analysis of the application's relevance. We will conduct a comparative analysis of remote management programs, highlight their advantages and disadvantages.

TeamViewer.

It is one of the most popular programs for remote access. It can be quickly downloaded and installed or immediately run without installation. Even a very inexperienced user can cope with this. At startup, the program displays a window with the ID and password for accessing this computer, and TeamViewer allows you to connect to another computer by setting its ID and password. An example of the user interface is shown in figure 1.

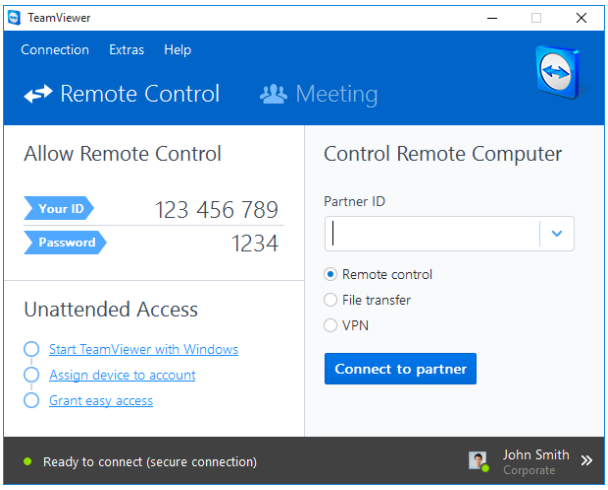

Figure 1. – User interface of the "TeamViewer" app

Advantages: the program has several main modes of operation: remote management, file transfer, chat, demonstration of your desktop. The program allows you to configure round-the-clock access to your computer, which will be convenient for system administration. The speed of work is quite decent, there are versions for all mobile platforms, for various operating systems, which is very pleasing. A simple and intuitive interface, plus a number of additional utilities to expand the program's functionality, will be useful for remote support services.

Disadvantages: although the program is free, it's only for non-commercial use, but also, when working with it for more than 5 minutes, a number of difficulties arise, for example, TV can block a remote connection session, recognizing it as commercial use. For round-the-clock remote access or administration of multiple computers, computer network, you have to pay for additional program modules. The cost of the program is high.

LiteManager.

It is a simple, but quite powerful program. It consists of two parts, the first is the Server that you need to install or run on a remote computer and the Viewer, which allows you to manage another computer. To work, the program requires a little more skills and experience from the Manager, although working with the server is even easier than in TeamViewer, the server can be installed once and no more actions are needed from the user, the ID will always be constant, it can even be set manually, which is very convenient for remembering. The LiteManager Free version is free for personal and commercial use. An example of the user interface is shown in figure 2.

Figure 2. – User interface of the "LiteManager" application

Advantages: in addition to the main remote access modes: remote management, file transfer, chat, task Manager, registry editor, there are also unique functions in the program, such as inventory, screen recording, and remote installation. The program is free to use on 30 computers, it can be used for round-the-clock access without any additional modules. There are no restrictions on working hours. You can configure your own server ID to configure the corporate support service. The program does not have any time limits and locks.

Disadvantages: there are no mobile platforms or versions for other systems, there are restrictions on 30 computers in the free version, to administer more, you need to purchase a license. Some specific operating modes are only available in the Pro version.

RAdmin.

It is one of the first remote management programs and well-known in its circle and I cannot but mention it. It is designed rather for system administration and the main focus is on security. The program consists of two components: a server component and a client component. It requires installation, it wouldn't be easy for an inexperienced user to deal with it, the program is designed to work via the IP address mainly, which is not very convenient for providing technical support via the Internet. The program is paid, but has a free test period. An example of the user interface is shown in figure 3.

Advantages: the program has a high speed of operation, especially in a good network, there is an increased reliability and security thanks to the video capture driver of the desktop. There is a built-in Intel AMT technology, which allows you to connect to the BIOS of a remote computer and configure it. Only the main modes of operation are implemented: remote management, file transfer, chat, etc.

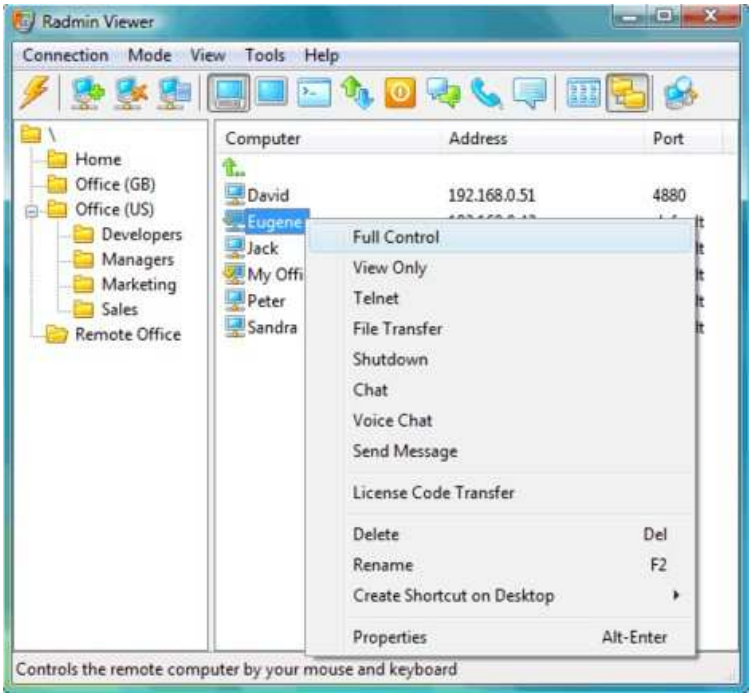

Figure 3. – User interface of the "RAdmin" application

Disadvantages: there is almost no way to work without an IP address, i.e. to connect by ID. There is no client for mobile systems. There is no free version, only a test period of 30 days. To work with the program, you need the skills of an experienced user. When connecting a video, the driver may disable the Aero graphical shell, sometimes the screen flashes.

The considered analogs do not fully satisfy the optimal functionality of the application being developed. The advantageous difference between the developed application and its analogues is that in this application the load on the network is much lower than that of the above-mentioned analogues. It is also worth noting that this application uses much less computer resources (processor, RAM).

Tools for solving the problem. You must select the Protocol for network communication between the server program and the client program.

Network sockets are divided into two main types – TCP and UDP. The choice of socket depends entirely on the functionality of the application and the tasks it will solve.

TCP is a Protocol that uses the secure connection principle. This means that you establish a connection between two computers, and then send data between them just as if you were writing information to a file on one computer and reading it from the same file on the other. In this case, the connection is considered reliable and consistent – that is, all information that you send is guaranteed to reach the recipient in the same order in which it was sent. Also, a TCP connection can be considered a continuous data stream – the Protocol itself takes care of splitting data into packets and sending them over the network [1].

UDP is one of the key elements of TCP / IP, a set of network protocols for the Internet [2]. With UDP, computer applications can send messages (in this case called datagrams) to other hosts over an IP network without the need for a pre-message to set up special transmission channels or data paths. The Protocol was developed by David P. Reed in 1980 [3].

In this case, the use of the TCP Protocol is not allowed, since our program is tied to real-time network interaction. For many aspects of the program, such as user clicks or changes in the state of the screen, it doesn't matter what happened a second ago, but only the most current state of the computer is important. The network part of this application are as follows: each iteration of the loop, the server sends to the client the report in the form of pictures, while the client sends the server the commands that must run without delay (pressing buttons, moving the cursor), and each iteration the server processes the received data, updating the current status of the screen and sends the screenshot to an array of bytes to the client so that the user rendered a new frame. So, in this application, if a packet is lost during transmission over the network, all server processes are suspended until the packet is delivered again. On the client side, the image freezes, and data will not reach the server either, since the server cannot accept new packets. When a lost package finally arrives, it contains outdated information

that is no longer relevant. In addition, after this, all the packets that have been accumulated in the queue during the waiting time also come, and they all need to be processed in one iteration of the cycle.

Based on the analysis performed, it was decided to use the UDP network Protocol.

Based on these characteristics, the functional structure of the software is developed, which consists of the following subsystems:

1. thread management subsystem is responsible for the correct distribution of application threads. It is designed for performing multiple tasks at the same time;
2. network socket management subsystem is responsible for opening sockets for connecting clients. Thanks to this system, the connection between the client and the server takes place;
3. subsystem of data transmission control is responsible for transferring data between a client and a server;
4. data reception management subsystem is responsible for receiving data between the client and the server;
5. connected client management subsystem is responsible for managing connected clients;
6. information output subsystem is used to display information about the server.

The functional structure of the system is shown in figure 4.

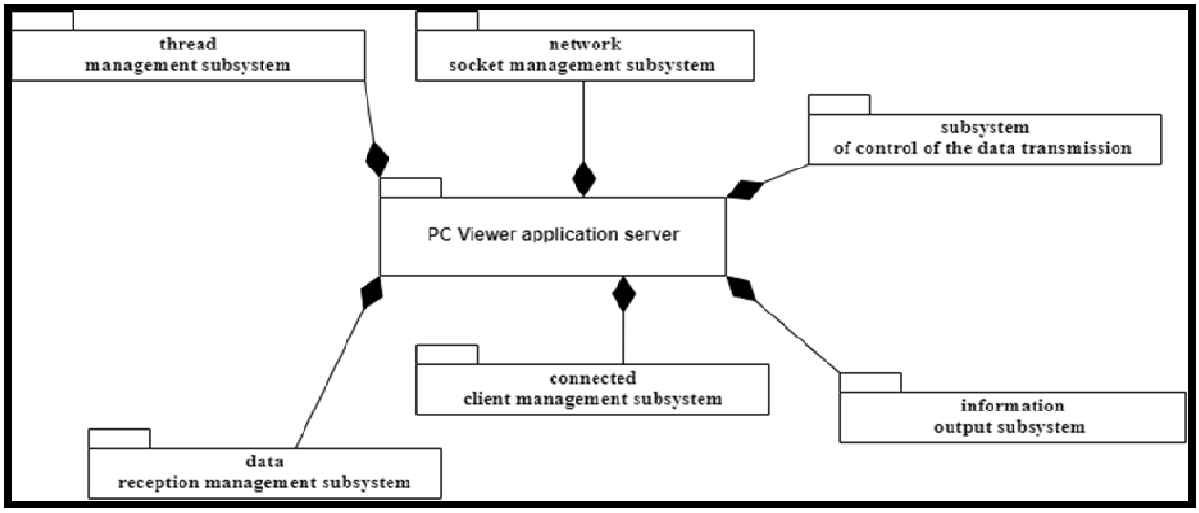

Figure 4. – Functional structure of the application

Conclusion. In the course of this study, we designed the software that is most suitable for architectural features as a basis for developing a network application for managing a personal computer using a mobile device. At the same time, the developed architecture is universal for any modern programming language, and also leaves opportunities for implementing the necessary functionality.

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ENSURING INFORMATION SECURITY WHEN SERIALIZING JAVA OBJECTS

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This paper describes how to serialize Java objects with support for encryption and electronic signature. Based on existing tools in Java, its own implementation with fixed security settings is proposed.

Today, Java is the most popular programming language according to the TIOBE Index. Java supports the object-oriented programming (OOP) paradigm. This means that any data is represented as objects of some class. One of the characteristics of the object is the state – information characterizing the object.

Often the state of an object needs to be saved to a file, database, or transferred over the network. Serialization is used for this. Serialization is the process of converting the state of an object into a data stream. Deserialization is the reverse process. Serialization of objects of some class is possible only when this class implements the Serializable interface.

In special cases, the serialization mechanism can be customized. Firstly, using the transient modifier, you can reverse the serialization of a certain field of the class. Secondly, you can change serialization behavior by defining methods:

– private void writeObject(ObjectOutputStream out) throws IOException;

– private void readObject(ObjectInputStream in) throws IOException, ClassNotFoundException.

Thirdly, in the place of implementation of the Serializable interface, you can implement the Externalizable interface and define its methods:

– public void writeExternal(ObjectOutput out) throws IOException;

– public void readExternal(ObjectInput in) throws IOException, ClassNotFoundException.

In this case, the serialization protocol is determined by the developer.

Sometimes a serialized object is required to be cryptographically secure. Cryptographic protection refers to ensuring confidentiality, monitoring the integrity and authenticity of information. The serialization control methods listed above have a significant drawback: you need to change the source code of the class. For example, a class must contain encryption and decryption algorithms for its fields. The developers of Java Cryptography Architecture (JCA) and Java Cryptography Extension (JCE) solved this problem and introduced two classes: SealedObject and SignedObject.

A SealedObject instance acts like a wrapper around another object. It contains an encrypted version of the serialized representation of the wrapped object. The following conditions are required to create an instance of SealedObject:

– the wrapped class must be serializable;

– the constructor, in addition to the wrapped object, requires an instance of the Cipher class, which is a cryptographic cipher [1].

Encrypted content can be decrypted and deserialized to obtain the original object. To do this, you must call one of the overloaded getObject() methods on the SealedObject instance [1].

A SignedObject instance also acts as a wrapper around another object. It contains the wrapped object in serialized form, as well as information about the signature required to verify the authenticity and integrity of the wrapped object. To create an instance of SignedObject, the following conditions must be met.

– The wrapped class must be serializable.

– The constructor needs the private key of the signer, represented by an instance of the PrivateKey class.

– The constructor needs a signature generation mechanism, represented by an instance of the Signature class [1].

Once the SignedObject instance has been created or obtained as a result of deserialization, you can verify the integrity of the wrapped object and the alleged authenticity of the signer. To do this, you must call the verify() method, passing it the public key and an instance of the Signature class, with which SignedObject was originally created [1].

Using the getObject() method, you can get an encapsulated object. The encapsulated object is deserialized before returning. It is worth noting that SignedObject does not encrypt the content, so you can get a wrapped object without first checking the sender's authenticity or integrity [1].

Having examined these classes and their dependencies in detail, you will notice that they also require quite a lot of settings before using them. We solved this problem and wrote classes for working by default with SealedObject and SignedObject.

For convenient use of SealedObject, the class SealedObjectCreator was written. It contains instances of the Key and Cipher classes. These instances are initialized in the SealedObjectCreator constructor. To initialize the Key, a KeyGenerator with the AES algorithm is used, which generates a 256-bit key using a SecureRandom instance with the SHA1PRNG algorithm. To initialize Cipher, the AES algorithm is used in GCM mode without a padding scheme (AES/GCM/NoPadding), the constant Cipher.ENCRYPT_MODE and the key obtained earlier are passed to the init() method of the Cipher instance [2]. SealedObjectCreator provides getter methods and an instance method for creating a SealedObject:

public SealedObject newSealedObject(Serializable wrappedObject) [3].

For convenient use of SignedObject, the SignedObjectCreator class was written. It contains instances of the Signature and KeyPair classes. These instances are initialized in the SignedObjectCreator constructor. Signature is initialized using the SHA512withECDSA algorithm. To initialize KeyPair, a KeyPairGenerator with an EC algorithm is used, which generates a 521-bit key using a SecureRandom instance with the SHA1PRNG algorithm [3]. SignedObjectCreator provides getter methods and an instance method for creating a SignedObject:

public SignedObject newSignedObject(Serializable wrappedObject).

For testing, the User class was created with the string fields name, phone, email and with the integer field id. The object of this class was constructed as follows:

final User user = new User(1L, "John", "8-047-429-28-05", "ragain.j@pol.com").

Using SealedObjectCreator, an instance of SealedObject was created, which was written to the file. An example of the contents of the file is shown in Figure 1.

Figure 1 shows that the information about the user object is encrypted. After deserializing the resulting SealedObject instance, you can call the getObject() method with the key from the SealedObjectCreator instance. In this case, the decrypted user object will be returned.

Using SignedObjectCreator, an instance of SignedObject was created, which was written to the file. An example of the contents of the file is shown in Figure 2.

Figure 2 shows that the information about the user object is not encrypted. For example, the phone number is highlighted in gray. Data types and other technical information are also visible here. It is worth noting that the file is written in binary form, and in a simple text editor you can read only string values. This file also carries digital signature information. If you change the contents of the file or pass the Signature instance different from the one provided by SignedObjectCreator to the verify() method of the deserialized instance of SignedObject, the verify() method will return false. This means that the integrity or authenticity of the data is compromised. Although the user object can be successfully obtained using the getObject() method of the SignedObject class.

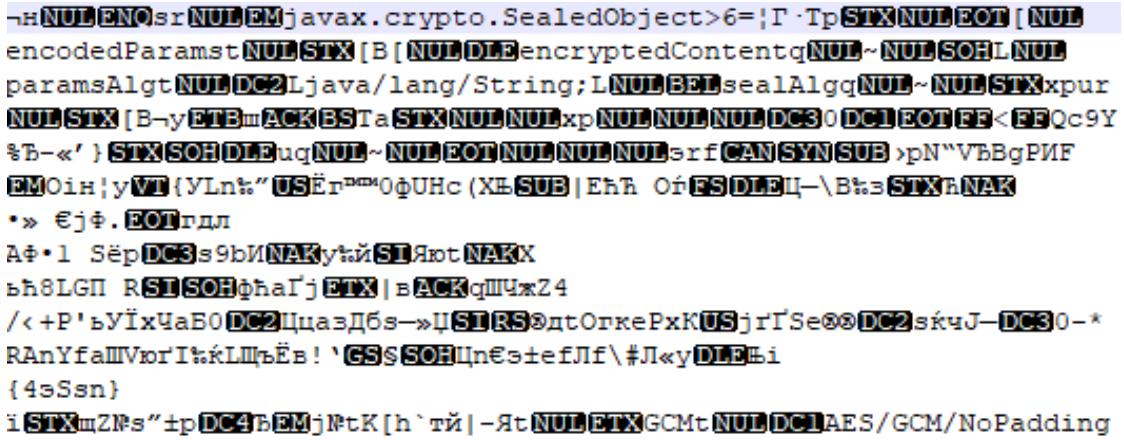

Figure 1. – Serialized SealedObject content

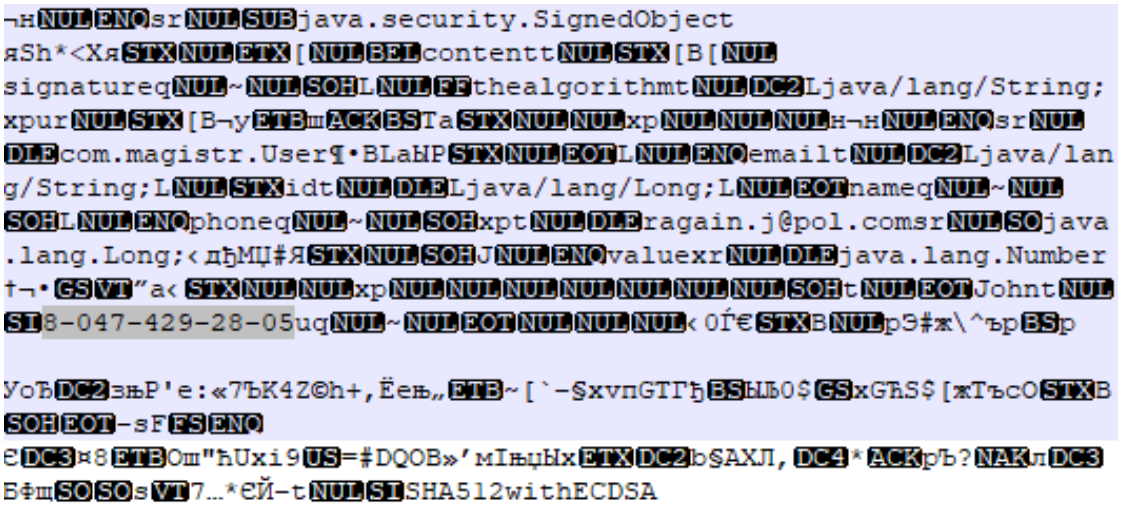

Figure 2. – Serialized SignedObject content

So, the classes SealedObjectCreator and SignedObjectCreator are a useful addition to SealedObject and SignedObject. They allow you to configure secure serializable objects by default and manage them.

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UDC 62-5

SWIVEL MECHANISM FOR ANTENNA WITH GPS SENSOR AND LAN CONTROL

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This article discusses the method of developing a rotary device with a GPS sensor and the ability to control the position of the antenna remotely from the workplace using a LAN connection.

Introduction. All that is needed for the development of the device is a reduction in the size of the case, a decrease in the weight of the device itself, and a higher antenna rotation speed. To compensate for the resulting deficiencies the device should be built-in and programmed to support network connections.

Task formulation. As a rule, to develop a device, we need to determine our technical characteristics, on the basis of which the elemental base of the developed device will be largely determined, and the operating conditions of this device must also be determined.

Technical details:

- The executive part of the motor has a power of 500W ± 10%;
- Connector for wired LAN;
- The presence of a GPS module;
- The device has several types of antenna rotation;
- The BRIGHTNESS adjustment knob allows you to adjust the brightness of the display;
- Using the VERTICAL knob, azimuth control is provided from 0 to 360º;
- Using the HORIZONTAL knob, you can control the elevation from 0 to 90º.

Operating conditions for use:

- Range of operating temperatures from minus 20 to plus 60 ° C;
- Atmospheric pressure 84 - 106 kPa;
- Relative humidity of 80% at a temperature of no more than 50 ° C.
- The overall dimensions of the device should not exceed 190x110x95mm, the mass should be no more than 3kg.

The device must be powered from a 24 V DC network.

Methods of research. The following basic elements were selected for the rotary device:

- Encoder-OCD-EIB1B-10V-IXARC;
- Microcontroller-ATmega328p-32KB Flash 2.5V / 3.3V / 5V-Vercial;
- Display-WH1602A-5V-WINSTAP;
- Motor-ZY1016-350W 24V2750 RPM-Funsport;
- GPS module - Beitan BN-880;

The principle of operation of the device is based on the processing of signals transmitted from control devices to the controller, followed by rotation of the device. The device consists of a control part, a controller and an actuator.

The actuator consists of several parts. The necessary signal received by the controller is processed and then transmitted to the motors of the device.

This rotary device is designed to rotate and accurately position even the largest television antennas to ensure the best signal reception. The rotation of the motor is synchronized with the position of the rotary switch on the control unit. This is achieved through the use of high-precision synchronous motors. The connecting cables between the controller and the motor are under safe voltage. After the end of the operating cycle, the device automatically turns off and does not consume current until you turn it on again by turning the switch on the control unit.

Based on the structural diagram, you can determine the principle of operation of the device

– The signal from the encoder is fed to the programmed microcontroller.

– From the microcontroller, the processed signal is sent to the display on which the angle of rotation of the antenna will be displayed.

– The microcontroller also receives a signal to the actuator that will rotate the antenna horizontally and vertically.

After a thorough analysis of the available data, the structural diagram, you can begin to develop a functional diagram on which there will be more components of the device, as well as the device itself will be divided into separate blocks for convenience in drawing up the electrical circuit.

The GPS sensor in this device is required for:

- Accurate location of the antenna;
- Accurate determination of the direction of the antenna;
- The exact azimuthal position (if the antenna was moved by a person to another place).

In the device under development, an absolute encoder was used. In the absolute encoder, the entire rotation circle is divided into a certain number of sectors, most often the same size. These sectors are numbered. The encoder at work gives the number of the sector in which it is currently located. Therefore, it is called absolute.

With this type of encoder, you can always determine by what angle relative to the zero sector the encoder is turned at a particular moment, that is, when turning it, it gives the values of the sector numbers to the maximum value. Then it goes back to zero. If the encoder shaft is turned in the other direction, then it will start to produce opposite values. [2]

Microcontroller ATMega328 is an 8-bit low-power CMOS microcontroller based on advanced AVR RISC architecture.

ATmega328 / P - the microcontroller of the AVR family, like all the others, has an 8-bit processor and allows you to execute most commands in a single clock cycle.

The reprogrammable read-only memory (EPROM) stores the microcontroller's program of work, as well as the values of the coefficients and constants necessary to calculate the value of the rotation value from the signals received from the sensor.

The random access memory stores intermediate values of variables necessary for calculating the measured temperature values.

I / O ports provide information exchange between the microcontroller and peripheral devices relative to it. These ports vary in purpose and functionality.

Atmega328p is used to receive the supplied signal, process it and transmit it to the actuator. ATmega328 / P - the microcontroller of the AVR family, like all the others, has an 8-bit processor and allows you to execute most commands in a single clock cycle.[1]

This microcontroller uses 5V power.

A display is an electronic device designed to visually display information. The display in most cases can be called the part of the finished device used to display digital, alphanumeric or graphic information electronically.

It is necessary to distinguish between the concepts of "display", as part of the device, and a monitor, which can have different types of displays - CRT, LCD, plasma, and so on. For example, a mobile phone has a display for displaying information, but it can also have a remote (plug-in) monitor.

Some displays serve as indicators. But you should distinguish between the concepts of "display" and "indicator". An indicator is a device (device, element) that reflects any process, the state of the observed object. Indicators can be, for example, raster, segment, arrow, acoustic, tactile and so on [3]. For example, the TV display is not an indicator, and the audio indicator is not a display.

Previously, in technology, only raster devices were called displays, and only segment devices were called indicators, but now modern multifunction indicators are also called displays.

Conclusion. As a result of the article on the topic "Swivel mechanism with GPS sensor and LAN control", the following results were obtained:

- The requirements for the developed device were formulated.
- The development of a structural diagram of the device.
- The development of a functional diagram of the device.

After the implementation of the above points, the economic justification of the thesis project was carried out, the total cost of the product was calculated. Information about analogues showed that the developed device is more competitive in price, and is not inferior to them in characteristics. Therefore, the production of this device can be considered economically and technically feasible.

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UDC 004.047

CREATING A MINESWEEPER GAME USING THE JAVA PROGRAMMING LANGUAGE

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In this article, we will look at the structure of the code on which the game "Minesweeper" is based and show step by step the methods that are used to create games like this. The Java language that is used for building is one of the most common and universal programming languages.

First, let's create a Game Object class (Fig.1), it will represent the cell that will make up our field for the game. In this class, you will need parameters such as:

```
class GameObject {
    int x;
    int y;
    boolean isMine;
    int countMineNeighbors;
    boolean isOpen;
    boolean isFlag;
    String status;
    GameObject (int x, int y, boolean isMine){
        this.x=x;
        this.y=y;
        this.isMine=isMine;
    }
}
```

Figure 1. –Cell coordinates x, y (simple integers);

• cell States: isMine (whether it is a mine or not), isOpen (whether we have already opened the cell or not), isFlag (whether we have set a flag on the cell or not);
• the count of mines adjacent to this cell countMineNeighgors(integer).

We also create a constructor for this class.
The next step is to build the MinesweeperGame class, which will represent the processes that take place inside the game. Here we need parameters (Fig.2) such as:
• the size of the side of the SIDE field (an immutable number);
• two-dimensional array of gameField objects (consisting of objects of the GameObject class);
• displaying the state of cells in the field: MINE, FLAG, CLOSED (immutable rows);
• counters: countFlags (how many flags are available for use), countClosedTiles (number of closed cells);
• the state in which the game is located is Game Stopped (if true, it ends the game and does not allow the player to perform further actions).

```
public class MinesweeperGame {
    private static final int SIDE = 9;
    private GameObject[][] gameField = new GameObject[SIDE][SIDE];
    private int countMinesOnField;
    private static final String MINE = "M";
    private static final String FLAG = "F";
    private static final String CLOSED = "X";
    private int countFlags;
    private boolean isGameStopped;
    private int countClosedTiles = SIDE * SIDE;
```

Figure 2. – Now we can start describing the processes that occur in the game. Let's create an Initialize() method (Fig.3 and 4) that is available for external use.

The method starts the game process and implements a simple interface through the console for the user. The createGame() method enabled by the process initializes objects in the gameField array, randomly creates mines with a given probability, and counts the number of mines in the countMinesOnField field. We also introduced methods to simplify code understanding: Input() and showField(). Which implement the user entering data from the keyboard and displaying the field on the console, respectively.

```
public void initialize() {
    System.out.println("Welcome");
    createGame();
    while (!isGameStopped) {
        showField();
        System.out.print("Open tile [o], set flag [f], exit [x]: ");
        int x, y;
        switch (input()) {
            case "o": {
                System.out.println("Set coordinates");
                System.out.print("x: ");
                x = Integer.parseInt(input());
                System.out.print("y: ");
                y = Integer.parseInt(input());
                openTile(x, y);
                break;
            }
```

Figure 3

```
            case "f": {
                System.out.println("Set coordinates");
                System.out.print("x: ");
                x = Integer.parseInt(input());
                System.out.print("y: ");
                y = Integer.parseInt(input());
                markTile(x, y);
                break;
            }
            case "x": {
                System.out.println("Goodbye");
                isGameStopped = true;

            }
            default:
                System.out.println("Wrong command");
        }
    }
}
```

Figure 4

Now we will create logical sequences that represent the game mechanics. To do this, we need to create several more methods.

First we implement openTile(x,y) (Fig.5), it is intended to open the cell that the user specified. This method checks the cell for a flag and that it is already open. After that, it reduces the number of closed cells of the field by 1 and checks the contents of the object: if the cell is a mine, it starts the process of completing the game. If there is no mine in the cell, it opens it and displays the number of mines in the neighborhood. If there

are no mines in the neighborhood, then the same method is called for all the cells around using recursion. This is followed by a check if the number of mines on the field and closed cells is equal to that the game is won and the win () method is called.

```
private void openTile(int x, int y) {
    if (!gameField[y][x].isOpen && !gameField[y][x].isFlag && !isGameStopped) {
        gameField[y][x].isOpen = true;
        countClosedTiles--;
        gameField[y][x].status = String.valueOf(gameField[y][x].countMineNeighbors);
        if (gameField[y][x].isMine) {
            gameField[y][x].status = MINE;
            gameOver();
        } else {
            gameField[y][x].status = String.valueOf(gameField[y][x].countMineNeighbors);
            if (gameField[y][x].countMineNeighbors == 0) {
                List<GameObject> r = getNeighbors(gameField[y][x]);
                for (GameObject gameObject : r) {
                    if (!gameObject.isOpen) {
                        openTile(gameObject.x, gameObject.y);
                    }
                }
            }
            if (countClosedTiles == countMinesOnField) {
                win();
            }
        }
    }
}
```

Figure 5

The getNeighbors(gameField[y][x]) method is intended to return a list of cells that are neighbors for the specified instance. The gameOver() method included in the method above assigns the value true when called, which is an indicator of the end of the game and other actions are prohibited, which should also be done if you win.

```
private void markTile(int x, int y) {
    if (!gameField[y][x].isOpen && !isGameStopped) {
        if (!gameField[y][x].isFlag) {
            if (countFlags != 0) {
                gameField[y][x].isFlag = true;
                countFlags--;
                gameField[y][x].status = FLAG;
            }
        } else if (gameField[y][x].isFlag) {
            gameField[y][x].isFlag = false;
            countFlags++;
            gameField[y][x].status = CLOSED;
        }
    }
}
```

Figure 6

We will also need the markTile(x,y) method (Fig 6) to implement the ability to put and remove "flags" in the place of the expected mines. To do this, first enter a check for whether the cell is already open and whether

the game is not over. This is followed by a sequence of actions depending on whether the cell has a flag: if it does not exist, we set it and change the cell status in the field; otherwise, we return the cell to its original values.

After implementing all these actions, we can already start the game(Fig 8) by simply creating an object of the MinesweeperGame class and calling its initialize() method (Fig.7).

```
public class Main {
    public static void main(String[] args) {
        MinesweeperGame game=new MinesweeperGame();
        game.initialize();
    }
}
```

Figure 7

```
Welcome
#   #   #   #   #   #   #   #   #
#   #   #   #   #   #   #   #   #
#   #   #   #   #   #   #   #   #
#   #   #   #   #   #   #   #   #
#   #   #   #   #   #   #   #   #
#   #   #   #   #   #   #   #   #
#   #   #   #   #   #   #   #   #
#   #   #   #   #   #   #   #   #
#   #   #   #   #   #   #   #   #
Open tile [o], set flag [f], exit [x]:
```

Figure 8

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UDC 004.021

THE DESIGN OF WEB INTERFACE FOR DIALOGUE WITH THE INTRODUCTION OF A CHAT BOT.

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This article discusses how to build the user interface for a chat bot.

Introduction. Long Polling is a technology that allows you to receive information about new developments with the "long queries." The server receives the request, but it doesn't send a response to it immediately, but only when there is an event (for example, a new message comes) or a specified waiting time elapses. Using this approach, you can instantly display important events in your application. Using the User Long Poll API You cannot send a message to this use method.

Callback API is a tool for tracking user activity in your community VKontakte. With it, you can realize, for example, the following: Bot has to send instant replies to incoming messages. System of automatic moderation of content.

The main section. Callback API sends a notification to your server, as a desired event happens in the community. An event can be anything: a comment to a photo, a new record on the wall, joining the community, sending messages, etc.

To connect the Callback API in the community you need to specify the address of the script on your server and select the events you want to receive. For example, if your bot has to recognize the text commands, mark the event "incoming message"

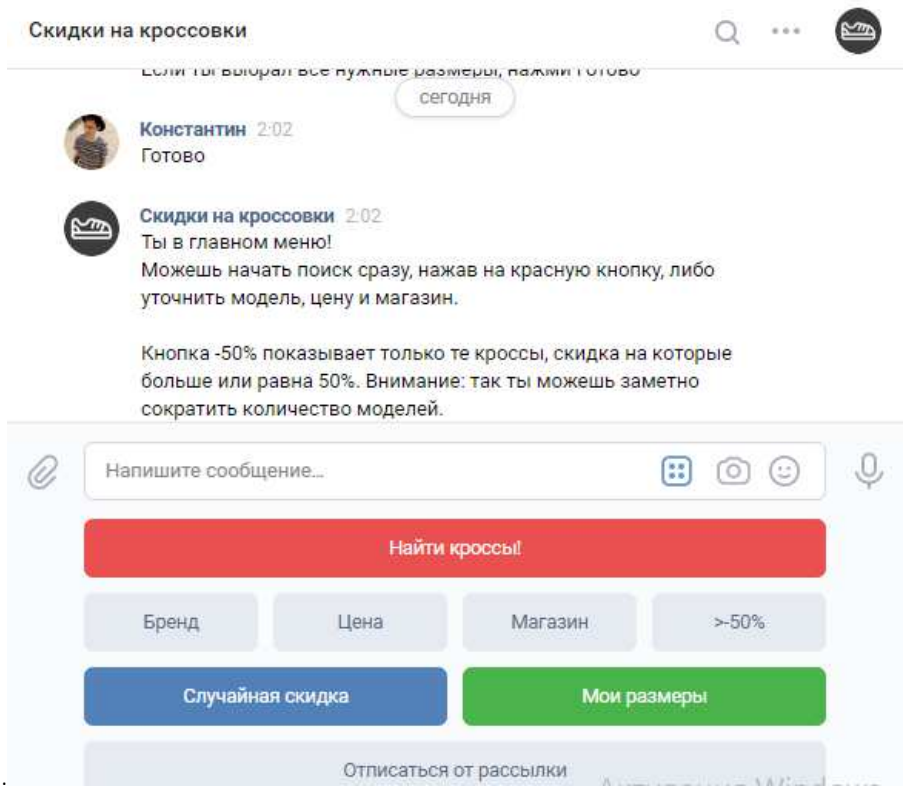

Figure 1. – Communication with the chat bot

Long Polling is a technology that allows you to receive information about new developments with the "long queries." The server receives the request, but it doesn't send a response to it immediately, but only when there is an event (for example, comes a new message) or a specified waiting time elapses. Using this approach,

you can instantly display important events in your application. Using the User Long Poll API You cannot send a message to this use method. Before connecting to Long Poll server needs to retrieve data session (server, key, ts) method messages. Get Long Poll Server. We recommend to transfer the actual version number of the Long Poll in lp_version parameter.

Then make a request like this:

https: // {$ server} act = a_check & key = {$ key} & ts = {$ ts} & wait = 25 & mode = 2 & version = 2?

It uses the following parameters:

key - a secret session key;

server - the server address;

ts - the number of the last event, since you want to receive data;

wait - wait time (as some proxy servers terminate the connection after 30 seconds, we recommend that you wait = 25). Maximum value - 90.

mode - additional response options. The amount of option codes from the list:

2 - receive attachments;

8 - Returns the extension of the set of events;

32 - return pts (required for operation of the methodmessages.getLongPollHistorywithout restriction in the last 256 events);

64 - in the event with the code 8 (each got online) to return additional information in the field $ extra (see.The structure of the event);

128 - return random_id field (random_id can be transmitted when sending a message bymessages.send).

version - version. Current version: 3. For Version 0 (default), identifiers communities will be coming in group_id + 1000000000 format for backward compatibility. We recommend using the latest version.

For the first request within the meaning of the session for the server parameters, key, and ts must be received by messages.getLongPollServer. In subsequent requests use the same server and the key and the new value ts, which come to you in a response from Long Poll server.

Conclusion. This article describes the basic elements of the construction of interface for a chat bot and presents examples and results.

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UDC 004.432

SWIFT OBJECT-ORIENTED PROGRAMMING LANGUAGE: FEATURES AND ADVANTAGES

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Swift is a general-purpose programming language built using a modern approach to safety, performance, usability and software design patterns.

Mobile application development industry in the last five years has multiplied in leaps and bounds, changing the way businesses function worldwide. With enterprises aligning mobile apps to their productivity in recent times, and with the rapid innovation in mobile devices across platforms, it calls for mobile app developers to write several versions of an application for many different platforms using a single language and many pieces of reusable code [1].

The iOS platform is a proprietary platform made by Apple. The iOS platform constituents are available for phone devices and tablet devices: Iphone and Ipad. Apps could be developed for the iOS platform, and then target the same app to both an iPhone and an iPad. For building apps for iOS, one must have an Apple developer account and the Xcode IDE on a Mac computer. Xcode comes with all the required Apple development toolkit: SDKs, a code editor, compile/build tools, simulators, and a debugger. Apps can be built for iOS devices either by using the native iOS SDK with Objective-C and Swift or with the various cross platform technologies that are written against the SDK of that framework, but targeted for iOS [2].

Swift is a general-purpose, multi-paradigm, object-oriented, functional, imperative and block structured language. It is the result of the latest research on programming languages and is built using a modern approach to safety, software design patterns by Apple Inc. It is the brand new programming language for iOS application, macOS application, watchOS application and tvOS application. Soon it became one of top 5 programming languages and gained popularity among Apple developer community over the few years of time replacing the old school Objective C [3].

Brief history. Chris Lattner began the development of Swift in the year 2010 and collaborated with other programmers at Apple in the course of the development of this language. The language ideas for Swift were taken from Rust, Objective-C, Ruby, Haskell, C#, CLU, Python, and a range of other programming languages.

Swift was introduced at Apple's 2014 Worldwide Developers Conference (WWDC). It underwent an upgrade to version 1.2 during 2014 and a more major upgrade to Swift 2 at WWDC 2015. Initially a proprietary language, version 2.2 was made open-source software under the Apache License 2.0 on December 3, 2015, for Apple's platforms and Linux.

Through version 3.0 the syntax of Swift went through significant evolution, with the core team making source stability a focus in later versions.

Swift 4.0, released in 2017, introduced several changes to some built-in classes and structures. Code written with previous versions of Swift can be updated using the migration functionality built into Xcode.

Swift 5, released in March 2019, introduced a stable binary interface on Apple platforms, allowing the Swift runtime to be incorporated into Apple operating systems. It is a source compatible with Swift 4. Swift 5.1 was officially released in September 2019. Swift 5.1 is built on the previous version of Swift 5 by extending the stable features of the language to compile-time with the introduction of module stability. The introduction of module stability makes it possible to create and share binary frameworks that will work with future releases of Swift [4].

Key programming features. Swift includes features that make code easier to read and write, while giving the developer the control needed in a true system programming language. Swift supports inferred types to make code cleaner and less prone to mistakes, and modules eliminate headers and provide namespaces. Memory is managed automatically, and you don't even need to type semi-colons. Swift also borrows from other languages, for instance the named parameters brought forward from Objective-C are expressed in a clean syntax that makes APIs in Swift easy to read and maintain [5].

Swift is a protocol-oriented programming language, such programming paradigm is used from the release time of Swift 2.0. in this approach, design protocols are similar to classes but this serves better compared to object-oriented programming. Since the concepts like structs and enums don't work properly as a struct cannot inherit from another struct, neither can an enum inherit from another enum. So inheritance which is one of the fundamental object-oriented concepts cannot be applied to value types. On the other hand, value types can in-

herit from protocols. The concepts used in protocol-oriented paradigm are: protocol extensions, inheritance and compositions.

Similarly to C# and in contrast to most other OO languages, Swift offers built-in support for objects using either pass-by-reference or pass-by-value semantics, the former using the class declaration and the latter using struct. Structs in Swift have almost all the same features as classes: methods, implementing protocols and using the extension mechanisms. For this reason, Apple terms all data generically as instances, versus objects or values. Structs do not support inheritance, however.

An important new feature in Swift is option types, which allow references or values to operate in a manner similar to the common pattern in C, where a pointer may refer to a value or may be null. This implies that non-optional types cannot result in a null-pointer error; the compiler can ensure this is not possible.

Advantages. The features of Swift are designed to work together to create a language that is powerful, yet fun to use. Some advantages of Swift include:

- Safety. Swift was designed to improve the code safety for iOS products. It was created as a type-safe and memory-safe language. Type safety means that the language itself prevents type errors. The importance of type memory safety is that it helps avoid vulnerabilities associated with dangling or uninitialized pointers. These types of errors are the most common in development and difficult to find and debug. These advantages of the Swift language make it more attractive. Swift, on the other hand, doesn't use pointers. If you miss a pointer in the code, perhaps nil value, the app will crash. This approach allows programmers to find and fix bugs quickly. As a result, the code will be cleaner and easier to understand. Such features as generics, optionals, and type interference make an app developed in Swift less inclined to contain unnoticed bugs. [6]

- Dynamic libraries support. Dynamic libraries are the executable parts of code that can be linked to an app. The difference between dynamic libraries and static libraries is that dynamic libraries can be linked to any program during run-time. The shared code is loaded once and can be used by a large number of programs. This code can be updated, changed or recompiled without recompiling the application that uses this library. Dynamic libraries are automatically included in the AppStore's download package. Static libraries are linked at the last step of the compilation process after the program is placed in memory.

- Perfomance. From its earliest conception, Swift was built to be fast. Using the high-performance LLVM compiler technology, Swift code is transformed into optimized native code that gets the most out of modern hardware. The syntax and standard library have also been tuned to make the most obvious way to write your code to perform the best whether it runs in the watch on your wrist or across a cluster of servers. Swift is a successor to both the C and Objective-C languages. It includes low-level primitives such as types, flow control, and operators. It also provides object-oriented features such as classes, protocols, and generics, giving developers the performance and power they demand.

- Open Source. Swift is developed in the open at Swift.org, with source code, a bug tracker, forums, and regular development builds available for everyone. This broad community of developers, both inside Apple as well as hundreds of outside contributors, work together to make Swift even more stable and powerful. Open-source Swift can be used on Linux to build Swift libraries and applications. The open-source binary builds provide the Swift compiler and standard library, Swift REPL and debugger (LLDB), and the core libraries, so one can jump right in to Swift development.

Despite its tender age and the attendant controversy, Swift already has a number of prominent success stories. Some of the companies that chose the new language are Lyft, LinkedIn, Coursera, Pandora, Vimeo, Twitter, Fitbit, and Groupon. Moreover, Facebook and Uber are reported to have shown significant interest in Swift. Swift has become a more mature language with the latest update, but there are a lot of things to fix. Apple is creating its own ecosystem with a stable ABI over its platforms, but it still lacks tooling and support for earlier versions, which might be fixed in the next releases. Thus, Swift adoption will continue to grow, which soon might lead to a complete displacement of Objective-C as the leading first-class language for iOS mobile application development. Though Swift and Objective-C can coexist, that is libraries written in Objective-C and Objective-C utilities can be used in Swift, Apple is making it very obvious that Swift is the new default choice for developing iOS apps. Swift is an easier, simpler, and a more compact language compared to Objective-C. Objective-C developers should not have any trouble moving over to Swift.

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INTERACTION OF PULSED ELECTROMAGNETIC WAVES WITH ENVIRONMENTS OVER HYDROCARBON DEPOSITS

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The article presents the results of the interaction of electromagnetic waves in the mode of pulsed signals with the environments over hydrocarbon deposits. The behavior of the components of the dielectric constant of an anisotropic environment over the reservoir in the mode of pulsed signals based on the quasi-hydrodynamic approach is investigated. An analysis of the constituent components of the dielectric constant of the medium over hydrocarbons for electromagnetic waves with right and left circular polarizations, depending on the pulse frequency.

Introduction. Methods for the search for hydrocarbon deposits are based on the analysis of electrophysical and electrochemical processes in anisotropic environment over hydrocarbon deposits [1 - 4]. Similar studies for plasma-like media make it possible to use existing solutions for studying the interaction of electromagnetic waves (EMW) with hydrocarbon deposits when studying plasma based on the quasi-hydrodynamic approach [5 - 8]. The propagation of radio-pulse signals in the environment above the reservoir can be the basis for many methods of hydrocarbon exploration [9 - 10]. The relevance of the tasks considered in this work is to improve the existing electromagnetic methods of geological exploration and to develop new methods for searching, identifying oil and gas (hydrocarbon) deposits, which are a strategic type of mineral resources. The characteristics of the environment above the reservoir during the propagation of electromagnetic waves with right and left circular polarizations are determined, which increases the information content of the methods of contouring and allocation of hydrocarbon deposits. It is shown that the research results can be used to identify the environment above the deposits by the nature and value of the total and difference components of the dielectric constant of the anisotropic layer.

The interaction of the medium over hydrocarbon deposits with pulsed signals. Consider the process of interaction of EMW with hydrocarbon deposits in the pulse mode of the form:

$$S(f) = \frac{U \cdot \tau_u}{2} \cdot \frac{\sin \frac{(\omega - \omega_0) \cdot \tau_u}{2}}{\frac{(\omega - \omega_0) \cdot \tau_u}{2}} + \frac{\sin \frac{(\omega + \omega_0) \cdot \tau_u}{2}}{\frac{(\omega + \omega_0) \cdot \tau_u}{2}}, \quad (1)$$

Where $\frac{U \cdot \tau_и}{2}$ =1 – amplitude ; $\omega = 2 \cdot \pi \cdot f$ – frequency ; ω_o – carrier frequency ; $\tau_и$ – pulse width.

The process of interaction of electromagnetic waves with local switching on the propagation path of radio waves can be represented in the form of an oblique incidence of a plane wave with vertical polarization in a medium with parameters $\varepsilon_0, \mu_0, \delta_0$ on an infinite surface with anisotropic impedance. This EMW is excited using a portable transmitter that moves along the studied profile.

It is of interest to analyze the frequency characteristics of combinational components.

$$\dot{\varepsilon}_R(\omega) = \dot{\varepsilon}_1 + \dot{\varepsilon}_2 = \mathrm{Re}\,\varepsilon_R + j\,\mathrm{Im}\,\varepsilon_R$$
$$\dot{\varepsilon}_L(\omega) = \dot{\varepsilon}_1 - \dot{\varepsilon}_2 = \mathrm{Re}\,\varepsilon_L + j\,\mathrm{Im}\,\varepsilon_L . \quad (2)$$

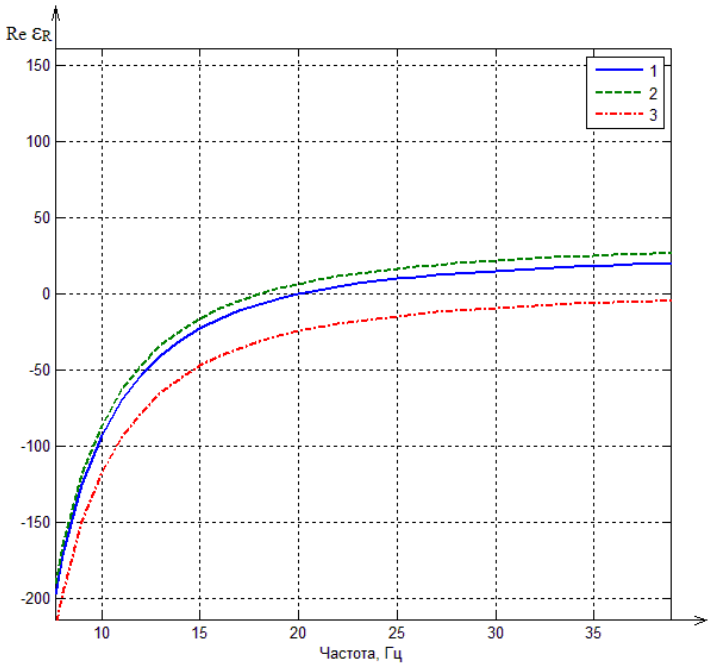
The expressions (2) contain matrix elements:

$$\dot{\hat{\varepsilon}} = \begin{bmatrix} \dot{\varepsilon}_1 & -j\dot{\varepsilon}_2 & 0 \\ j\dot{\varepsilon}_2 & \dot{\varepsilon}_1 & 0 \\ 0 & 0 & \dot{\varepsilon}_3 \end{bmatrix}. \quad (3)$$

Information on the properties of the anisotropic medium is contained in the components of the tensor (3) $\dot{\varepsilon}_1, \dot{\varepsilon}_2, \dot{\varepsilon}_3$, that are studied in various modes of interaction of the environment with EMW. The calculation of the components of the dielectric constant tensors was carried out on the basis of experimentally obtained parameters of the environment over hydrocarbon deposits [3]: electrical conductivity δ_r =10^{-5} s/m; particle

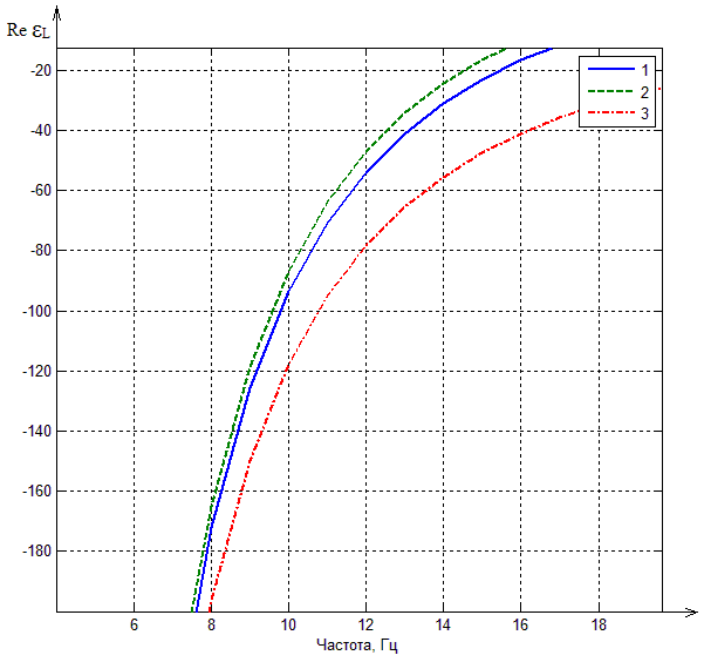
concentration $N_e = N_и = (10^{15} – 10^{17})$ m^{-3}; particle collision frequency $\nu = 2 \cdot \pi \cdot 10^9$ rad / s. The dielectric constant of the environment was studied in the range from 1 to 25. The research technique involves irradiating the profile under investigation with an electromagnetic wave at a fixed frequency, receiving a reflected signal. The electric field strength of the reflected signal is measured at the measurement points of the studied profile, and the boundary of the hydrocarbon deposit is determined from the anomalous values of the electric field strength of the reflected signal.

A frequency analysis of expressions (2) for the combinational components has been carried out (Fig. 1, 2).



P 1 – for εr = 25; 2 – for ε_r = 20; 3 - for ε_r = 2

Figure 1. – Dependencies Re ε_L = ψ (Fi)



1 – for εr = 25; 2 – for ε_r = 20; 3 - for ε_r = 2.

Figure 2. – Dependencies Re ε_L = ψ (Fi)

There was conducted an analysis of the interaction of the anisotropic layer over hydrocarbons with EMW in the mode of radio-pulse signals. The AC dielectric permittivity tensor is derived over hydrocarbon deposits in the mode of radio-pulse signals. The results of the study can be investigated in exploratory geophysics. In this connection, it should be noted:

- AC dielectric permittivity tensor over hydrocarbon deposits in the mode of radio-pulse signals can be used to determine the electrodynamic characteristics of the environment above the reservoir in a wide frequency range of the probed signals when the pulse frequency changes;

- studies can be used to determine the characteristics of the environment over the reservoir during the propagation of EMW with right and left circular polarizations, which increases the information content of the contouring and separation of hydrocarbon deposits.

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UDC 621.37/39(075.8)

MODELING OF CHARACTERISTICS OF FIBER OPTICAL AMPLIFIERS FOR INFOCOMMUNICATION SYSTEMS

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This article discusses fiber optic amplifiers used in fiber optic transmission systems. Methods of modeling their characteristics are demonstrated.

Fiber optic amplifiers (HEU) are most widely used in fiber optic transmission systems. This is due to a number of their undeniable advantages:

- simplicity of design;
- high reliability;
- large gains;
- small noises;
- wide gain band;
- insensitivity to polarization of amplified light, etc.

The functional diagram of the HEU is shown in Figure 1.

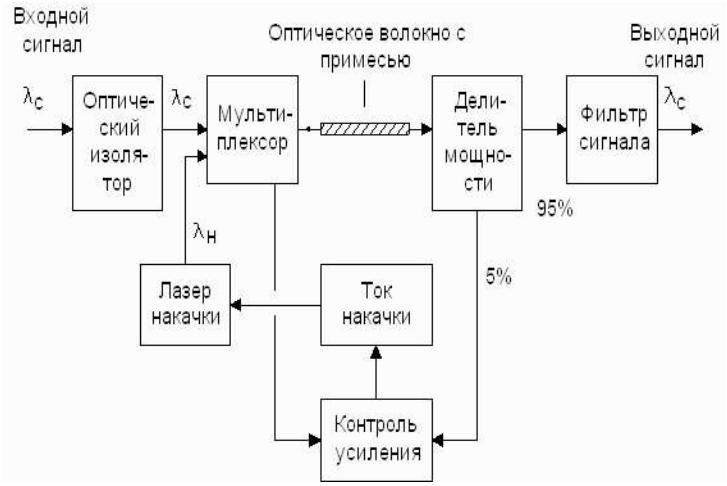

Figure 1. – The functional diagram of the HEU

The most important characteristics of fiber amplifiers are given in table 1.

Table 1. – Characteristics of fiber amplifiers

Transparency windows	0,82-0,85 μm		1,28-1,33 μm		1,53-1,56 μm	
Chemical compound	$Tm^{+3}+SiO_2$		$Pr^{+3}+SiO_2$		$Er^{+3}+SiO_2$	
The purpose of the amplifier	Advance Admission	Transmit power	Advance Admission	Transmit power	Advance Admission	Transmit power
Amplification value, dBm	25	10 - 12	20 - 30	10 - 15	35 - 50	10 - 15
Amplification frequency band, nm	100	100	90	90	40	40
Pump power, mW	40 - 60	40 - 80	60 - 80	100 - 150	60 - 80	100 - 150
Power consumption, W	4	7,5	5	8	2,4	7,5

For clarity, some characteristics are shown in Figures 2, 3, 4. These are the dependences of the gain on the length of the active fiber, the pump power, and the input signal.

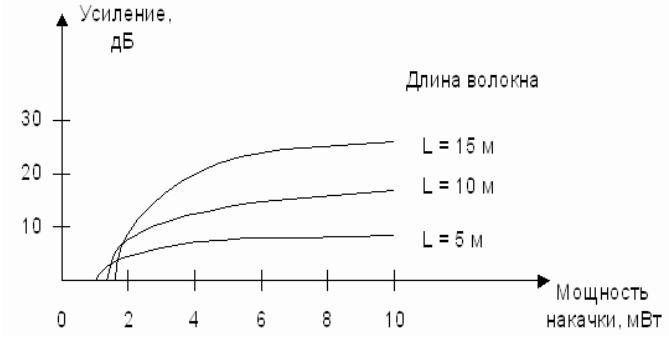

Figure 2. – Amplification of an erbium amplifier depending on fiber length and pump power

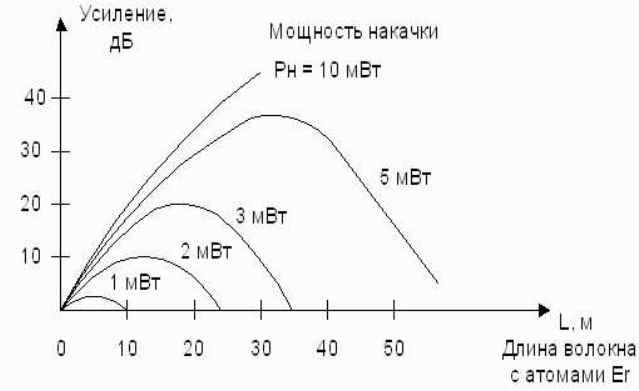

Figure 3. – Amplification of an erbium amplifier depending on fiber length and pump power

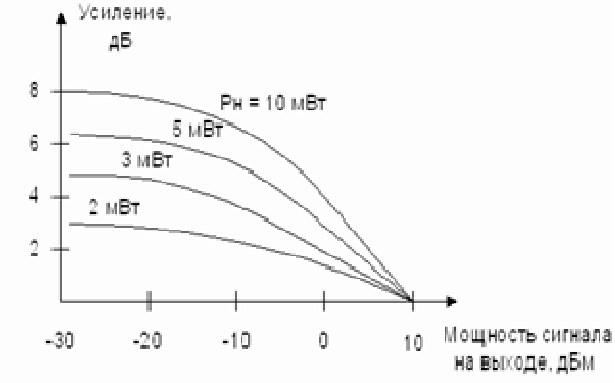

Figure 4. – Amplification of an erbium amplifier depending on the output signal

Fiber optic amplifiers can have a large non-uniformity of the amplitude-frequency characteristic, which is unacceptable for multi-wave transmission systems (systems with WDM). A number of solutions are known for smoothing the frequency response of erbium amplifiers and expanding their gain frequency band, for example, using automatically tunable attenuators for each transmission wave.

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UDC 004.05; 004.921

DIGITAL DISTRIBUTION. INFFLUENCE OF ONLINE SERVICES FOR USERS AND DEVELOPERS. EXTERNAL PAYMENT SYSTEM AND ITS INFLUENCE ON SERVICE SECURITY

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This paper presents digital distribution and its importance for the distribution of software products. Also online services, and their impact on business and the ability of users to manage the purchased goods are considered. Additionally, it also presents an external payment system for an online service and its impact on the overall reliability of online service in general. Various systems will also be considered and the comparison of them will be made.

Distribution of goods occupies an important part of the history since the founding of trade. It allows you to effectively find new customers and sell the right goods, regardless of location. One of the methods of distribution is digital distribution. The importance of digital distribution has played an important role since the development of the Internet: it allows you to quickly and safely distribute software or distribute advertising of it. In fact, everybody uses it nowadays: from simple users to experienced businessmen and distributors. This means that in addition to digital software, it is possible to distribute other products, ranging from ordinary items to very rare things. So now there are many online shops where you can buy absolutely everything. To better understand the problem of product distribution on the Internet, we will research the concept of digital distribution and the way it affects the trade via the Internet.

Digital distribution is a method for distributing digital content without using a tangible medium, usually consisting of downloading via the Internet to a user's terminal device [1]. The advantage of digital distribution is easy, quick search and purchase of copies of the necessary software.

There are several options for distributing software over the Internet.

The main protocols used in digital distribution are HTTP, P2P and FTP. Systems that distribute proprietary software usually contain technical means of copyright protection that prevent the buyer from selling/distributing his copy of the software (programs).

There are several options for purchasing software rights:

1. PayPlay - products will be available only after their purchase.

2. Try before you buy - user downloads the program and gets the opportunity to use it for some time. In case the user wants to continue using the full version of the program, he must pay. After that (as a rule) a special serial number is provided, by entering which the user gets the opportunity to use the program for an unlimited time.

3. Advertising - in this case, the program is absolutely free, but the user is shown advertising in the program, on display of which the software owner earns.

4. Subscription - monthly payment for the right to use the program or programs from a specific set provided by a digital distributor. There are also single subscriptions for one specific program and for a different period (including unlimited) [1].

For the implementation of digital distribution is used online service, where you can get all the necessary goods for the mentioned methods.

The main products of digital distribution are:

Books - electronic books are the most popular and the main difference from a traditional purchase is the storage in an indefinite amount in an electronic book reader or any electronic device supporting the book format.

Music - the main representatives are online buying or streaming. In the first case, the artist's album or several of his songs are purchased for the specified amount, and in the second case, free access to listening to the songs of the specified artist is provided for subscription or under the specified conditions. The main difference from the traditional purchase of physical media is easy access to music files and the ability to store in unlimited quantities on a certain device.

Films - the main representatives are also online purchase or subscription. In the first case, for the specified amount of money unlimited access to a particular film or series is given, and in the second case for a specified period of time an access to viewing through the service where the subscription was made is given.

he main difference from the traditional form is easy access to the video and the ability to store in unlimited quantities on a certain device.

Video Games - the main representatives are also online purchase or subscription. In the first case, for a specified amount of money unlimited access is given to a certain film or series, and in the second case, access to viewing through the service where the subscription was made is given for a certain amount of time. The difference from the traditional form is also easy access to video and the ability to store in unlimited quantities on a certain device.

In addition to online services, a launcher may be included. Launchers are the programs that allow you to install, to launch and play purchased or activated software. These are programs such as iTunes, Spotify, Steam, Netflix, etc. The main advantage is storage of all purchased software under your account, the automated process of downloading application from the server and installing it on user's machine.

The main impact of digital distribution over traditional retailing can be seen in areas such as:

Books – some companies like Bookmasters Distribution have spent $4.5 million on hardware upgrades to work with more users. In addition, the vice president of Perseus Books Group noted a 68 percent increase with the transition to e-books and the Independent Publishers Group announced sales growth of 23 percent in the first quarter of 2012 [2].

Music - the growth of digital distribution has led to a 2-fold drop in CD sales over the course of the 2000s. The development of systems such as iTunes and later Spotify contributed to the independent distribution of music. In addition, since the beginning of digital sales, the increase from 160 million in 2004 to 795 million in 2006 was noted, with remittances ranging from $397 million to US$2 billion [2].

Films - due to digital distribution, there has been a sharp transition of films and series to platforms such as YouTube, Netflix, Amazon Prime, etc. In addition, due to the services, one can note the growing popularity of views on Smart-TV, computers, smartphones, game consoles and tablets [2].

Video games - the main development of digital distribution began in 2004 with the release of the Steam platform, which, instead of selling games gives rights to store game by accepting an agreement (result of rules violation store has a full right to withdraw product or user profile). Since the late 2000s, digital distribution of games has been reached an increasingly broad audience, with major game publishers and retailers have focusing more on digital sales - including Steam, PlayStation Store, Amazon.com, GAME, GameStop and the others. And as a result, the sale of physical media fell from $5.03 billion in 2007 to $2.15 billion. According to a Superdata Research, revenue from games sold in this way worldwide reached around $6.2 billion per month during February 2016. In early 2019, services such as Epic Games, Rockstar Games Launcher, battle.net and Bethesda Game Launcher were developed, which led to competition, as it's profitable for companies to use their own service. For example, Ubisoft with the release of Tom Clancy's Division 2 under the Uplay service received 4.5 times more income than other services, which led to the decision to release their products only under their own service.

Thus, one can point out a noticeable increase in digital distribution and its replacement by the traditional sale of physical media.

In addiction any digital distribution should have a good and reliable payment system.

A payment system is an essential part of any online service where payments are necessary, because without it there cannot be any possibility of trading. The payment itself can occur both in the internal system and through external systems, where the system we specified will execute the transaction. But first, we have to understand the concept of e-commerce, internal and external payment systems and their features.

E-commerce is a sphere of the economy that includes all financial and trading transactions carried out using computer networks, and business processes associated with such transactions. To e-commerce include:

1. Electronic information interchange (Electronic Data Interchange, EDI),
2. Electronic Funds Transfer (EFT),
3. Electronic commerce (e-trade),
4. Electronic money (e-cash),
5. Electronic marketing (e-marketing),
6. Electronic banking (e-banking),
7. Electronic insurance services (e-insurance) [1].

Electronic payment system - a system of payments between financial institutions, business organizations and Internet users when buying and selling goods and for various services via the Internet. Such systems are electronic versions of traditional payment systems and are divided into:

1. Debit (working with electronic checks and digital cash);
2. Credit (working with credit cards) [2].

Figure 1 will show the purchase scheme of payment system.

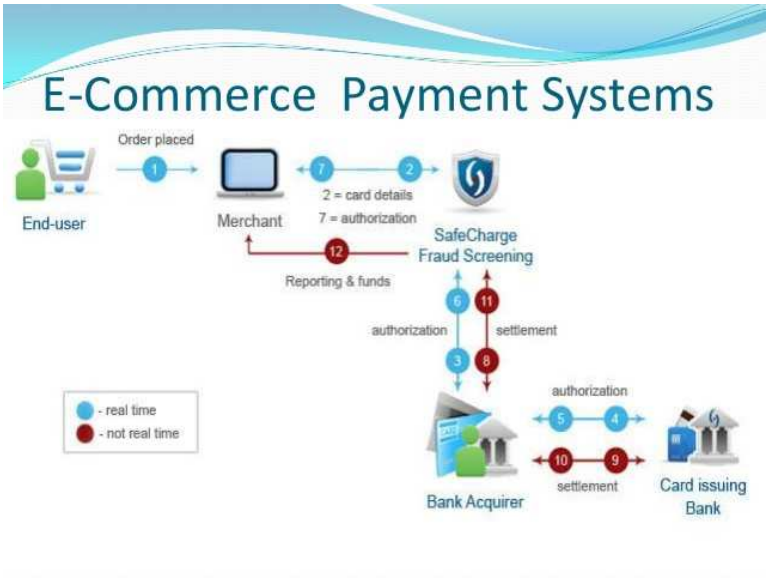

Figure 1. – The process of payment through the payment system

The payment system in services can be divided into two types:

Internal (or integrated) is a payment system which is built into an online service and conducts a transaction to a bank through a bank card. The only thing the buyer needs is his own payment card information. The pros are full control of the transaction and the absence of the user having additional data on other services, and the cons are increased load due to the personal conduct of the necessary transactions and the vulnerability of leakage of important data in case hacking.

External (or third-party) is a system that receives data from an online service and then independently conducts the necessary transaction. For payment, data from service and/or customer data is used. The pros are reduced service load and protection against hacking due to transfer of responsibility to a third-party service, and cons are possible additional payment for use, requirement of additional data from the buyer and possibility of a third-party system refusing to work in case of a load.

The main payment systems are:

PayPal is a payment system founded in 1998 and gained popularity in 2002 with the purchase of an online auction site Ebay. It is the most popular (450 million people) in the world and has a guaranteed transaction for both the user and the buyer. There is also a sandbox version for developers that, when integrated into an online service, can safely check the operation of a payment and transaction.

Amazon Payments is a payment system developed by Amazon and is the most popular mobile payment service. It also has a library for integration into its own service for sale.

WebMoney is a system founded in 1997 and is the most popular system in the post-Soviet space. And one of the most reliable because of the multi-level identification. It differs from the others by the presence of opening an unlimited number of wallets in different currencies (WMZ - dollar, WMR - rubles, WME - euro, etc.) for convenience of use combining into special storages (keeper), where a unique WMID holder number is assigned.

QIWI is a payment system founded in 2007 and being the most popular system in Russia due to the availability of terminals for creating an account and replenishing funds.

Figure 2 will show the rest of the systems that were not indicated above.

As a result of the study, the main directions of digital distribution were investigated, and as a result of the development of recent trends, the development of online services for the distribution of video games was deduced. Since users, after obligatory registration on the service and purchase/activation, are given the right to keep the product under their account, which gives the necessary control and allows developers to distribute and release their project without a deal with the publisher, which leads to additional sales. You can also add a solution to the problem of archaic storage of purchased applications by creating a system which allows you to purchase, download and install everything you need. Additionally, a comparison was made among several types of payment systems, their features, pros and cons in comparison to each other. And third-party payment systems were listed and their features indicated.

Figure 2. – Basic payment systems

Based on the analysis, it's planned to develop a project whose main task is to provide conditions for the distribution of non-gaming software with the ability to launch purchased applications using a special launcher. In addition, it was decided to use the external PayPal payment system for the implementation of the project because of satisfaction with security indicators, ease of payment through the service and libraries available for different programming languages.

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MODERN TOOLS FOR SCALABLE WEB DEVELOPMENT

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In this work we analyze modern approaches to web development and explore a set of tools, including the vue.js JavaScript framework and the cloud based virtual Firebase server for the subsequent creation of an adaptive dynamic website of the cinema with the possibility of three-dimensional display of halls with the screen, a convenient interactive process of choosing places for reservations and a custom admin panel.

In this work, we analyze modern approaches to web development and study a promising set of tools, including vue.js [1] JavaScript framework for component application development, a library of graphic components quasar [2], a scalable real-time database Firestore, an effective authentication system, cloud data storage and hosting from Firebase (google) [3], as well as the most relevant CSS specifications, such as flex [4] and grid [5] layout for efficient construction of responsive layout of web pages, and tools for compact presentation of the html code – (template engine pug [6]) and of the CSS styles (CSS-preprocessor stylus [7]).

Using this stack of web-technologies, we develop a modern adaptive dynamic web-site of a cinema network with the possibility of three-dimensional display of halls and a convenient interactive process of choosing places for booking. The created unique administration system allows authorized administrators directly on the site to manage data of the web application and receive various statistical information on the activity of the users.

To ensure the best perception of the site by users, will be implemented an interactive 3d-model of the cinema hall, which is used (on wide browser screens) when booking a place to demonstrate the advantages and disadvantages of specific places when watching a movie. On the site, users have the opportunity to view a movie poster and detailed information for each of the films After registration or authorization by e-mail, the user will have the opportunity to choose the date and time of the session and book a ticket for the movie he liked. Upon successful booking of a ticket, the user will see an electronic ticket with a unique reservation code. Using this code, the user will be able to pay for the ticket he booked at the box office immediately before watching the movie.

Information about movies and cinema sessions will be stored in the Firebase real-time Firestore database. To provide the ability to quickly manipulate this data, will be created a separate administrator page directly on the website. Only authorized users with administrator rights will have access this page, and it will be possible to delete / add / edit a movie on it, including uploading a poster (image) and trailer (video file) to the Firebase cloud storage. There is also ability for administrator to edit sessions, view occupied seats (with details) on a two-dimensional plan of the cinema, manually add occupied seats (when offline buying tickets), as well as edit other session parameters (ticket price, etc.).

Important components of the frontend of modern web sites are: organic design, adaptive layout and interactivity. Note that website design should be carried out within the framework of a single own or existing design system, and to date, the most popular is material design from google [8]. Adaptive layout of the site involves the use of transformations to display page content depending on the device (desktop computer, tablet, smartphone, etc.) used for web surfing. For example, on the smartphone's screens, the site's navigation menu can change from the line display mode to the form of a drop-down menu when a button is pressed. And finally, the interactivity of the site implies the presence of graphical interface components that respond to user actions (drop-down menus, tooltips, etc.).

Development of the user interfaces (frontend parts) of such sites using only the standard (and only possible) html, CSS and JavaScript web languages is an extremely difficult task, which is why today we have acquired:

1. html template engines, which allows creating reusable compact html-code; one of the most popular is pug [6];
2. CSS-preprocessors, which allows to create compact CSS styles; one of the most popular is stylus [7];
3. JavaScript frameworks, which allow scalable component development of dynamic web applications; one of the most popular is vue.js [1] and its associated library of graphical components named quasar [2].

In recent years, serverless systems have become more relevant for the backend part of applications, allowing one to use already configured virtual servers, the functionality of which can be close to the capabilities

obtained when using own server. One of the most common serverless systems is Firebase from google [3], which allows to significantly reduce labor costs when developing applications due to the lack of the need to independently configure the server and deploy the application to the server.

The task of deploying a modern application on the own server becomes extremely difficult due to the need to develop a security system, optimize the load, back up data, etc. In this regard, the use of cloud technologies and serverless application architectures is becoming more and more popular. In this case the custom server is replaced with a virtual one provided by the provider of the corresponding service. At the same time, part (and sometimes significant) of the important opportunities that exist when using the own server is certainly lost, in particular, the processing of critical and private data that cannot be fully processed on the client side for security reasons. So, for example, validation of data before saving to the database can certainly be done on the client side, and it is really carried out for quick reaction of the application to incorrectly entered data, which significantly reduces the load on the server, however, on the client side the data can always be falsified, which makes it necessary mandatory revalidation of data on the server side. A convenient compromise is achieved by the Firebase system, which offers a complete serverless system with a wide range of features for developers, including:

1. Hosting - full hosting for web-applications. Created or updated web-application can be uploaded to Firebase using one console command, it is also possible to connect the own domain name for free;
2. Storage - cloud storage that allows users to display relevant files in a web application, as well as dynamically save user files;
3. Cloud Firestore - scalable real-time nosql database;
4. Cloud Functions - a system that makes it possible to load in Firebase specific own JavaScript functions that are performed during specified operations (reading from the database, registering a new user, etc.). This feature is significant because it allows to partially remove the main limitation of serverless approaches - the inability to execute essentially server-side code (for example, analysis of the correctness of CAPTCHA recognition, etc.);
5. Authentication - a system for registering and authenticating users in a web application by email and password, phone number, social network account, etc.

Today, due to the rapid development and growing popularity of the Internet, for almost any company, organization, or a thematically related group of people, it is important to place relevant information on the Internet that is accessible to citizens interested in it. Information on the Internet is placed in the form of static web sites or dynamic web applications, and in many cases duplication of the site / application functionality in the form of a mobile or desktop application is also important. The set of web technologies considered in this work makes it possible to develop attractive applications with minimal time.

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UDC 003.042

ATTACKS ON THE STEGANOGRAPHIC SYSTEM OF DIGITAL WATERMARKS AND PROTECTION AGAINST THEM

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In this paper, we examine a list of possible attacks on a stegosystem of digital watermarks, and ways to counter these attacks.

Classification of attacks on the DW. DW must satisfy the conflicting requirements of visual (audio) stealth and robustness to the basic signal processing operations. In the future, without loss of generality, we will assume that the image is used as a container.

We turn to the message embedding system by modifying the least significant bit (LSB) of the pixels. Almost any method of image processing can lead to the destruction of a significant part of the embedded message. For example, consider the operation of calculating a moving average over two adjacent pixels $\frac{(a+b)}{2}$, which is the simplest example of low-pass filtering. Let the values of the pixels a and b be even or odd with a probability $p=\frac{1}{2}$. Then the value of the least significant bit will change after averaging in half the cases. A change in the quantization scale, say, from 8 to 7 bits, can also lead to the same effect. A similar effect is exerted by lossy image compression. Moreover, the use of noise purification methods using noise estimation and subtraction will distort the vast majority of bits of a hidden message. [1] There are also much more harmful image processing operations for the DW, for example, scaling, rotation, truncation, pixel permutation . The situation is aggravated by the fact that the conversion of stego messages can be carried out not only by the violator, but also by the legitimate user, or be a consequence of errors during transmission over the communication channel.

A shift of several pixels may result in non-detection of the DW in the detector. Analog video recorders, as a rule, somewhat shift the image due to the uneven rotation of the tape drive engine or the wear of the tape. The shift can be invisible to the eye, but lead to the destruction of the DW.

Now consider the attacks specific to DW systems. The following categories of attacks against such stegosystems can be distinguished [3].

1. Attacks against the built-in message - aimed at removing or damaging the DW by manipulating the stego. Attack methods that fall into this category do not try to evaluate and highlight a watermark. Examples of such attacks include linear filtering, image compression, adding noise, aligning the histogram, changing the contrast, etc.

2. Attacks against the stode detector - aimed at hindering or making impossible the correct operation of the detector. In this case, the watermark in the image remains, but the possibility of its reception is lost. This category includes attacks such as affine transformations (i.e. scaling, shifts, rotations), image truncation, pixel permutation, etc.

3. Attacks against the protocol for the use of DW - mainly associated with the creation of false DW, false stego, inversion of DW, the addition of several DW.

4. Attacks against the DW itself - aimed at evaluating and extracting the DW from the stego message, if possible without distorting the container. This group includes such attacks as collusion attacks, statistical averaging, methods for cleaning signals from noise, some types of nonlinear filtering [4] and others.

It should be noted that the classification of attacks under consideration is not the only possible and complete one. In addition, some attacks (such as noise removal) can be categorized into several categories.

In accordance with this classification, all attacks on DW systems can be divided into four groups:

1) attacks aimed at removing the DW;

2) geometric attacks aimed at distorting the container;

3) cryptographic attacks;

4) attacks against the protocol used to embed and verify the DW.

Methods of counteracting attacks on DW systems. In the simplest DW stegosystems, a pseudo-random sequence is used when embedding, which is a realization of white Gaussian noise and does not take into account the properties of the container. Such systems are practically unstable to most of the attacks discussed above. To increase the robustness of stegosystems, a number of improvements can be proposed [2].

In a robust stegosystem, the correct choice of pseudo-random sequence parameters is necessary. It is known that in this case, systems with spreading the spectrum can be very robust with respect to attacks such as adding noise, compression, etc. It is believed that the DW should be detected with a sufficiently strong low-pass filtering (7x7 filter with a rectangular characteristic). Therefore, the signal base must be large, which reduces the bandwidth of the stego channel. In addition, the memory bandwidth used as a key must be cryptographically secure.

The reason for the instability of the DW systems with the expansion of the spectrum to such attacks is due to the fact that the sequence used for embedding usually has a zero mean. After averaging over a sufficiently large number of implementations, the DW is deleted. A special method of constructing a watermark is known that is directed against such an attack. In this case, the codes are developed in such a way that with any averaging there always remains a non-zero part of the sequence (static component). Moreover, it is possible to restore the rest of the sequence (dynamic component). The disadvantage of the proposed codes is that their length increases exponentially with the increase in the number of distributed protected copies. A possible way out of this situation is the use of hierarchical coding, that is, the assignment of codes for a group of users. Some of the analogies here are with Code Division Multiple Cellular (CDMA) cellular systems.

Various countermeasures have been proposed to solve the problem of property rights. The first way is to build an irreversible DW algorithm. The DW must be adaptive to the signal and be embedded using a unidirectional function, for example, a hash function. The hash function converts 1000 bits of the original image V into the bit sequence b_i, $i = 1 \dots 1000$. Further, depending on the value of b_i two embedding functions of the DW are used. If $b_i = 0$, then the function $v_i(1 + aw_i)$ is used, if $b_i = 1$, then the function $v_i(1 + aw_i)$, where v_i - is the i-th image coefficient,, w_i - is the i-th bit of the embedded message. It is assumed that such an algorithm for the formation of the DW will prevent falsification.

The second way to solve the problem of property rights is to embed in the DW a certain time stamp provided by a third, trusted party. In the event of a conflict, a person with an earlier time stamp on the image is considered the real owner.

One of the principles of building a robust DW is to adapt its spectrum. A number of studies have shown that the envelope of the spectrum of an ideal DW should repeat the envelope of the spectrum of the container. The spectral power density of the DW, of course, is much less. With such a spectral envelope, the Wiener filter gives the worst estimate of the DW possible: the variance of the error values reaches the variance of the filled container values. In practice, adaptation of the DW spectrum is possible by local assessment of the container spectrum. On the other hand, the methods of embedding DW in the field of transformation achieve this goal through adaptation in the field of transformations. [4]

To protect against attacks such as affine transformation, you can use an additional (reference) DW. This DW does not contain information, but is used to "register" the transformations performed by the violator. There is a predistortion circuit in the DW detector that performs the inverse transform. There is an analogy with the test sequences used in communication. However, in this case, the attack can be directed precisely against the supporting DW. Another alternative is to embed the DW in visually significant areas of the image that cannot be removed from it without significant degradation. Finally, we can place the stego in the conversion-invariant coefficients. For example, the amplitude of the Fourier transform is invariant to image shift (in this case, only the phase changes).

Another method of protection against such attacks is a block detector. The modified image is divided into blocks of 12x12 or 16x16 pixels, and all possible distortions are analyzed for each block. That is, the pixels in the block undergo rotations, permutations, etc. For each change, the correlation coefficient of the DW is determined. The transformation, after which the correlation coefficient turned out to be the largest, is considered to be actually performed by the violator. Thus, it becomes possible to reverse the distortions introduced by the intruder. The possibility of this approach is based on the assumption that the intruder will not significantly distort the container (this is not in his interests).

Conclusion. Summing up, we can say with confidence that you can protect yourself from every attack by knowing all the details of this attack, and you should always close the vulnerabilities of your system and conduct attacks against it by testing for resistance to them. Carrying out attacks on our own CEH, we analyze its vulnerability to this attack, which in the end we can close. It is impossible to fully ensure the security of our CEH, because while we close one vulnerability, the attacker is looking for a new one, and this race between the attacker and the computer security specialist will be eternal. The surest way to defend this is an "attack", if we ourselves can identify vulnerabilities, then we can successfully close them, this remains the main aspect of the work of KB experts - the study and practice of attacks, and the development of defense systems.

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REVIEW OF METHODS FOR SMARTPHONE APPLICATION FOOT SIZE ESTIMATION FROM IMAGES

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The task of obtaining real-world coordinates of an object is quite challenging. In this paper proposed brief explanation of algorithms dedicated to overcome this challenge. They were analyzed including their advantages and disadvantages in application to possible implementation in smartphone app.

Introduction. The Internet technologies grow rapidly. With that traditional approach from selling goods directly to the customer in offline switched to the online space. Nowadays more and more shops use Internet to perform commercial transactions. Online stores have a variety of products and it helps to the customers to purchase a product with the better price. Also there is no need to go out and all shopping can be performed right inside the house. The online retailers trying to make system even more comfortable and all payment procedure can take about 2 minutes.

But online shopping has some disadvantages too. For instance, a customer has to buy a product without seeing actually how it looks like. Customers may click and buy some product that is not really required by them. The electronic images of a product are sometimes misleading. The color, appearance in real may not match with the electronic images. If the size does not fit the customer want to return goods back. A big percentage of refund leads to business owner money loss.

The buyers also can choose wrong size that does not fit to their body parameters and get bad experience items purchasing in online stores. To avoid this experience some online shops propose free fitting when the currier deliver all purchased good and then taking back things that does not fit to the customer by the appearance or size. But it consumes a lot of time and money as well.

This problem became very crucial for the shoe shopping. Correct foot measurements requires a trained skills and special instruments like calipers for linear measurements that used for heights, lengths and widths calculation as well as measuring tape for girths. The accuracy of final results depends of skills level.

To make process of foot size estimation more comfortable for the customer a lot of companies propose image processing algorithms to acquire and measure surface of the foot. In this paper we will review approaches that can be used in application to this task.

Algorithms review. Nowadays, state-of the art approaches can be separated on the few categories. Some of approaches use additional sensor to achieve more information about object. For example, approach presented in [1] use RGB-D cameras. A RGB-D image is simply a combination of a RGB image and its corresponding depth image. A depth image is an image channel in which each pixel relates to a distance between the image plane and the corresponding object in the RGB image. The image of the foot pictured on the A4 sheet with the set of AR codes. The depth map obtained from an image converted to cloud points. After performed noise removal algorithm and performed a 2-Dprincipal component analysis (PCA) to find the long-axis and the short-axis of the 2-D foot print. Measurement error for proposed algorithm varies from the left and right foot. Also it depends on measurement type. In this paper were evaluated measurements of foot length, width and girth. For the left foot the minimal deviation in length measurements was 2.1 mm, in width it was 1.45 and for girth this value was 2.76. For the right foot the minimal deviation was 1,18 for foot length, 1.32 for width and 2,16 for girth. Proposed approach has a big inaccuracy that can be crucial for shoe size measurements. Also it uses hardware that cannot be used in average smartphone application.

The next algorithm presented in [2] also use RGB-D camera to measure an accurate distance to an object and from with that information obtain real world measurements. The RGB image from the camera goes to Convolutional Neural Network (CNN) from [3] for object detection. As output it produce bounding box that isolate object of interest from the background to perform more accurate measurements. Than was performed recalculation from image coordinates to real world measurements using e LIDAR/IR sensor. For hardware this algorithm use smartphone Lenovo TangoPhab 2 phone that collects point cloud of depth data. The main problem that phone can obtain RGB information at 30 fps(frames per second) and depth information at 5 fps. Also, there is a spatial shift between camera coordinates and depth sensor. Moreover, during experiments was found that IR sensor has missing spots in black or metallic surface. Proposed approach has deviation from 3 to 10 cm. These values are too big to take this approach into account for foot measurements.

In [4] presented another algorithm that uses depth information with image data to obtain real world measurements of on-tree mango fruits. For fruit detection was used cascade classifier with HOG features. Than was perdormid sematic segmentation of fruit area with Otsu[5] method in CIE Lab color space. After was performed filtration of mango peduncle with following dilatation. Than object geometrically filtered to check that the object has elliptical shape. The following operation is real world size calculation using the data from depth sensor. As mentioned earlier approach that use additional sensors to acquire depth information cannot be used by average smartphone owner.

Some of them use a template to compare image distance with real world measurements. In [6] authors presented algorithm that use A4 sheet of white paper as a pattern. The foot in a black sock is standing near or on the white pattern. The algorithm requires 3 photos with the different views of the foot. For each photo performed Canny edge detection to find edges of the pattern and foot. They are distinguished by the algorithm using geometrical information about form and size of template. The extracted template contour is refined with the Snakes algorithm from [7]. Than the foot size is recalculated using real world coordinates of the template. In paper mentioned that the accuracy is strongly associated with the shooting angle. If the angle is 10˚ than measurement error is equal to 1,5 mm. But if the angle if 15 degrees the error becomes 3,4 mm. Also, proposed approach do not use specific algorithm to extract points of a foot and there can be errors due to complicated background.

In [8] proposed an algorithm to estimate the size of rain drops. Authors take the videos of rain drops as input. All videosequence separates on frames that processed and each frame is threated as individual image. Each image goes to filtering and morphological operations to extract raindrop shape from background. For real world measurements performed static pixel to millimeter ratio. Proposed algorithm unsuitable in application to foot measuring via smartphone app due to static ration for coordinates recalculation and weak algorithms for object detection.

In [9] performed comparison of an app that use template and the booth with mirrors. An app uses 3 images of the foot on A4 white sheet. The paper used for camera calibration and real world size calculation. The 3 images should contain the foot pictured on the top and from both sides' also known as zenithal, lateral and median views. Than authors use 5 points landmark extraction to accurate measurements of foot length, toes girth, toes width, ball girth, ball width, instep girth and instep height. The booth for foot measurement contains mirrors that also present foot in 3 points of view. To distance between camera and booth bottom is a constant value and real world values are simply recalculated by it. The error for every measurement amounted from 0.5 mm to 2.2 mm for the app and from to 0,6 mm for 1.8 mm the booth.

Some researches focused their attention on stereo photogrammetry. In [10] is presented approach to obtain real world measurements of objects of interest for object tracking. The input image pictured by set of cameras. They are mounted on a stable bar with the stable distance of 413 mm. The object detected by fast and adaptive median background subtraction algorithm from [11]. Real world coordinates recalculated using camera rig distance. Authors performs static camera calibration using «chessboard» pattern. The error of measurements lays above the 10%. Proposed algorithm does not use any additional operations to reduce noise from an image which is leads to false positive result of the detector. Also, static calibration with the pattern requires skills and knowledge which makes it harder to potential implementation in smartphone app.

Another one algorithm presented in [12] uses the system of two cameras that mounted on the static distance. In paper proposed enhanced algorithm for tomatoes detection. That use active contour model from [7] with shape constant. As shape constant is used ellipse. On the detection algorithm output there are four proposals of tomato location and authors manually choose the best of them. For stereo image formation was used set of features. These features obtained by SIFT [13] descriptors. The best match between them is calculated using Euclidean distance measurement. The camera parameters are determined once, at the beginning of the season, by observing a calibration pattern at different positions and orientations in the scene. This method was first tested under ideal acquisition conditions and using manual segmentation. In this case, the percentage error between the actual radius and the estimated size was always less than 10 % with most (91 %) of the error less than 5 %, which demonstrate the robustness of radius estimation. The complete system was also applied to estimate the size of tomatoes cultivated in open fields for the agriculture season 2013. The percentage error was less than 10 % in most of the cases, despite the poor quality of images during this season (small size, pixelated images).Proposed approach also require static camera calibration and cannot be applied by average smartphone user.

In [14] reported that object of interest size also obtained using two cameras which are not movably fixed. The input images converted to gray colorspace. After, medial filtering for noise reduction was performed. Than

performed simple background subtraction algorithm that assume that firs frame is background. That binarized image goes to morphological processing. This is followed by object detection using connected components algorithm from [15]. The real world measurements were calculated using the distance between two cameras. Proposed algorithms works very fast and achieved error deviation at ± 3 cm. This is very high value and proposed approach cannot be applied to our task. Also in paper presented images that does not contain complicated background and these algorithm unsuitable for real world scenarios.

Similar to previous work the authors [16] propose an algorithm of object detection and size estimation in underwater areas. Two camera located on the static distance between each other and both of the previously calibrated with pattern. Then performed object detection using background subtraction algorithm. For each object is calculated the centre of mass and these values used for the following calculation of real-world coordinates. The main disadvantages of proposed approaches are the same as previous: calibration is difficult to perform by the average app consumer and not accurate algorithm for object detection that almost unsuitable for real world scene.

Some approaches uses surprising algorithms and non-standard sensor types to measure the object. For example in [17] reported on their attempts to use a standard flatbed scanner - the type that would normally be found in the office environment for digitizing documents - to scan the foot sole and translate the output to a 3D form. The distance of the sole away from the scanner glass was estimated using the albedo of the sole surface and the pixel intensity of the resulting image, inspired by techniques used in the analysis of satellite images. The authors claim they are able to achieve an average error of <1 mm, in line with those achieved by more expensive scanning systems, however the system was tested using a foot model with a uniform color and it was noted that scanning a real foot, especially those with damage or injury could present problems for the reconstruction process. And proposed approach cannot use smartphone software as well.

Finally, at this moment a lot of attention focused on Neural Network (NN) approaches dedicated to this problem. There we will review not only algorithms dedicated to real-world object size estimation but and dense map calculation algorithms. As we mentioned earlier some approaches use RGB-D information to obtain object size. There we look at the state-of-the art algorithms that can help us get depth information without sensors.

In [18] presented algorithm that use stereo images. First of all images goes to stereo matching part. In this paper used algorithm mentioned in [19]. It uses SVM classification with Laplacian of Gaussian (LOG) transform and Euclidean distance correlation function. The Laplacian measures directed edge intensities over some area smoothed by the Gaussian. The depth map is obtained after this step. Then the depth map goes to three layer feed forward network that produce bounding boxes from it. This algorithm was tested on low resolution images. In contrast, smartphone cameras have much higher resolution that example of images that was proposed in paper. Consequently, there has to be much more inputs and hidden layers in NN architecture.

In [20] was used stereo matching algorithm too. There is stereo matching is performed using CNN. The architecture contains 8 layers. For the first 3 of them images processed independently. Than performed features concatenation. The final layer, projects the output to two real numbers that are fed through a softmax function, producing a distribution over the two classes (good match and bad match. The final stereo matching is performed by coss-based cost aggregation from [21]. Than is performed matching cost refinement by enforcing smoothness constraints on the disparity image. Proposed algorithm is more accurate than late approaches but it is too heavy for smartphone application.

In [23] was performed depth estimation using CNN architecture U-Net[24]. As input used original inage, lense parameters and binned depth map calculated like in [25]. As output they get simulation of sensor image and depth map. Proposed approach has the lowest values of distortion error. Unfortunately, it still heavy weighted approach for smartphone owners.

Conclussion. There is a lot approaches dedicated to digital foot measurements. Some of them has measurement accuracy even higher that mutual methods. At the same time automated approaches much faster and cheaper than hand crafted. Also the data obtain from this algorithm can be used for health insurance, shoes recommendations, deceases diagnostics and so on.

Proposed review showed that for digital measurements widely used different techniques that trying to maximize cost and accuracy , reduce processing time and learning period for average user. Bringing researchers in the field, scanning equipment manufacturers, orthotic, footwear companies, users and other stakeholders together to further explore these issues may result in cross disciplinary activity needed to resolve current needs and issues.

Currently almost every state-of-the art smartphone has more than one frontal camera that means that approaches that use stereo photogrammetry can be applied for our task. Also, algorithms that use foot landmarks to extract more contextual information from an image seem very promising too.

The CNN approaches mentioned there are heavy and cannot be implemented in smartphone app, but there is a chance to improve CNN architecture to make it more suitable for mobile devices.

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A MODIFIED METHOD OF ENCRYPTING TEST DATA WITH ELLIPTIC CURVES USING A UNIQUE ALPHABETIC KEY STRING

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In the paper presents the mathematics of elliptic curves. As well as the derivation of addition formulas and doubling elliptic points. A description of the encryption and decryption algorithm is presented. The work of the developed program based on the mathematics of elliptic curves in the console is shown.

Introduction. Elliptic cryptography is a section of cryptography that studies asymmetric cryptosystems based on elliptic curves over finite fields. The main advantage of elliptic cryptography is that today, the existence of subexponential algorithms for solving the discrete logarithm problem is unknown. The role of the main cryptographic operation is performed by the operation of scalar multiplication of a point on an elliptic curve by a given integer, determined through the addition and doubling of the points of the elliptic curve. The latter, in turn, are performed on the basis of the addition, multiplication and inversion operations in the final field, over which the curve is considered. Of particular interest in the cryptography of elliptic curves is due to the advantages that its use in wireless communications provides - high speed and short key length.

The mathematics of elliptic curves. Cryptographic methods use elliptic curves over a field of integers with a field characteristic r = 2 or more r ≥ 3. In the future, we will consider the field of integers with the characteristic r ≥ 3.

Cryptographic curves with characteristic r > 3 have the canonical form:

$$y^2 = x^3 + ax + b \quad (1)$$

Where a, b are integer coefficients of the curve, p is a simple sufficiently large number. As can be seen from formula (1), if the point with coordinates (x, y) satisfies equation (1), then point c (x, -y) also satisfies equation (1). An elliptic curve is understood to mean a geometric set of points (1) supplemented by an infinitely remote point.

The following number is called the discriminant of the curve: Δ = $-16(4a^3 + 27b^2)$, the discriminant must not be zero (in this case, there are no self-intersection points and return points). If the discriminant is positive Δ > 0, then the graph has 2 parts, if Δ < 0, then one part.

On the set of points of an elliptic curve, a group is determined by the addition of points of the elliptic curve (the section of mathematics is called algebraic geometry). The sum of two points of the elliptic curve P, Q is the third point R lying on the line PQ and the elliptic curve at the same time, and is denoted as R = P + Q, i.e. -R + P + Q = 0. The operation of group addition is called 3 points of an elliptic curve that satisfy the equation:

$$R' + P + Q = 0. \quad (2)$$

This shows that R '=–R (R', R are elements mutually inverse in the group operation). On the other hand, a straight line parallel to the coordinate axis y intersects exactly 2 points of elliptic curves (mirror symmetric about the x axis) and an infinitely distant point (in opposite directions), therefore, the mutually inverse points of the elliptic curves R ', R - have coordinates (x, y) and (x, -y), respectively. A group addition group defines a geometrically infinitely distant point and denotes 0. So, for a group addition operation, it is necessary to draw a secant through the points P, Q and mirror the point R, R '=–R.

Special cases are possible:

1) P = Q - the secant line degenerates into the tangent R '+ 2P = 0

2) P + Q + 0 = 0 <=> P =–Q points P, Q (mirror symmetric) have the same abscissas. The next point in addition is the point Q + 0 = Q (the forming element of the abelian group).

3) P + P + 0 = 0 <=> P = 0 - the secant line is simultaneously a vertical line and a tangent. Cryptography uses finite cyclic abelian groups with a generating element G. Moreover, any point of the elliptic curve of the cyclic group 1 ≤ k ≤ n0 is obtained by the formula: $P_k = (GG \ldots G)$. The order of the group of points of an elliptic curve is the number n0 such that P_{n0} = 0 is the zero element of the group. Knowing the generating element of the group G, we can compile a table of all points of the elliptic curve, when adding points with order k> n0,

all points are periodically repeated: $P_k = P_{k-n0*s}$, where $1 \le k - n0 * s \le n0 - 1$, $s \in N$. Depending on the general situation of particular cases 1), 2), 3) the coordinates of the points of the elliptic curve are calculated by the formulas (indices 1 and 2 correspond to points P, Q, respectively):

$$\begin{cases} x = (\frac{y_2 - y_1}{x_2 - x_1})^2 - x_1 - x_2 = k^2 - x_1 - x_2 \\ y = -y_1 + (\frac{y_2 - y_1}{x_2 - x_1})(x_1 - x) = -y_1 + k(2x_1 - x_2 - k^2) \end{cases} \quad (3)$$

$$\begin{cases} x = (\frac{3x_1^2 + a}{2y_1})^2 - 2x_1 = k^2 - 2x_1 \\ y = -y_1 + (\frac{3x_1^2 + a}{2y_1})(x_1 - x) = -y_1 + k(3x_1 - k^2) \end{cases} \quad (4)$$

The derivation of formulas (3) and (4):

The angular coefficient of a straight line passing through 2 points is: $k = \frac{y_2 - y_1}{x_2 - x_1} = \frac{y - y_1}{x - x_1}$, where the point of the line (x, y) is moving along the line. We get for points 1(x_1, y_1), 2(x_2, y_2), (x, y):

$$y^2 = x^2 + ax + b,$$
$$y_1^2 = x_1^2 + ax + b,$$
$$y_1^2 = x_2^2 + ax_2 + b.$$

Subtract $(y_2 - y_1)(y_2 + y_1) = (x_2 - x_1)(x_2^2 + x_1x_2 + x_1^2) + a(x_2 - x_1)$, where

$k = \frac{y_2 - y_1}{x_2 - x_1}, k(y_2 + y_1) = (x_2^2 + x_1x_2 + x_1^2) + a,$ similarly,

$k = \frac{y - y_1}{x - x_1}, k(y + y_1) = (x^2 + x_1x + x_1^2) + a,$ and the last formula

$k = \frac{y - y_2}{x - x_2}, k(y + y_2) = (x^2 + x_2x + x_2^2) + a.$

Subtract the second from the third formula, we get $k(y_2 - y_1) = x(x_2 - x_1) + (x_2 - x_1)(x_2 + x_1)$

Where $k^2 = x + x_2 + x_1 \Leftrightarrow x = k^2 - x_2 - x_1.$

For coordinate $y = y_1 + k(x - x_1) = y_1 + k(k^2 - 2x_1 - x_2).$ It remains to recall that for a group operation you need to select a mirror point :

$$(x, -y) = (k^2 - x_2 - x_1, -y_1 + k(-k^2 + 2x_1 + x_2)) \quad (5)$$

Thus, formula (3) is proved.

If the secant is tangent, we get $x_2 = x_1$, $x = k^2 - 2x_1$

Next, we differentiate equation 1) with respect to x:

$$2yy' = 3x^2 + a, \Leftrightarrow k = y' = \frac{3x^2 + a}{2y} = \frac{3x_1^2 + a}{2y_1},$$

From formula (5) we obtain $(x, -y) = (k^2 - 2x_1, -y_1 + k(-k^2 + 3x_1)), k = \frac{3x_1 + a}{2y_1}.$ Thus, formula (4) is proved. The cyclic group is formed from the set of points of the elliptic curve (equation (1)), connected by a geometric group structure (formulas (3), (4)), supplemented by a field integer structure in

Modulus of a prime p, i.e. instead of (1) solve comparisons:

$$y^2 = x^3 + ax + b(\mathrm{mod}\ p) \tag{6}$$

Ultimately, we use formulas (3), (4) and (6), obtaining successively all points of the elliptic curve of a cyclic abelian group. As can be seen from formulas 3) and 4), the coordinates of the points of the elliptic curve are rational numbers if the first 2 points of the curve are also rational, i.e. geometric group operation leaves the coordinates of the points rational further. An analysis of formulas (3) and (4) shows that if the angular coefficient of the line takes integer values, then the x, y coordinates will continue to be integer. Thus, it is necessary to solve the comparison:

$$\begin{cases} (\frac{y_2 - y_1}{x_2 - x_1}) \equiv (y_2 - y_1) \bmod p * (x_2 - x_1)^{-1} \bmod p, (x_2 - x_1)(x_2 - x_1)^{-1} \equiv 1 \bmod p \\ \frac{3x_1^2 + a}{2y_1} \equiv (3x_1^2 + a) \bmod p * (2y_1)^{-1} \bmod p, (2y_1) * (2y_1)^{-1} \equiv 1 \bmod p \end{cases} \tag{7}$$

A brief description of the algorithm for constructing a sequence of points:

1) Find the inverse element in (7) to $2y_1$, or to $x_2 - x_1$.

2) Find the numbers $k_1 = (y_2 - y_1) \bmod p * (x_2 - x_1)^{-1} \bmod p$, or $k_1 = (3x_1^2 + a), \bmod p * (2y_1)^{-1} \bmod p$.

3) Find the numbers

$$\begin{cases} x = (k_1^2 - x_1 - x_2) \bmod p \\ y = (-y_1 + k_1(2x_1 + x_2 - k_1^2)) \bmod p \end{cases} \tag{8}$$

Either by the formulas:

$$\begin{cases} x = (k_1^2 - 2x_1) \bmod p \\ y = (-y_1 + k_1(3x_1 - k_1^2)) \bmod p \end{cases} \tag{9}$$

Description of the encryption and decryption algorithm

The encryption and decryption formula is as follows:

(kG, Pm + k * Pb) (encryption) - - -> Pm + k * nb * G-nb * k * G = Pm (decryption), where nb is the private key of subscriber b and Pb is the public key of subscriber b.

The message (number) should be equal to the difference of the x coordinate and the coordinate of the points of the elliptic curve. Since this is not possible for all residues modulo a prime number p. Then we create our own alphabetical string, which is also an additional encryption key, in which there are all letters of the Latin alphabet and all numbers arranged in order as in the English alphabet or not in order. In addition, you have to make spaces to fill them with an asterisk. The idea is as follows. It is necessary to arrange all the letters and numbers in the alphabetical line at those positions (serial numbers) for which there is an elliptic curve point whose coordinate difference is equal to the position number of the letter in the alphabetical line. Thus, we display the numbers of all letters in the alphabetical string at the points of the elliptic curve. An example of an alphabetical string: '* b * a *** cdefghi * jkl ** mnopqrs ** tuvwxyz01 * 2 ** 3456789 **'.

Further, letters are read out from another line-word by characters and written into its array. After, the next character of the word and the characters of the alphabetical string are compared. As soon as the letters coincide, the word symbol is mapped to the position number in the alphabetical location line of this symbol and its corresponding elliptic curve point, the difference of coordinates of which is equal to the given position of the symbol in the alphabetical line. When deciphering by the found point, you need to subtract its x and y coordinates and read the symbol with the given position in the alphabetical string and write this letter of the alphabet at the output. Alphabetical strings are determined experimentally, so that all letters and punctuation marks, numbers of the English alphabet are encrypted and decrypted uniquely using elliptical cryptography.

Testing the program in the console. We enter a phrase to test data encryption: "polotsk state university 2019" with a string length of nn = 29. The result of text entry, the parameters of the elliptic curve a = -1, b = 188, p = 751, the public key (kx, ky) = (201, 5) are shown in Figure 1.

We see the result of encryption and decryption in Figure 2. Each source character of the text corresponds to four integer coordinates of two points of the elliptic curve located on one line. For ease of input and line-

by-line reading, the same cipher in one column is written to the text file balka1.txt. We see a complete coincidence of the cipher in two stages.

In addition, it is also seen that the random number k = 17 introduced into the program in Figure 1 and recorded by the program in the text file balka2.txt also match.

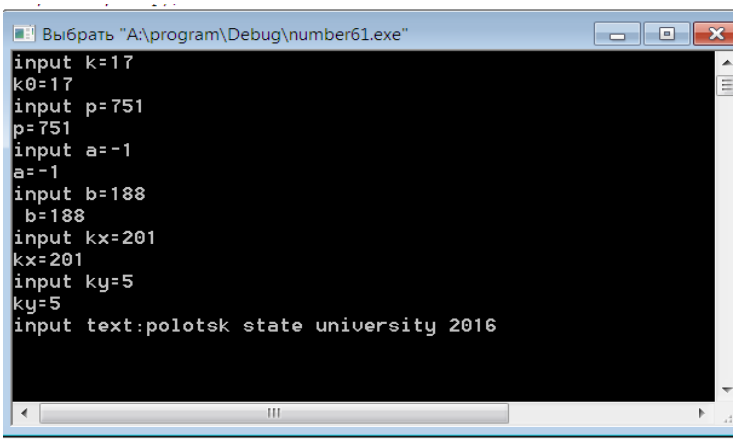

Figure 1. – Entering data into the program

The encryption protocol indicates the coordinates of the point of the elliptic curve corresponding to each input character and the difference of the coordinates of the x-y point, which is equal to the position of the original character in the alphabetical string. For example, from a point of an elliptic curve with coordinates (xm, ym) we can determine $(xm, ym) = (680, 657), des = xm - xy = 680 - 657 = 23$ the original character using the alphabetical string (the numbering of characters in the alphabetical string starts from zero, therefore $des = 23$ matches 24 characters, i.e. Latin letter p (Fig. 2 below).

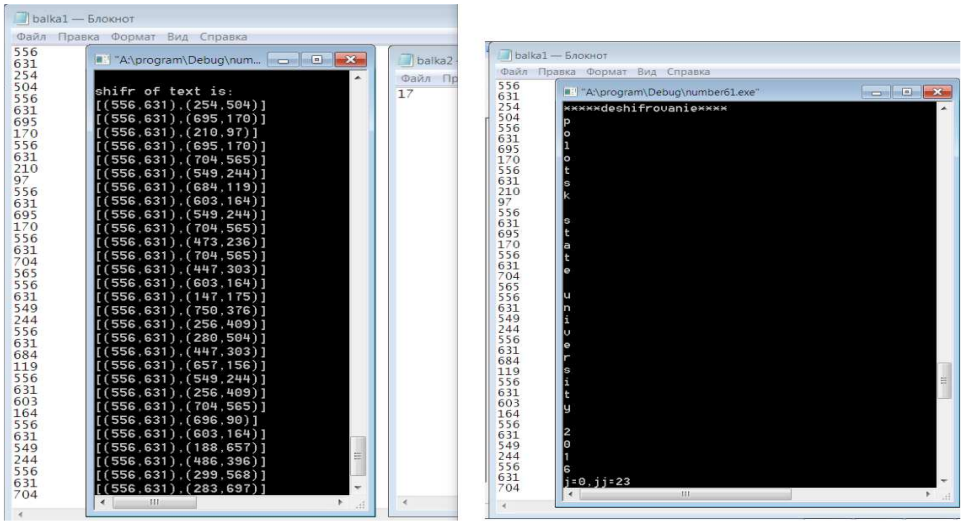

Figure 2. – The result of the operation of encryption (left) and decryption (right)

Indeed, the phrase "polotsk state university 2019" begins with the letter p. Second character $(xm, ym) = (266, 244), des = xm - xy = 266 - 244 = 22$ matches 23 in a row character in the alphabetical string, i.e. latin letter o, which corresponds to the second letter in the word polotsk. It can be seen from the console that the cipher has other coordinates than the coordinates of the point of the elliptic curve, the difference of coordinates of which is the position of the symbol, that is, in the clear, the cipher does not contain the coordinates of the message points. We also see that all points of the text give the check function a value of zero, that is, all points are points of an elliptic curve

Conclusion. The development of encryption and its methods has led to their widespread prevalence. Now it is not difficult for the end user to encrypt a partition on a hard disk or correspondence and establish a secure

connection to the Internet. Due to the fact that encryption and other information technologies penetrate our everyday lives, the number of computer crimes is growing. One way or another, encrypted information is an object of protection, which, in turn, must be subject to legal regulation.

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UDC 004.223.2

PROTECTED TRANSFER OF MESSAGES BETWEEN USERS ON THE BASIS OF POST-QUANTUM CRYPTOGRAPHY

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The article discusses the design of a secure data transfer scheme between users according to the peer-to-peer scheme, as well as the issues of protecting this data. The analysis of the technologies most suitable for the development of this scheme.

Some means of transferring information between users, such as Viber and Telegram, use message encryption, but transmit messages through their own servers. Thus, it turns out that all user messages can be stored on the server and, subsequently, be transmitted to someone.

There are two primary problems: the problem of intercepting transmitted data, the vulnerability of encryption algorithms to cryptographic attacks. These problems can be solved using public key cryptosystems and peer-to-peer connections.

A peer-to-peer network is an overlaying computer network based on equal rights of participants. Often there are no dedicated servers in such a network, and each node (peer) is both a client and acts as a server. Unlike the client-server architecture, such an organization allows the network to remain operable with any number and any combination of available nodes. Members of the network are peers. [1]

Benefits from using peer-to-peer:

1. Protection against server data leakage;
2. Reducing the load on the application server, because the server will cease to participate in the process of sending messages.

Existing solutions. None of the popular messaging tools use message protection at the highest possible level. Viber and Telegram use end-to-end encryption, but their common problem is control of the entire message passing process by the servers of these services.

Ent-to-end encryption is a data transfer method in which only users participating in communication have access to messages. Thus, the use of pass-through encryption does not allow access to the cryptographic keys by third parties. [2]

The topic of combining end-to-end encryption and peer-to-peer connections is not well developed. Only one article in English was found on the Internet. But in this article only theoretical issues were considered without considering the options of the technologies used.

Means of solving the problem. This article deals only with the case of the transfer of text data. However, the technologies used in this scheme can be applied to transfer other types of data.

A public key cryptographic system allows encrypting messages with a public key that can be transmitted over insecure channels. The NTRUEncrypt algorithm was chosen as a public-key cryptographic system.

In addition to solving the problem of intercepting transmitted data, NTRUEncrypt solves the urgent problem of instability of traditional encryption algorithms, such as RSA, to the Shore algorithm. The Shore algorithm allows solving the factorization problems of integers or the discrete logarithm problem using a quantum computer. In turn, NTRUEncrypt is based on a trellised cryptosystem. The stability of the algorithm is provided by the difficulty of finding the shortest lattice vector. Unlike its predecessors, the NTRU does not work on a residue ring modulo an integer N , but on a ring of polynomials of degree $n-1$, reduced modulo x^n-1 . Addition of elements in such a group occurs as usual addition, and when multiplying, the element x^n is reduced to 1, x^{n+1} to x , and so on. Multiplying two elements of the ring $a(x)*b(x)$, we get the element $c(x)=c_0+c_1x+\cdots++c_{n-1}x^{n-1}$, in which the coefficient c_k is calculated by formula 1. Such a ring is called the ring of truncated polynomials. [4]

$$c_k = a_0b_k + a_1b_{k-1} + \cdots + a_kb_0 + a_{k+1}b_{N-1} + a_kb_{N-2} + \cdots + a_{N-1}b_{k+1} \quad (1)$$

Description of the message transfer scheme:

1. N, q and p are predefined parameters;
2. Generating a public / private key pair. To generate keys, customers select two "small" polynomials f and g from the ring of truncated polynomials. The private key is a pair (f, f_p), and the public key h is calculated by the formula 2. The public key is sent to the server;

$$h = (pf_q * g) \bmod q \quad (2)$$

3. Before sending messages, clients through the server receive each other's public keys and exchange messages to establish a peer-to-peer connection via WebRTC. To reduce the load on the server, peer-to-peer connection installation messages are transmitted via the WebSocket protocol;
4. The first client converts the message m to the polynomial $M(x) \in L_m$. Then the "blinding" polynomial $r(x) \in L_r$ is selected and using the public key of the second client it calculates the ciphertext using formula 3. The polynomial $C(x)$ will be the ciphertext;

$$C(x) = p * r(x) * h(x) + M(x) \bmod q \quad (3)$$

5. The second client receives $C(x)$ and, using its private key, restores the original message M using formulas 4, 5 and 6 .. Then it computes. Then. The second client restores the original message M .

$$a(x) = r(x) * p * g(x) + f(x) * M(x) \bmod q \quad (4)$$

$$b(x) = f(x) * M(x) \bmod p \quad (5)$$

$$f(x) * b(x) * f_p(x) = M \quad (6)$$

Table 1. – JavaScript encryption speed measurements NTRUEncrypt

Characters	Time, s
200	2,1
500	2,6
1000	3,3

End-to-end encryption in the peer-to-peer network will avoid the problem of intercepting the data being sent. Also, this application should work in the browser so that the user does not have to install anything.

In connection with the requirements to install peer-to-peer connections between clients using WebRTC:

WebRTC is an open source project designed to transfer streaming data between browsers or other applications supporting it using peer-to-peer technology. [3]

Technology benefits:

1. Conducting a conference in a browser greatly simplifies the process of holding a conference — the user does not need to install separate applications for this;
2. Used codecs provide good quality of communication;
3. The ability to implement any interface elements using HTML5 and JavaScript;
4. Open source gives you more options.

Technology flaws:

The technology defines only the general standard of data transmission (video and sound), but individual solutions of different browsers regarding the addressing of subscribers and other control processes are not compatible with each other. Therefore, even calls between a pair of different browsers present a separate complexity.

Establish a peer-to-peer connection between two clients (Figure 1).

A simplified connection scheme between two clients:

1. The first client sends Offer to the second client through the server;
2. The second client sends a response through the server to the first client;
3. A peer-to-peer connection is established between clients.

For quick transfer of messages to the server, the WebSocket protocol is used. WebSocket is a full-duplex protocol over TCP connection designed for real-time messaging between a browser and a web server. [5] Compared to HTTP, WebSocket sends much less service information with each request.

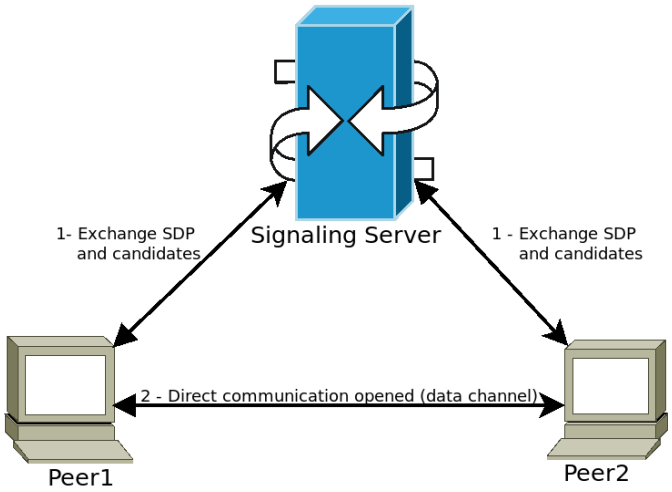

Figure 1. – Peer-to-peer connection between two clients

Conclusion. In the course of this study, a scheme for secure data transfer between users using a post-quantum encryption algorithm in a peer-to-peer network was designed. WebRTC was used to establish a peer-to-peer connection in the browser. For encryption, the NTRUEncrypt algorithm was used. It should be noted that the developed scheme leaves the opportunity for revision and introduction of additional protective equipment.

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UDC 004.004.658.2

APPROACHES TO DEVELOPING AN INTERFACE FOR AN AUTOMATED INFORMATION SYSTEM FOR MANAGING A THRIFT STORE

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The article presents a practical way to create an interface for working with an automated information system.the analysis of technologies that are most suitable for the development of this system is Carried out. Task, implementation of an interface prototype based on web technologies.

Keywords: automated information system, Commission shop, programming language, 1C: Enterprise, database, analog, prototype, interface.

Introduction. Today, almost every second product of human activity offered to the buyer is related to high technologies. This means that it not only meets specific human needs, but is also the embodiment of scientific and engineering thought. The automated information system being developed is aimed at significantly facilitating the work of the Commission store. In addition to providing the user with convenient access to all data, the system simplifies the maintenance of working documentation.

In this automated information system, the process of creating an application interface is used for direct interaction of the application with the database, which combines all the necessary information for output directly to the information system. The interface is created by adding the necessary components to 1C and then configuring them. The interface of any information system has components that allow the program to interact with the user.

Thus, this system being developed will provide a convenient mechanism for storing and selling Commission products, as well as processing information on Commission products.

Analogues and prototypes. There are several analogues and prototypes of the Commission store information system. The first analogue and prototype was the product "Commission store 1.1". The program is designed for making payments to the Commission store's customers, accounting for the receipt, sale and return of goods. Printing and recognition of barcodes.

Features of the program:

– maintaining a directory of operations, departments, and units of measurement;
– maintaining a directory of clients (legal and individuals) with their basic data;
– maintaining product balances for each committer, the ability to view balances, turnover of any product, amounts of payments and debts to the committer on any day;
– quick entry of receipt, sale, revaluation and return operations, including using a barcode scanner. Ability to select operations using filters;
– printing invoices and receipts, product labels with barcodes; - printing a report on the amounts to be paid, calculating the Committee debt and the amount of commissions;
– printing of the register of accepted and sold goods for any day, the list of available goods in the context of committees or departments;
– module for the cashier's workplace;
– enter sales in the database and output the receipt directly to the cash register (supplied separately). Requires BDE 5.xx + InterBase 4.2 or higher.

The next analogue and prototype, which is an IP developed in 1C, is called "Commission trading 4.1.3". The author of the program is Sergey Komkov. Interface language: Russian. Operating systems: Win 9x, Win NT, Win ME, Win CE, Win 2000, Win 2003 Server, Win XP, Win 2008 Server, Win Vista, Win 7. This program was created on February 26, 2004.

Briefly: accounting for goods on the account cards of the Committee with an indication of the contract price and the percentage of Commission.

Details: Commission trading-accounting for goods on the account cards of the Committee with the indication of the contract price and the percentage of Commission. Documents to be generated: the account card of the Committee, the act of markdown of the product, the act of removing the product from sale, the product report, price tags.

Figure 1 shows the interface of the demo version of the information system "Commission trading 4.1.3".

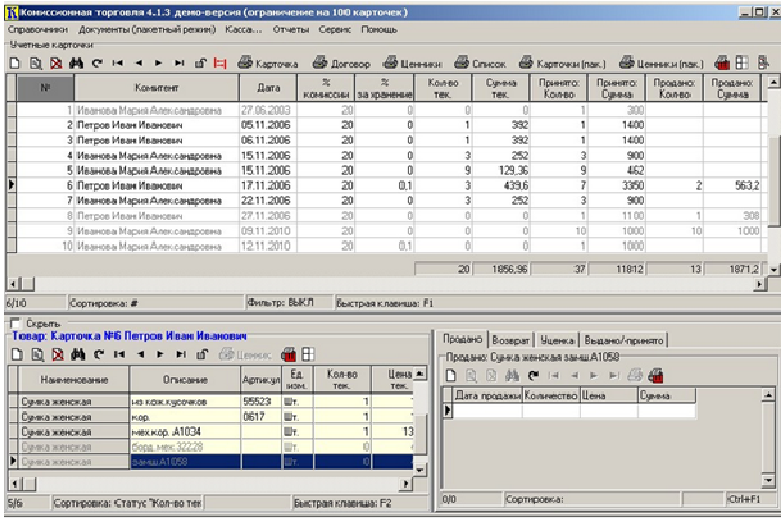

Figure 1. – Interface of the program "Commission trading 4.1.3".

The next analogue and prototype of the "Commission store" is the program for automating grocery stores "Mini-Shop".

Opportunities:

– "Mini-Shop" – a simple and convenient free accounting program in grocery stores, household chemical stores, etc.;

– "Mini-Shop" is the first program in our line of programs for automating trade and warehouse operations of grocery and similar stores (see also Laitik-Shop and Kors MAG);

– accounting in grocery stores, household chemical stores, household goods, etc.;
– used for a large flow of sales;
– allows you not to enter data about each sale;
– calculation of the balance between the product released to the point and the delivered revenue;
– calculation of debts for the point of sale;
– reconciliation of balances on a point using inventories;
– warehouse operations: receipts, returns to the supplier;
– operations with retail outlets: vacation, return, entering balances (inventory);
– cash transactions: revenue, debt write-off;
– printing invoices;
– batch accounting;
– report (inventory inventory, settlements with the point of sale);
– 1 warehouse and 1 point of sale;
– up to 10 items in the invoice for the arrival and release of goods.

Examples of the work are shown in figures 2-4.

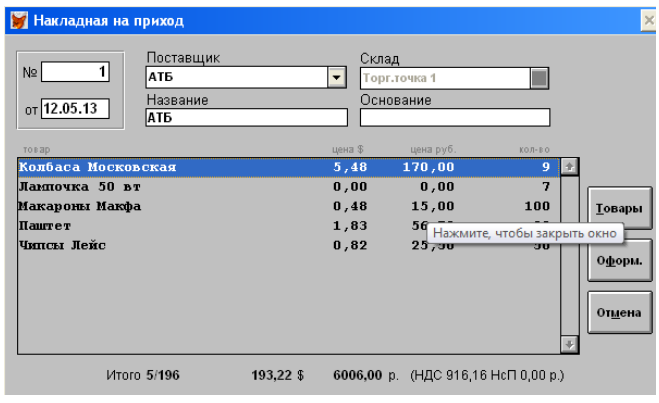

Figure 2. - "Receipt Invoice" Interface».

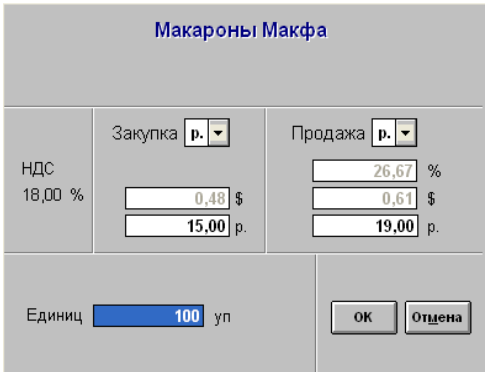

Figure 3. – Example of working with "Pasta macfa".

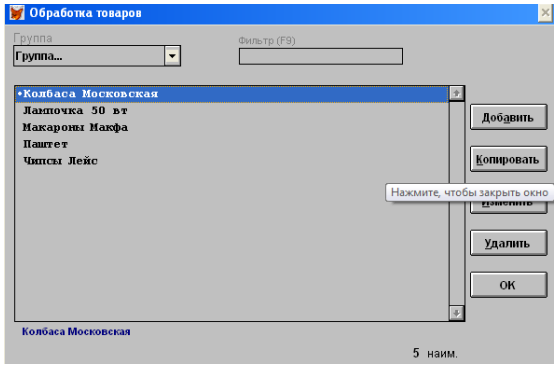

Figure 4. – Example of "Processing goods".

Changes:

– version 1.2 from 30.05.2012 - fixed a problem when printing invoice headers (incorrect encoding);

– version 1.1 from 06.12.2008 – a mechanism for filtering the list of products by several fragments. For example, to search for lines like "sausage boiled doctor", type "number of Wardak" in the "Filter" field and press Enter;

– version 1.0 from 08.02.2005 - release of the program.

The choice of development technologies interface. This web application is planned to be developed using the 1C:Enterprise 8.3 platform using the built-in programming language. It follows that web interface development technologies should be optimized for the operating system as much as possible, and the 1C:Enterprise development environment is suitable for all Windows families.

According to experts, the market for development tools is now shifting from specific programs that support development (compilers, IDES, profilers, etc.) to systems that support the entire development lifecycle. If we talk about this trend more simply, then suppliers tend to invest in their complexes all the tools necessary for the development team, or provide convenient connection of other available tools. Of course, this is a difficult task, and it is almost impossible to solve it in full.

1C: Enterprise as a subject-oriented development environment has certain advantages. Since the range of tasks is more precisely defined, the set of tools and technologies can be selected with greater certainty. The platform's task is to provide the developer with an integrated set of tools necessary for rapid development, distribution, and support of an application solution for business automation. In this case, individual "parts" may be inferior in functionality to universal development tools and specialized lifecycle management tools used by developers. However, the effect is achieved through a common set of tools and their close integration.

Development in "1C: Enterprise" is based on the General model of the application offered by the platform "without fail", i.e. the main and most complex architectural and technological solutions (such as the mechanism of a three-level architecture, issues of interaction of components, user authentication, etc.) are offered to developers in a ready-made form.

The information system being developed, according to its structure and basic needs, should provide opportunities for working and presenting a large amount of data that could change dynamically with the user's

actions. Development in "1C: Enterprise" is based on the General model of the application offered by the platform "without fail", i.e. the main and most complex architectural and technological solutions (such as the mechanism of a three-level architecture, issues of interaction of components, user authentication, etc.) are offered to developers in a ready form.

The 1C programming language is a formal sign system designed for writing computer programs. The programming language defines a set of lexical, syntactic, and semantic rules that define the appearance of the program and the actions that the performer (computer) will perform under its control.

A very important advantage of 1C:Enterprise is the openness of the system. For a Manager who makes a decision about choosing an automation tool, it is important to be sure that the system will not be a "black box" for the company, and there is a real opportunity to understand the system's operation and, if necessary, change it. This work can be performed by franchising organizations that specialize in supporting 1C: Enterprise, as well as by it specialists of the enterprise itself. The system package includes the tools necessary for updating the application solution and making changes to it of any complexity, as well as a full set of documentation for them. A specialist who supports the system in a particular organization uses the same tool as the developers of 1C or companies that develop replication solutions. 1C:Enterprise features allow you to minimize efforts to change the automation system and its subsequent maintenance.

Building a system based on the application's technological model, metadata, and application model allows you to significantly simplify and speed up development. First, based on metadata and a single model, all components of the system interact with each other without significant effort on the part of the developer. Secondly, a significant part of the technological complexity of implementation is solved by the platform and is not "piled" on the developer of the solution.

The system does not limit the use of modern technologies, but focuses on their most convenient and easy integration into the overall application development infrastructure. The implementation of this approach can be seen in the gradual inclusion of a whole range of technological solutions in the platform.

Based on the above, we can conclude that the 1C:Enterprise development environment is the best option.

Interface design. When developing the interface, for ease of use, a functional structure was used, which consists of a number of modules, presented below:

1. Product arrival module. Responsible for generating receipt documents, calculating the percentage value of goods, entering information in the registers of information and savings.

2. Product sales module. Responsible for selling products and entering information in the savings register.

3. Markdown module for products. Responsible for creating a new price, entering information in the data and savings registers.

4. The module of the returned merchandise. Responsible for returning unsold goods to the Committee and entering information in the savings register.

5. Report generation module. Responsible for generating a report on sales of goods (for various parameters), generating a report on receipts by comitents, generating a product report, and generating a report on returns.

6. Module for filling and printing documentation. Provides opportunities for creating and printing a product label, printing a Commission agreement and a markdown act.

7. Reference module. Provides the ability to fill directories with the necessary content.

The functional structure is shown in figure 5.

Conclusion. The correct approach when developing the interface is to use modern technologies that allow you to solve your problems in all operating systems. This, first of all, saves time when developing the interface, as well as resources for data processing, and is also very relevant, with a large amount of information that is subject to constant change.

The information system of the Commission store allows you to significantly facilitate the work of the Commission store. It enables structurally store data about the clients (customers), commodities, characteristics of commodities, to control the time markdown of the goods, if it is necessary to calculate the markdown of goods and Commission Commission, to deduct from the original price markdowns and commissions and to pay the consignor for the goods sold. Trading, drafting and processing of documents is simplified and partially switched to automatic mode.

When developing an automated information system for managing a Commission store, due attention is paid to the informativeness of the application, which allows the user to get all the necessary information in the form of reports and acts.

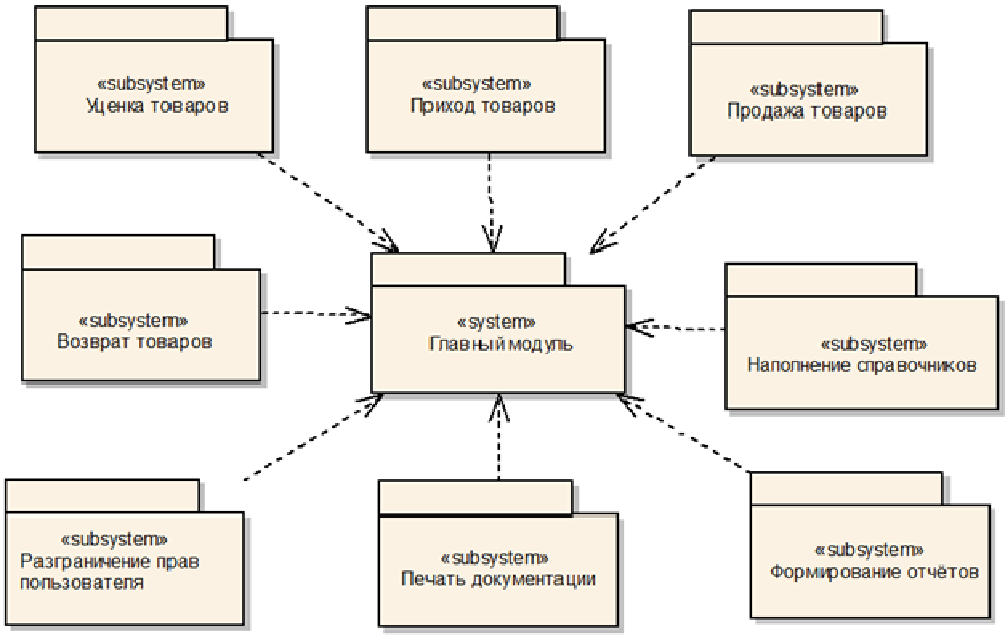

Figure 5. – Functional structure

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UDC 004

AMPLITUDE-TYPE SENSORS IN FIBER-OPTIC DEVICES

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This article discusses some of the sensors used in fiber-optic devices. The advantages of their use are analyzed. The principles of operation of some sensors are shown.

The material of fiber-optic sensors (FOS) is a dielectric. FOSs do not require electrical power and grounding [1], therefore they can be used in explosive environments without the risk of an electric spark; they offer good accuracy and performance; they may have a small size (up to 0.1 cm2 for a Bragg sensor); they have low cost, with the possibility to be placed at a far distance from the recording equipment. Modern fiber-optic sensors can measure pressure, temperature, strain, liquid level, gas concentration , radiation dose, and more.

Physical effects on the optical fiber, such as temperature, pressure, and tension force, locally change the characteristics of light transmission and, as a result, lead to changes in the characteristics of the back reflection signal. Measurement systems based on fiber-optic sensors are based on comparing the spectra and intensities of the original laser radiation and radiation scattered in the opposite direction after passing through the fiber.

The so-called Raman effect is particularly suitable for measuring temperature using light guides made of quartz glass. Light in a glass fiber is scattered by microscopically small density fluctuations that are smaller than the wavelength. In contrast to incoming light, backscattered light contains both a component with an initial wavelength (due to elastic or Rayleigh scattering)and components that have undergone a spectral shift to a frequency corresponding to the resonant frequency of the scattering nodes (Raman Raman scattering). Components with a shifted wavelength form satellite lines in the scattered light spectrum, which are divided into Stokes (shifted to longer wavelengths and lower frequencies) and anti-Stokes (shifted to shorter wavelengths and higher frequencies). The amplitude of the anti-Stokes component depends on the local temperature.[1]

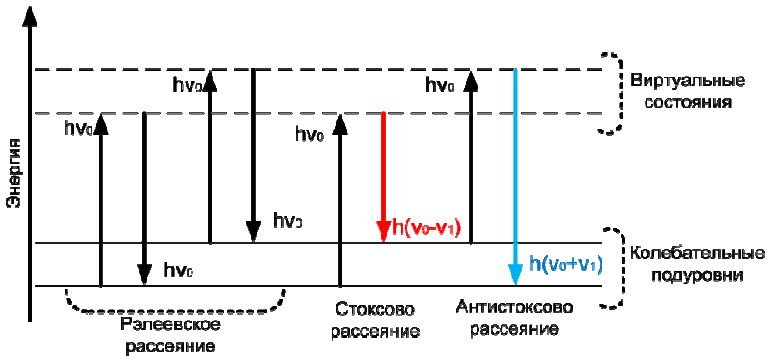

Figure 1. – Rayleigh and Raman light scattering

One of the most popular sensors in the modern manufacturing process is the optical distance sensor. Laser distance sensors are an optoelectronic device for determining the distance to an object. Contactless distance measurement has countless applications. For example, an optical distance sensor is used to determine dimensions (thickness, height, length, width), control the minimum or maximum distance, positioning, level of filling or emptying the tank, and so on.

The optical rangefinder works on one of two basic principles:

1.The principle of measuring the time of flight of the beam. That is, the laser diode of the sensor emits pulses that are reflected from the target (measurement object) and then captured by the photodetector of the same sensor. By measuring the time between the moment of the pulse emission and the moment of its "return", the electronics calculates the distance to the object.

2.The principle of triangulation. The light emitted by the sensor is reflected by the object and then "returned" to the sensor's photodetector. The distance is calculated by determining the phase difference between the sent and received signals. This method is also called the phase measurement method.[2]

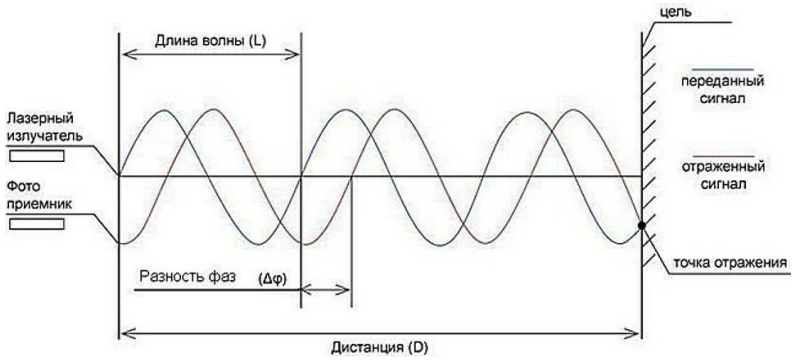

Figure 2. – Principle of operation of the laser rangefinder

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UDC 004.221

DEVELOPMENT OF A SYSTEM FOR HIDDEN INFORMATION IN A SOUND ENVIRONMENT

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This article discusses various algorithms for hiding information in a sound environment and their advantages. In the course of research, the optimal version of the algorithm has been chosen.

Introduction. The task of reliable protection and concealment of information comes since the earliest times. Even in ancient times, various methods were used to protect important information from prying eyes of wanderers, the Polybius square and the first shift ciphers. Later ciphers of simple replacement (Arthur Conan Doyle's story "Dancing Men") and permutation ciphers (Cardan grille) appeared. In the XVIII century, the code "according to the book" arose, which can be considered as the development of Caesar's cipher (used by the hero Yu. Semenov - Stirlitz in the novel "17 Moments of Spring").

But all ciphers have finite strength and can be decrypted in a finite period of time. Steganography, which hides the very fact of transmitting a secret message, helps to solve this problem.

The main section. The article will examine the steganographic methods of hiding information in sound files, both from the point of view of resistance to attacks, and from the point of view of maintaining an acceptable quality of the sound signal.

The least significant bits method is used for digital representation of the audio signal and is suitable for use at any communication speeds. When converting an audio signal into digital form, there is always a sampling noise that does not introduce significant distortion. The "noise" bits correspond to the lower bits of the digital representation of the signal, which can be replaced by hidden data. This method has extremely low stegosity and simple implementation. A change in the sound signal can be detected.

Broadband coding methods use the same principles as the methods of hiding data in images. Their essence lies in the slight simultaneous modification of a number of certain bits of the container while hiding one bit of information. This method has medium resistance to attacks and distortions and is difficult to implement. The sound signal is practically unchanged.

The echo hiding method hides data by incorporating the echo into the audio signal. It is known that at small time shifts the echo signal is almost indistinguishable by ear. Therefore, if certain time delays are introduced, the value of which does not exceed the detection threshold, then, dividing the initial sound signal into segments, you can enter the corresponding echo signal in each of them, depending on the hidden bit. This method is stego-proof and difficult to implement. The sound signal is practically unchanged.

Phase hiding methods are used for both analog and digital signals. They use the fact that a smooth phase change cannot be determined by ear. In such methods, the protected data is encoded either by a specific phase value or by a phase change in the spectrum. Changes in the sound file using this method cannot be detected using human hearing, but it is extremely difficult to extract information at the slightest damage to the signal.

As for musical stegosystems, the musical form of the sound environment occupies most of the information space of the Internet. In addition, it is widely used in general purpose radio networks and is distributed on electronic information carriers, which, due to the development of computer technology, have become widespread. In this regard, the use of the music environment to conceal information messages seems quite promising. To conceal data, methods based on the modification of those parameters of the musical environment that can be qualitatively described in music theory can be used. The musical environment has its own textual display in the form of notes and other signs that allow adequately to reflect the musical work and its internal structure with such elements as notes, scales, periods, measures, cadences, chords, motives, modulations, tones, various types of development, sequences, etc. The construction of musical fragments obeys syntactic rules that can be described, which allows you to build logical relationships and, accordingly, a description of the structures of musical works.

Musical stegosystems provide information hiding in the musical environment by analogy with the improvisation of musical works. Essentially, improvisation is such a change in a musical work or its fragments that preserves the main themes of the original work in the form of melodies, but at the same time expands the image of the musical theme with other features that complement the main image that were not in the main musical work. The main difference between musical steganography and improvisation is that the goal is not to expand the im-

ages of the basic musical work, but to make changes that preserve the melody of the main work, comply with all the rules for constructing this work, and at the same time encode the message to be hidden without distorting the main theme of the work.

A fragment of a musical work can be described as a logical structure. An analogue of a text sentence word in a musical work will be one beat of a melody, and fragments shared by censorship will be considered an analogue of a sentence in music. Typically, a piece of music consists of a series of phrases that consist of measures. The introduction of the text into a musical work is carried out in separate sentences, each of which can be compared with a separate melody. Next, a musical display of the expanded musical composition with a hidden message embedded in it is formed. Based on the musical representation of the extension, its musical realization is carried out using modern computer systems, which are software and hardware sound synthesizers. The musical stegosystem is highly resistant to attacks and almost impossible to detect, however, to implement this system, you need to spend a huge amount of resources.

Conclusion. In this article, algorithms for hiding data in sound files have been considered, the operation of the musical stegosystem has been described, and the conclusion has been drawn on the optimal method for implementing the system.

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UDC 004. 622

APPROACHES TO THE INTERFACE DEVELOPMENT FOR THE AUTOMATED INFORMATION SYSTEM OF THE INSPECTION ON THE MATTERS OF THE MINOR, POLOTSK REGIONAL EXECUTIVE COMMITTEE

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The article presents a practical way to create an interface for working with the commission for minors. The analysis of the technologies most suitable for the development of this system is carried out. Task, implementation of a prototype of an interface are based on windows - form.

Introduction. The automation and creation of information systems are currently one of the most resource-intensive areas of technogenic society. One of the reasons for the active development of this area is that automation serves as the basis for a radical change in management processes that plays an important role in the activities of man and society. Control systems arise, the action of which is aimed at maintaining or improving the operation of an object using a control device (a set of means for collecting, processing, transmitting information and generating control signals or commands) [1].

The automated information system (AIS) is a set of software and hardware designed to automate activities related to the storage, transmission and processing of information.

AIS are, on the one hand, a type of information systems (IP) and, on the other hand, automated systems (AS), as a result of which they are often called IP or AS.

AIS can be defined as a complex of automated information technologies designed for information services – organized continuous technological process of preparation and delivery to consumers of scientific, managerial and other information used for decision-making, in accordance with the needs to maintain effective activities [2].

The choice of interface development technologies. The choice of means for solving the problem proceeded from the kind of software and hardware needed for development. Here the choice was made in favor of the Windows 10 operating system.

Microsoft Visual Studio 2017 was chosen as the development environment for the project due to the following reasons:

1 Flexible support structure for an object-oriented programming approach.

2 Ease and simplicity of project development. This property includes the implementation of all kinds of hints in the source code editor, wide possibilities for working with project resource files, such as image files, icons, cursors, menus, accelerators.

3 The presence of a powerful debugger to detect errors in the implementation of the program.

4 A large amount of documentation on the capabilities of the development environment, on the types of modules used and descriptions of the main functions.

5 When developing a project, there are many options for setting the optimization of a developed project, for example, optimizing the size of an executable program module, or optimizing its execution speed.

6 Support for working with services, both by means of API functions, and at the level of special built-in service designers.

7 The productivity of the program is improved due to special built-in libraries of functions – .NET Framework 7.4.2. It all depends on the version of the components installed in the operating system.

8 Relatively small system requirements for installing the environment and for its launch.

The object-oriented language C # was chosen as the programming language for writing the application. This choice is due to the fact that this language is a key language in working with the .NET Framework. For the implementation of the project, the necessary and sufficient version of this set of libraries is the .NET Framework 4.7.2. This version is necessary to maintain work at the application level with databases and organize networking between individual program modules.

Interface Design. When designing the interface, the tabbed structure was applied. With the information logically divided by tabs, simplifying its search, it does not clutter the home page and does not need to create additional forms.

The main information about the violators is stored in a database, with the ability to take action over it, after selecting the appropriate data. This structure is the simplest and most understandable for users with

a different level of personal computer skills. Using standards of controls allows you to minimize the time spent learning how to work with the application.

To visualize some operations, user interface components were created. The developed components and their descriptions are presented in Table 1.1.

Table 1.1. – List of developed custom components

Component Name	Component Assignment
Button_Open	Implementing a button for selecting a document
Button_Save	Saving a copy of the document as amended
FilterTextBox	Filtering data from a database
PrintCheckBox	Implementing an element to print a document while saving
dataGridView	Implementing a control to display the current state of the database

Using the program, the user interacts with the document generation subsystem. The program in its composition has a separate window through which the user receives all the necessary information.

All functionality can be divided into specific tasks, each of which has its own method. A list of several methods and their significance are shown in table 1.2.

Table 1.2. – List of application methods

Method name	Purpose
Form1	It contains the implementation of the interface element, which displays all the information from the database
FindAndReplace	Contains the implementation of part of the program for working with a document
CreateWordDocument	Describes a method that performs text substitution

Conclusion. The correct approach when developing an application is to use modern technologies that allow you to solve your problems. This primarily saves time in developing the interface, as well as resources for data processing. This is very relevant, with a lot of information that is subject to constant change.

The win - form technology is considered, which allows creating an adaptive interface of any complexity, while maintaining its functionality and attractive appearance. Based on the results of this work, the possibility of their application to the built interface and dynamic query processing was described.

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UDC 004.588

IMPORTANCE OF JSX AND CSS ON THE EXAMPLE OF THE DEVELOPED GAME WEB APPLICATION "LEARNING CSS FEATURES"

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The rationale for the development of modern gaming applications is given. The technologies used to create web applications are analyzed. CSS technologies and JSX technology are considered in detail, with the aim of using them for demonstration in the form of an entertaining game "Learning CSS Features".

Most people spend their free time in games, especially children and teenagers. There is such an approach to learning as submitting material for study while playing that will be useful and interesting to people of any age. Under this topic, a cross-platform, gaming web application "Learning CSS Features" is developed.

At the initial stage of its development, the "web" consisted only of static HTML pages and when the address was opened, the server returned the page content. Page-making, styles, scripts – everything was in the mass. With the development of Internet technologies, there are more and more single-page web applications, where the main part of the logic is focused on the client side. On any Uniform Resource Locator (URL), the server gives the same static HTML, and the JavaScript code in the user's browser determines the current address and makes a request to the server for the necessary data. When you click on the link, the page does not reload entirely, but the URL is updated, and the JavaScript code makes a new request for the next page. The emergence of web applications has fundamentally changed the approach to development. There are new special frameworks designed for creating web applications with a large amount of code and complex user interface logic. Rendering (the process of getting an image from a model using a computer program) of data now takes place on the client, the page resources store static html templates that are filled with data received from the server. The most suitable way to organize such a mass of code is the component approach. Each more or less independent block is made out into a separate component, with its own styles, template and JavaScript (JS), and then the whole page is assembled from these blocks. This approach is implemented by most modern JS frameworks, but with one difference: Angular, Ember encourage the creation of a separate file with a template, and React offers to write HTML inside JS [1]. The technology that allows us to write HTML inside JS is JavaScript XML (JSX) technology.

JSX is a technology that was introduced by React. This technology extends The JavaScript syntax, which looks similar to XML. Many people think that using JSX is like a mixture of HTML and JavaScript, but this is not exactly true, we can also manipulate CSS. JSX is mainly used as building blocks in React. Essentially, JSX is nothing more than a component in which we can control page making, logic, and styles. Everything is in one place, which already gives a huge advantage in development.

CSS is considered as cascading style sheets, which are a consequence of the further development of HTML and give us the opportunity to move to the next level of presentation of information. Style sheets allow you to separate the semantic content of the page and its design. When learning CSS, you may encounter a number of problems: different styles, properties, and technologies for layout of blocks and tables. HTML is said to be a markup language that is a tool for creating hyperlinks, inserting images, tables, and much more [2].

In the modern world, web technologies and programming languages are developing rapidly, hence, the number of web developers, as well as users who want to learn or develop their programming skills, is increasing. However, when studying web technologies, many people face various problems, and spend a lot of time searching for solutions. In order to facilitate the study of CSS, it is proposed to develop a web application that focuses on teaching the complex CSS properties and its layout technologies: flexbox, grid layout, working with animation, positioning elements on a web page using the position property. Thanks to visualization and game presentation, the technologies under consideration will become more accessible for studying and memorizing material. You can hardly become a programmer just by playing. But you can get a positive charge at the start, study the basic algorithmic constructs and programming logic, acquire the skills of action planning in solving practical problems [3].

When implementing this web application, it is planned to use the following technologies: ReactJS as a framework on the client side, the Node.JS software platform and the Express framework as well as the Javascript programming language for developing the server side. ReactJS is an open source JavaScript library for developing single-page and mobile applications. Its goal is to provide high speed, simplicity and scalability.

As a library for developing user interfaces, React is often used with other libraries such as Redux [4]. Node.js is a software platform based on the V8 engine (translating JavaScript into machine code) that turns JavaScript from a highly specialized language into a general-purpose language [5]. Express is a minimalistic and flexible web framework for Node.js applications, providing an extensive set of functions for mobile and web applications [6]. JavaScript is a full-fledged dynamic programming language that is applied to an HTML document and can provide dynamic interactivity on websites [7].

The application will consist of two pages: the main page with the listed items of the studied technologies and various CSS properties, and a dynamically loaded page with the game itself, which characterizes the selected technology.

Next, we will describe the layout technologies and properties that are used in the application and which people have most problems with. In CSS, there are 4 most problematic technologies: flexbox, grid layout, working with animation, positioning elements on a web page using the position property.

Flexbox is a new way to place blocks on a page. This is a technology created specifically for the layout of elements, as opposed to floats. With Flexbox, you can easily align elements horizontally and vertically, change the direction and order of elements, stretch blocks to the full height of the parent, or nail them to the bottom edge [8]. But there is one aspect – this technology is not supported by all browsers:

1) IE: 11.0, 10.0 -ms-;
2) Firefox: 28.0, 18.0 -moz-;
3) Chrome: 29.0, 21.0 -webkit-;
4) Safari: 6.1 -webkit-;
5) Opera: 12.10 -webkit-;
6) iOS Safari: 6.1 -webkit;
7) Opera Mini: 8;
8) Android Browser: 4.4, 4.1 -webkit;
9) Chrome for Android: 44.

Problems with this technology occur when the support for older browsers plays a huge role, in this case, you need to abandon this technology. However, at the moment the development is moving towards using new technologies rather than supporting older browsers. It should be noted that many users do not know what properties exist and how to use them for the correct arrangement of elements. There is both the old syntax and the new one, and each of them has its own aspects and this also needs to be sorted out. Thus, all these aspects will be considered in the developed application.

The next technology to be considered is Grid layout. Grid layout-brings a two-dimensional layout tool to the web, with the ability to place elements in rows and columns. A CSS grid can be used to achieve many different layouts. It divides the page into large regions, or defines relationships in terms of size, position, and layer, between parts of the control built from HTML primitives. Like tables, Grid layout allows the author to position elements in columns and rows. However, unlike tables, Gridlayout does not have a content structure, so it is not possible to include a large number of layouts in tables [9].

CSS3-animation makes sites dynamic. It animates web pages, improving user interaction. Unlike CSS3 transitions, animation creation is based on keyframes, which allow you to automatically play and repeat effects for a given time, as well as stop the animation inside the loop.

CSS3 animation can be used for almost all html elements, as well as for pseudo-elements :before and :after. When creating an animation, you should not forget about possible performance problems, since changing some properties requires a lot of resources [10].

Next, consider the CSS position property, which sets the way the element is positioned relative to the browser window or other objects on the web page. This property takes 4 basic values:

1) Absolute – it indicates that the element is absolutely positioned, while other elements are displayed on the web page as if there was no absolutely positioned element. The position of the element is set by the left, top, right, and bottom properties, and the position property of the parent element also affects the position. So, if the parent value of position is set to static or there is no parent, then the coordinates are counted from the edge of the browser window. If the parent's position value is set to fixed, relative or absolute, then the coordinates are counted from the edge of the parent element;

2) Fixed – this property is close to absolute in its action, but unlike it, it is bound to the point specified by the left , top, right, and bottom properties on the screen and does not change its position when scrolling the web page.

3) Relative – the position of the element is set relative to its original location. Adding the left , top, right, and bottom properties changes the item's position and moves it one way or another from its original location;

4) Static elements are displayed as usual. Using the left, top, right, and bottom properties does not produce any results.

5) Inherit-inherits the value of the parent [11].

Thus, the above- described CSS technologies and properties will initially be included in the web application being developed in order to eliminate developers' weaknesses, as well as to introduce and provide the correct knowledge base for users to work with these technologies.

Conclusion. All the nuances described in the article will be taken into account in the developed web application. When developing software, most people are looking for certain technologies that will fit their criteria. If you consider JSX as a way to use it together with ReactJS, it has a number of advantages that can be supplemented with various libraries, which will help you quickly and efficiently develop software. In the future, it is planned to refine this application by adding new CSS technologies.

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UDC 004.75

SYSTEM FOR STATIC OBJECTS DETECTION IN VIDEO WITH DIFFERENT ROADWAYS AND CLOUD TECHNOLOGIES USAGES

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This article deals with the main points in the architecture of static objects detection in video with different roadways system using Amazon Web Services (AWS) cloud services. The author considers what parts this system includes and what protocol will be used in order to send video to the server.

Currently, computer vision is used to solve various problems: self-driven vehicles, identification of objects on photos / videos, facial recognition, etc.

Computer vision is an interdisciplinary scientific field that deals with how computers can be made to gain high-level understanding from digital images or videos. From the perspective of engineering, it seeks to automate tasks that the human visual system can do.

Computer vision tasks include methods for acquiring, processing, analyzing and understanding digital images, and extraction of high-dimensional data from the real world in order to produce numerical or symbolic information, e.g. in the forms of decisions [1].

In order to implement a system for static and dynamic objects detection on a video sequence, we need to define the necessary steps of the algorithm:

1. Pre-processing video. At this stage, it is necessary to stabilize the frame of the video sequence.
2. Road Detection on a video:

a. Highlighting edges on the road. For highlight edges on the video frame usually Sobel operator is used, that can solve the task well [2]. The highlight edges process is necessary to determine the threshold values for the perspective transformation of each frame.

b. Perspective transformation of a frame of a video sequence. For this is used transformation of a video frame into a bird's-eye view:

a) b)

(a) a video frame before applying the transformation, b) the resulting frame

Figure 1. – The perspective transformation of a video frame

c. Detection of road lines. Sobel operator can easily solve this task in order to detect road lines.

d. Detection of the road curvature. In order to find the curvature of the road, it is necessary to use a second-order polynomial. The formula is described in expression (1).

$$f(y) = Ay^2 + By + C \quad , \qquad 1)$$

where A , B , C are variables of the function y.

In order to find the radius of curvature, it is necessary to solve a differential equation of the 2nd order by the formula (2):

$$R_{curve} = \frac{[1+(\frac{dx}{dy})^2]^{3/2}}{|\frac{d^2x}{dy^2}|} \qquad 2)$$

After solving this equation, the radius of the road curvature is obtained, thereafter this value can be applied to the original video frame. Figure 2 shows the highlighting of the road on the video frame:

Figure 2. – Obtaining the road curvature and highlighting it on the original video frame

3. Detecting objects on the road.

Image segmentation process. For image segmentation, the WaterShed algorithm is used, which is already implemented using the OpenCV library. The result of segmentation is illustrated in Fig. 3.

Figure 3. – Detect objects on the road using image segmentation

Cloud computing is the on-demand availability of computer system resources, especially data storage and computing power, without direct active management by the user. The term is generally used to describe data centers available to many users over the Internet. Large clouds, predominant today, often have functions distributed over multiple locations from central servers. If the connection to the user is relatively close, it may be designated an edge server [3].

The system for static objects detection on a video with different roadways will be distributed system of multiple applications: the client side of the system (a program that performs general video processing from the device), the server side (represented AWS services). Figure 4 shows the entire system architecture.

The client side is represented by an application that performs the following actions on an incoming video stream from the device inside a vehicle:

1. Pre-processing:
a. Aligning color balance.
b. White balance.
c. Noise reduction.
2. Video compression. This operation is necessary to reduce the transmitted traffic between cloud services and the client side.
3. Post-processing.

a. Getting the resulting video frame from cloud services.
b. Showing the frame on the device screen.

AWS cloud services are presented as the server side that performs video processing and object detection, so that the load of the client side can be decreased:

1. AWS Cloud Front. This service is necessary to receive all incoming requests from the client. It is a design template "Facade", which closes the entire system from external sources of exposure.
2. AWS Route 53. This service is necessary to redirect requests from the client to the appropriate subnet within the AWS network.
3. AWS EC 2 instance. It is a virtual machine with a pre-installed operating system to perform various kinds of actions. This type of machine is used for the video processing, its segmentation and objects detection, etc.
4. AWS Elastic Load Balancer.

The process of transmitting a video stream between the client and the server will be implemented via the RTSP protocol, which serves to transmit streaming video to the server.

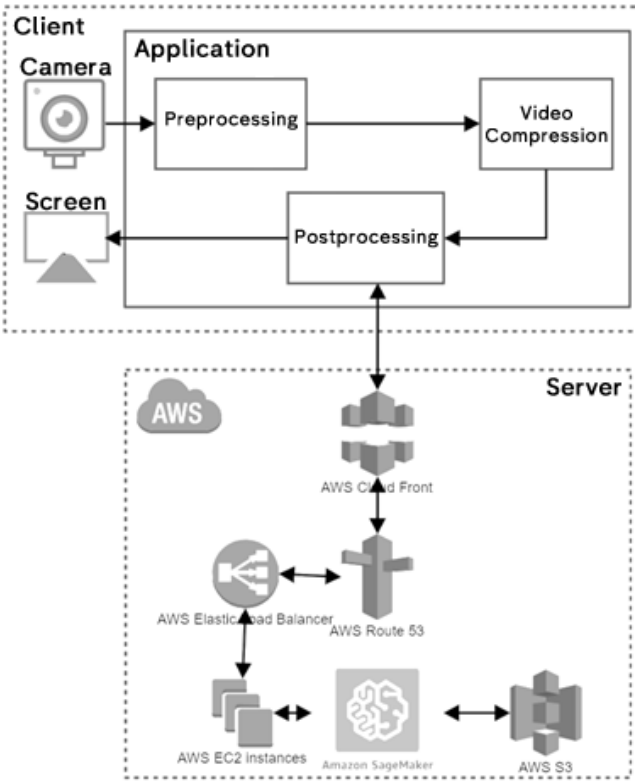

Figure 4. – System architecture

In conclusion, the architecture of this system is complex, but on the other hand, it allows several clients to use it at the same time. While analyzing the system, simple ways to implement load balancing between several AWS EC 2 instance were defined. The main difficulty in the implementation is the transmission of the client-server-client video stream, because the server needs to do a full analysis of the video stream, which requires additional time. Based on this, the resulting video stream containing all objects will be transferred with a little delay.

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APPLICATION MONITORING WITH SPRING BOOT ACTUATOR

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The article introduces a way to monitor and controls Spring Boot applications using Actuator. It describes the functionality of this tool, settings and integration with external application monitoring systems.

After the application is developed and deployed in a working environment, it is very important to monitor its performance. Enterprise applications are changing and becoming multi-level, distributed between different servers or even continents, moving to the clouds. Therefore, such complex distributed applications require control, as in some companies they are the basis of business. Application performance monitoring solves the tasks of monitoring, managing the availability and directly application performance.

Spring Boot Actuator is a subproject in the Spring Boot project. The Spring Boot Actuator module helps you monitor and manage your Spring Boot application by providing ready-to-use features such as health checks, audits, metrics collection, HTTP tracing, etc.

Actuator also integrates with external application monitoring systems such as Prometheus, Graphite, DataDog, Influx, Wavefront, New Relic and many others. These systems provide excellent dashboards, graphs, analytics and alarms to help you monitor and manage your application from a single interface. Actuator uses Micrometer, a facade of application metrics, to integrate with these external application monitoring systems. This makes it very easy to connect any application monitoring system with minimal settings.

To enable Actuator, you just need to add the dependency to the Spring Boot application package manager. Examples of dependencies for Maven and Gradle are shown in Listings 1 and 2, respectively.

Listing 1 – Add a dependency to a Maven project

```
<dependencies>
  <dependency>
    <groupId>org.springframework.boot</groupId>
    <artifactId>spring-boot-starter-actuator</artifactId>
  </dependency>
</dependencies>
```

Listing 2 – Add a dependency to a Gradle project

```
dependencies {
  compile("org.springframework.boot:spring-boot-starter-actuator")
}
```

Actuator creates several so-called endpoints that can be accessed via HTTP or JMX so that you can track and interact with your application. For example, there is a /health endpoint that provides basic application health information. The /metrics endpoint shows some useful metric data, such as used JVM memory, system CPU usage, open files, and more.

By default, all endpoints open through JMX, but only /health and /info are provided through HTTP. To access all endpoints via HTTP, add the management.endpoints.web.exposure.include = * property in the application.properties file. If you need to add access only to some endpoints, then you should list the id of these endpoints in the property value.

A list of available endpoints available via HTTP can be obtained from the base endpoint /actuator. The list of end points is presented in the table.

The /health endpoint shows only a simple UP or DOWN state. For complete information, including the status of each health indicator that was checked during the health check, add the management.endpoint.health.show-details = always property to the application.properties file. After that, /health displays more information, including details of the DiskSpaceHealthIndicator, which starts as part of the application health check process. If a database is connected to your application, then /health will show the current state of connection to it. You can also create your own health indicator by implementing the HealthIndicator interface or by extending the AbstractHealthIndicator class.

Table. –Spring Boot Actuator endpoints and description

ID	Description
auditevents	Exposes audit events information for the current application
beans	Displays a complete list of all the Spring beans in your application
caches	Exposes available caches
conditions	Shows the conditions that were evaluated on configuration and auto-configuration classes and the reasons why they did or did not match
configprops	Displays a collated list of all @ConfigurationProperties
env	Exposes properties from Spring's ConfigurableEnvironment
flyway	Shows any Flyway database migrations that have been applied
health	Shows application health information
httptrace	Displays HTTP trace information (by default, the last 100 HTTP request-response exchanges)
info	Displays arbitrary application info
integrationgraph	Shows the Spring Integration graph
loggers	Shows and modifies the configuration of loggers in the application
liquibase	Shows any Liquibase database migrations that have been applied
metrics	Shows 'metrics' information for the current application
mappings	Displays a collated list of all @RequestMapping paths
scheduledtasks	Displays the scheduled tasks in your application
sessions	Allows retrieval and deletion of user sessions from a Spring Session-backed session store
shutdown	Lets the application be gracefully shutdown. Disabled by default
threaddump	Performs a thread dump

The /metrics endpoint lists all the metrics you can track. To get detailed information about a particular metric, you need to pass the metric name to a URL, like this http://localhost:8080/actuator/metrics/{MetricName}. In response, the details of the metric in JSON format will be received.

The endpoint /loggers displays a list of all loggers configured in the application with the appropriate logging levels. You can also view information about an individual logger by passing its name in the URL, for example: http://localhost:8080/actuator/loggers/{name}. The endpoint /loggers also allows you to change the logging level of the specified logger during application execution. This functionality will really be useful in cases where your application encounters problems with work, and you want to enable DEBUG logging for a while to get more detailed information about the problem.

The endpoint /info displays arbitrary information about your application. Actuator obtains assembly information from the META-INF/build-info.properties file, Git information from the git.properties file. It also displays any information available in the environment properties with the info key. You can add properties with the info key in the application.properties file as in Listing 3.

Listing 3 – Add custom information to Spring Boot Info Actuator

info.app.name=@project.name@
info.app.description=@project.description@
info.app.version=@project.version@
info.app.encoding=@project.build.sourceEncoding@
info.app.java.version=@java.version@

Endpoints Spring Boot Actuator is recommended to protect against unauthorized access. If Spring Security is present in your application, then these endpoints will be protected by default. You can also set your own security settings for them.

Spring Boot Actuator allows you to implement your custom breakpoints. To get the endpoint, you need a bean that can be created using the @Component annotation. To access the endpoint, you must specify the id parameter in the @Endpoint annotation, which will be responsible for the path /actuator/{id}. The annotations @ReadOperation, @WriteOperation, @DeleteOperation process HTTP GET, POST and DELETE, respectively, and execute the methods that apply.

It provided a description of a powerful tool for controlling, monitoring and managing applications - Spring Boot Actuator. This Spring Boot subproject has the ability to flexibly configure, customize, and create custom

endpoints. Actuator can be used with external monitoring systems, which allows the user to work with all metrics and parameters through a single interface

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UDC 004.054

TEST-DRIVEN DEVELOPMENT - DEVELOPMENT THROUGH TESTING: ADVANTAGES AND DISADVANTAGES

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This article is devoted to the TDD development method. Its advantages and disadvantages are analyzed.

Introduction. Software testing is a procedure that allows you to confirm or deny the efficiency of the code and the correctness of its operation. During testing, the input data is transmitted to the application and the execution of a certain command is requested, after which the results are checked for compliance with the standard, if the result is as expected, the test is considered passed. This procedure can be automated, in this case, checking the operability and correct operation of the application in comparison with manual testing is much faster, more complete and actually more often.

To create a successful IT project, an important step is the selection of a development methodology that contains its own approach to the process of creating programs in the form of steps, tasks, actions. There are many such methods, each has its own advantages and disadvantages, and the choice mainly depends on the task. One of them is Test-Driven Development method – development through testing. Methods of counteracting attacks on DW systems.

The main part. TDD is a software development process that requires a programmer to write an automated test case for the required functionality (initially faulty), then add the minimum code necessary to pass the test and, finally, reorganize the code and make sure that the automated tests still pass. In traditional methods, code is first written, and then test cases are developed to test the code. In TDD, test cases (usually called unit tests) to satisfy the requirement are written before the implementation begins.

TDD consists of a "red – green – refactor" cycle

Stage Red. A test is written that represents the necessary behavior of the system, then a stub method is created so that you can quickly assemble the project. The test compiles, but does not return the desired result. There is a need to write a program.

Stage Green. Minimal code is written that would allow the test to execute correctly. In reality, this means that code is written without structure, without design, without any design patterns. Now there is a need to give the code a "beautiful look".

Refactoring phase. The external structure of the code changes, without changing its external behavior. This division into methods, adding elements of a design pattern, creating additional classes, etc. The sequence of steps in a cycle is very important. The principle of the Test First method implies that only code is written that is absolutely necessary for all tests to pass successfully.

The TDD operation algorithm can be described as follows:

- Add a test for new (not yet implemented) functionality or for playing an existing bug.

When developing through testing, adding each new feature to the program begins with writing a test. Inevitably, this test will not pass because the corresponding code has not been written yet. (If the written test passes, it means that either the proposed "new" functionality already exists or the test has flaws.) To write a test, the developer must clearly understand the requirements for the new feature. For this, possible usage scenarios and user stories are considered. New requirements may also entail changes to existing tests. This distinguishes development through testing from techniques when tests are written after the code has already been written: it makes the developer focus on requirements before writing code - a subtle but important difference.

- Run all tests and make sure the new test fails.

At this point, verify that the tests just written do not pass. This stage also checks the tests themselves: a written test can always take place and, accordingly, be useless. New tests should not pass for obvious reasons. This will increase the confidence (although it will not guarantee completely) that the test really tests what it was designed for.

- Write a code that will pass the test:

o Run the tests and make sure that they all were successful: passing the new test confirms the implementation of the new functionality or correcting the existing error, and passing the rest allows you to make sure that the previously implemented functionality is still working correctly.

o To do refactoring and optimization - it is advisable to carry out improvement of maintainability and speed of performance already after it turned out to achieve verifiable performance.

- Restart tests and make sure they still pass successfully.
- Repeat cycle.

The described cycle is repeated, realizing more and more new functionality. Steps should be made small, from 1 to 10 changes between test runs. If the new code does not satisfy the new tests or the old tests stop passing, the programmer should return to debugging. When using third-party libraries, you should not make such small changes that literally test the third-party library itself, and not the code that uses it, unless there is a suspicion that the library contains errors.

Methodology advantages:

- Reduced debugging time. If you do not use the TDD methodology, it will take less than pure time to write code. However, the time spent on tests pays off when debugging code and catching errors - and this part of the development process is always present, because it is almost impossible to write code without a single error, and this is normal. Thanks to TDD, there is no need to guess where the error is located, the tested code is easier to maintain.
- Convenience of changeability. Coverage with tests helps to avoid the situation when, when changing the code in one place, an error occurs in a completely different part of the code. In the end, this allows you to safely change or refactor the code, because if something goes wrong, then the tests will immediately handle the emergency situation.
- Tests, especially if they are written in an expressive style, can serve as the technical documentation of the project, which describes how the code should work. Such documentation is very useful for new developers in the project who, in order to get involved in the work, must first deal with the code. The test in this case serves as a concrete example of the use of code. Full coverage of the code with tests provides a huge practical documentation of the code that reflects the real state of the system.
- Modularity. One of the principles of development through testing provides that each function performs a certain, small part of the work, because it is simply impossible to test the "omnipotent" method, which performs a dozen functions in several threads. All this forces the program to be divided into modules so that all branches of the code can be tested.
- Full tests. There is a big difference between writing regular tests and TDD tests. When tests are written after implementation, it is likely to receive defective tests due to the fact that not all scenarios of the method can be taken into account. For example, it may be considered that the written method works because it passes the test, but in fact it may turn out that not all conditions are covered in the method with tests. Using TDD prevents this from happening because the condition cannot appear in code without a test.
- TDD is the best way to ensure that tests actually cover all requirements, not just code. In addition, TDD helps you avoid falling into the "trap": adding functionality that the client does not really need, but would be nice to have.

Disadvantages TDD:

- The ability to apply TDD is not always available. There are tasks that cannot be solved only with the help of tests. For example, these are tasks in the field of data security and interactions between processes. Sometimes it's difficult to immediately imagine how the module will look. In addition, it is impossible to solve with the help of TDD the development of databases, compilers and interpreters of programming languages, it is impossible to automate testing of the graphical interface and distributed objects.
- Initial requirements cannot always be understood and correctly interpreted. As a result, you can get an error in the test, in the code and in understanding. The danger of the situation lies in the fact that it seems that everything works correctly, because the tests pass the green stage. On all this, you can lose a lot of time.
- The need for test support. The base of the code with one hundred percent coverage of tests is almost doubled. And besides, this entire database needs to be documented, maintained, and refactored.

Conclusion. This methodology allows us to achieve the creation of an application suitable for automatic testing and a very good coverage of the code with tests, since TK is translated into the language of automatic tests, that is, everything that the program should do is checked. TDD also often simplifies software implementation: since redundancy is eliminated - if a component passes the test, then it is considered ready. If the existing tests pass, but the component does not work as expected, this means that the tests do not yet reflect all the requirements and this is an occasion to add new tests.

The architecture of software products developed in this way is usually better (in applications that are suitable for automatic testing, the responsibility between the components is usually very well distributed, and complex procedures that are performed are decomposed into many simple ones). The stability of the application

developed through testing is also higher due to the fact that all the main functional capabilities of the program are covered by tests and their performance is constantly checked. Accompanying projects where everything or almost everything is tested is very high - developers may not be afraid to make changes to the code, if something goes wrong, the results of automatic testing will inform about this.

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UDC 004.223.2

DEVELOPING A SYSTEM FOR HIDDEN INFORMATION USING A TRANSPOSITION CIPHER

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This article discusses: an algorithm for hiding data using a permutation cipher and the main functions of the developed software product.

Introduction. The problem of protecting information by transforming it, excluding it from being read by an outsider, has worried the human mind since ancient times. The history of cryptography is the same age as the history of human language. Moreover, in the beginning, writing itself was a cryptographic system, since in ancient societies only the elite owned it. The sacred books of Ancient Egypt, Ancient India are examples of this.

Main section. To develop a software tool for the organization and functioning of the program, you must select the development environment with which the design will be carried out.

To develop this application, C # was chosen.

The main functions of the developed software product are data encryption and decryption.

A permutation cipher is a symmetric encryption method in which elements of the original plaintext are interchanged. Elements of the text can be individual characters (the most common case), pairs of letters, triples of letters, a combination of these cases and so on.

Permutation cipher algorithm:

The original message is divided into blocks of length m, where m is the key length.

The key in the permutation cipher is as follows:

1	2	3	4
2	4	1	3

Permutation Cipher: Key

The first line of the table shows the numbers of the block characters in order, and the second line shows the numbers of the positions that these characters should occupy in the encrypted text block.

Coding is carried out by permutation of letters. Thus, the first character from the source block should be rearranged in second place, second in fourth, third in first, fourth in third.

If you encrypt the word coffee with this key, you get the word phkeo.

Decryption is performed in reverse order. Using the specified key as an example: put the second character from the encrypted block in first place, fourth in second, first in third, third in fourth.

When using any block cipher (permutation cipher is no exception), a situation may arise when the text is not divided into equal blocks of length m. That is, the remainder of dividing the length of the text n by the length of the key m is not equal to zero.

In such cases, the length of the original message is increased by m - (n% m) characters so that it is divided into equal blocks of length m.

Listing 1 – Transposition cipher

```
1::  class Transposition
2::  {
3::  private int[] key = null;
4::  public void SetKey(int[] _key)
5::  {
6::  key = new int[_key.Length];
7::  for (int i = 0; i < _key.Length; i++)
8::  key[i] = _key[i];
9::  }
10:: public void SetKey(string[] _key)
```

```
11::  {
12::  key = new int[_key.Length];
13::  for (int i = 0; i < _key.Length; i++)
14::  key[i] = Convert.ToInt32(_key[i]);
15::  }
16::  public void SetKey(string _key)
17::  {
18::  SetKey(_key.Split(' '));
19::  }
20::  public string Encrypt(string input)
21::  {
22::  for (int i = 0; i < input.Length % key.Length; i++)
23::  input += input[i];
24::  string result = "";
25::  for (int i = 0; i < input.Length; i += key.Length)
26::  {
27::  char[] transposition = new char[key.Length];
28::  for (int j = 0; j < key.Length; j++)
29::  transposition[key[j] - 1] = input[i + j];
30::  for (int j = 0; j < key.Length; j++)
31::  result += transposition[j];
32::  }
33::  return result;
34::  }
35::  public string Decrypt(string input)
36::  {
37::  string result = "";
38::  for (int i = 0; i < input.Length; i += key.Length)
39::  {
40::  char[] transposition = new char[key.Length];
41::  for (int j = 0; j < key.Length; j++)
42::  transposition[j] = input[i + key[j] - 1];
43::  for (int j = 0; j < key.Length; j++)
44::  result += transposition[j];
45::  }
46::  return result;
47::  }
}
```

Conclusion. This article examined the information hiding algorithm using a permutation cipher, as well as the main functions of the software product being developed.

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UDC 338.45.01; 004.05

ORGANIZATIONAL AND ECONOMIC CONDITIONS FOR THE DEVELOPMENT OF A MOBILE APP FOR FINDING SPORT PARTNERS

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The idea of a healthy lifestyle is actively promoted around the globe nowadays. It is very prestigious to be a professional sportsman. However, sport has low priority for the young generation. Modern young people in every way try to get away from various physical activities, which leads to scoliosis, obesity and other health problems. It is possible to avoid all of that just by doing sport. It would be great to have a team that shares your interests. The youth are actively accessing internet-based resources using their smartphones. It could help them find team members. A mobile app for finding sport partners could make it much easier especially if it contains actual info about sport events nearby and allows joining them as a sportsman or a fan.

Innovation projects (apps) usually have a pretty short life cycle because the number of analogues with the same or even better functionality is rapidly growing. There are almost no competitors on the Belarusian market (unlike the Russian market). Moreover, not many companies are interested in building social projects. They are pretty popular abroad including the Russian Federation. Usually these are social networks or brand apps like Nike [1]. During app creation, it is important not only to develop (that requires investments) an app but also sell it and get profit. Profit could be made only in case of demand on the app. That is the reason for the research on the prospects of the development and usage of a mobile app for finding sport partners in the Republic of Belarus.

The results of the research are presented below.

Logical-structural approach (LCA) is effective during all the phases of the life cycle (introduction on the market, growth, maturity and decline) of the project, especially during its identification, development, and monitoring. This approach is widely used in different kinds of projects (launching new products to the market, modernization of existing products), carried out by a variety of international, governmental and commercial organizations.

The logical-structural matrix for the development of a mobile app for finding sport partners in the Republic of Belarus is presented in table 1.

Table 1. – Logical-structural matrix of the app

Participation logic	Objectively verifiable indicators of achievements	Sources and resources of verification	Assumptions
1	2	3	4
Common goals	Improving the health of the young generation	Promoting app at schools and universities, thematic groups, targeting	People are passive, they prefer to spend time on gadgets
Project aims	Involving young people in doing sports, increasing the level of their live communication	Apps are changing rapidly, so there's need for swift tech support. Authorization is possible only via social networks or messengers	People do not want to do sports, there are no sport events nearby
Expected results	Income from users for a subscription (extended functionality of application)	People will buy a monthly subscription. Sports events will become more popular. Sport event organizers will reduce their marketing expenses	A small number of subscribers, the difficulty in finding free places for sports, a small number of organizers of free sports events
Activities	Searching for sponsors during sports events, notifying users about upcoming free sport events	Making relationships with popular brands, educational institutions, sports equipment shops	A lot of rejections in participating in the startup app. The events announcement can be late

The tree of issues for the realization of a project to launch an app on the market is presented in picture 1.

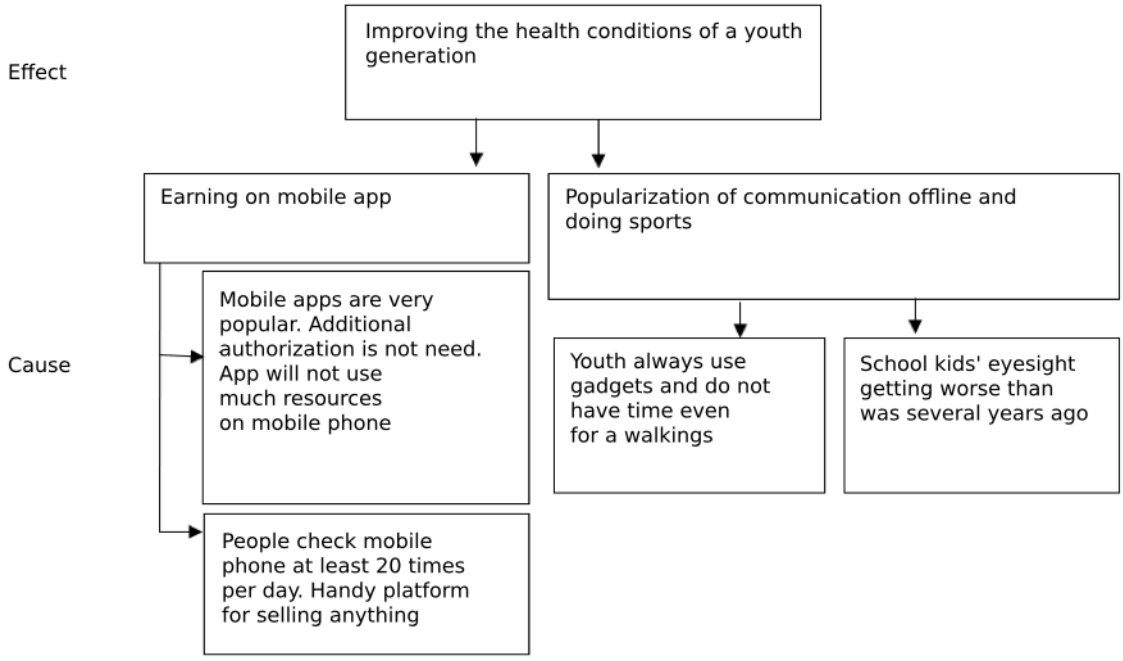

Figure 1. – Tree of issues for the realization of a mobile app

The main problem is the fact that the team of developers of the app is unknown and, as a result, big brands will not collaborate with us. It will not be possible to announce sports events consistently because of a small number of them in the cities nearby. The transportation problem has to be solved to announce sports events in suburban area.

The tree of goals that was created to solve the specified problems is presented in picture 2.

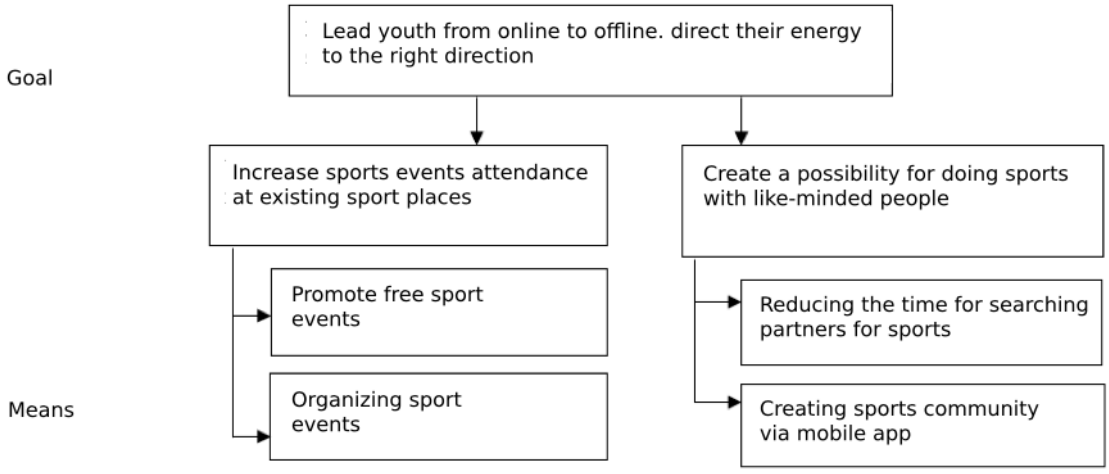

Figure 2. – Tree of goals

The key goals are reducing the time for searching for sport partners as well as involving the youth in active lifestyle and minimizing their being online.

Currently, the youth usually like to spend time on social networks, the internet as well as visit clubs and bars that leads to health issues. There are a small number of places for sports in the Republic of Belarus. It results from the fact that people are inactive and can't afford to pay rent. Moreover, the existing sports grounds are not used in a proper way.

Work breakdown structure clearly shows the final goal of the project for participants and all people interested in the project. Usually, structure for dividing (decomposition) of work is a hierarchical structure of consistent decomposition of project to sub-projects, packets for different types of work, detailed work packets.

Table 2. – Work breakdown structure for creating an app

Intervention logic	Objectively verifiable indicators of achievements	Sources of verification	Assumptions
1	2	3	4
Common goals	Improving the health of the young aged 14-30	Number of participants in sports events	Failure to meet expected indicators, cancellation of sports events, non-interactive sport events. They may be organized on the «broken» sports grounds
Project aim	Number of users, downloads, users who have a monthly subscription	Services of statistics. Funds deposited to the payment platform	Weak promoting, unclear user interface
Results	Monthly income of 30,0K BYN. Number of organized events and people who visited them	The app will generate barcode for visiting sport event	Low activity of advertisers. Low level of interactivity in the app. Lack of intention to organize sports events for free
Actions	Targeted advertising, implementing a referral system (set of exercises or subscription for 1 month as a gift in case of inviting 3 new users)	Conversion rate to the downloaded app. Weak user growth	Wrong setup of advertisements (the target audience will not see it). The referral system will not work as expected

The main goal on the mission level is improving the health condition of the youth as presented in table 2. The objective indicator of the success of the app is the number of download and users who bought paid subscription. As a result, the mobile app will bring 30,0K BYN monthly. Targeted advertising will be required to promote the mobile app at the first stage. Also, the app will be promoted during organized sports events. Google Play and App Store will show the application in the top 10 results in thematic sections and promoted region.

Functional-oriented work breakdown system for the development of a sport mobile app as an innovative product in the Republic of Belarus is presented in picture 3.

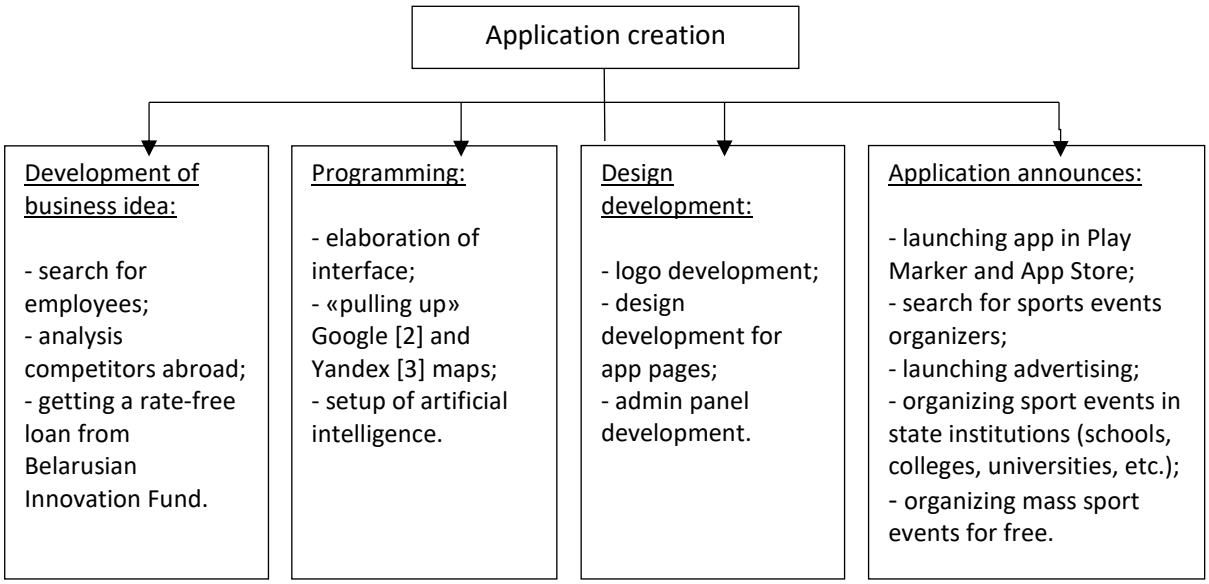

Figure 3. – Functional-oriented work breakdown system for developing a mobile app

Developing and launching of a mobile app for finding sport partners in the Republic of Belarus consists of 4 blocks of work: development of business idea, programming, design development and application

announcement. It is planned to borrow an interest-free loan for developing and launching the project. School kids and students will be the main users of the developed application. Public and private educational institutions will be the main advertising places. Along with this, advertising is planned on social networks where all the target audience (the youth) are located. This project is very important for the government because its main goal is the youth health improvement. Also, the project will create demand for places for sports which will lead to reduced rental rates of sports grounds. This means that school kids and students will be able to afford it. The mobile app will allow people to find sport partners and jointly rent sport places as well as organize free events to involve the youth in sport. The basic functionality of the app is presented in picture 4.

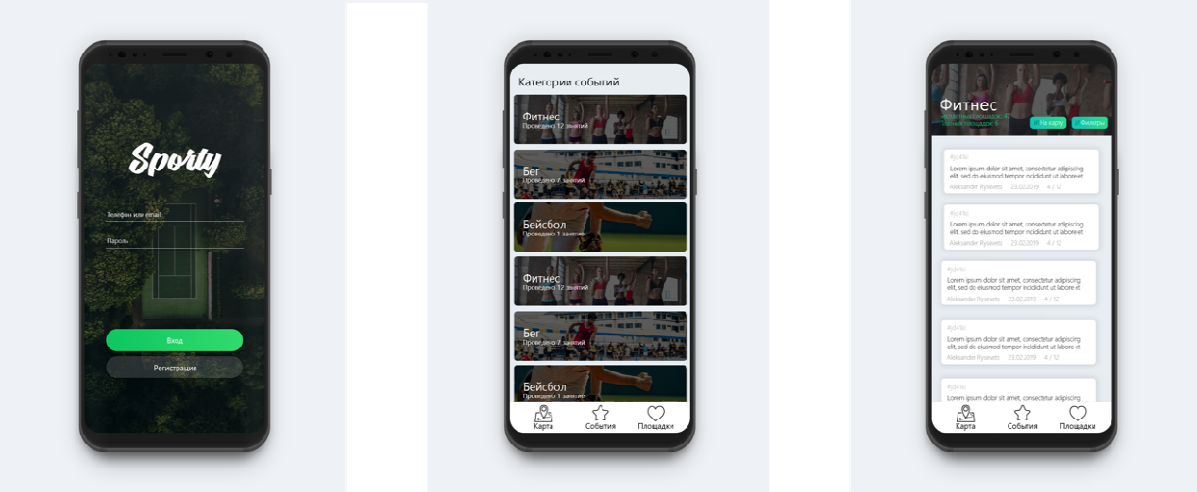

Figure 4. – Basic functionality of the mobile app

Thus, this article presents the main principles of launching a mobile app for finding sport partners and justifies the resources for its implementation. Hopefully, the use of the developed app will lead to the growing number of people who do sports and will help them to create and join teams as well as reduce rental rates of sports grounds. The detailed investigation of the issues presented in the article helped to avoid a lot of mistakes during the development of the project.

The project has high social orientation because it corresponds to the priority areas of the Government Action Program of the Republic of Belarus for 2016 – 2020 (Resolution of the Council of Ministers of the Republic of Belarus 05.04.2016 № 274) on issues of socio-economic development of the country and focuses on the improvement of the level and quality of life in the Republic of Belarus.

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UDC 004.415.25

MEANS OF MOVEMENT OF THE USER MODEL IN THE VIRTUAL REALITY APPLICATION

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In this paper, we examine different means of movement of the user model in the vr application and explore how they can effect human player.

The effect of staying in virtual reality. To this day, the most urgent issue of developing virtual reality applications is minimizing the discomfort associated with the dissonance of the organs of the audio-visual attitude and spatial orientation organs during the use of virtual reality applications.

The basis of this discomfort is the player's movement in the virtual world. In total, five movement options are distinguished: natural movement, teleportation, physical movement, artificial movement and vehicles.

Teleportation, in fact, transfers the entire fixed game space to the place indicated by the player, otherwise the player, as with natural movement, is limited to the physical space registered by the sensors. Vehicles help limit motion sickness by allowing the player to have a visual anchor in the form of a virtual object within which the player moves in the virtual world. Physical movement allows the player to move themselves with some physical actions, such as flapping wings, which leads to the expected result for the player and reduces the motion sickness effect [1][2].

Artificial movement gives the player more freedom than other options and is suitable for creating action games and quest-labyrinths, it is controlled with the minimum movements for the player (pressing a button on the controller), which is familiar to most users and makes it easier to transfer existing games in VR [1].

During the development of the application, three of the five types were implemented, namely: teleportation, physical movement and artificial movement. Natural movement is inherent in the very essence of detecting virtual reality equipment with sensors, so that it consists of the project initially. Transport movement was not implemented due to the inappropriate artistic theme of the project.

Engineering of the application. Application was implemented using Unreal Engine 4.

Based on the characteristics, requirements and standards of the structure of such projects, a functional diagram was compiled, consisting of the modules presented below:

1. MotionControllerPawn - a player model containing a camera, collisions, additional objects and part of the logical structure of the player's actions.
2. BP_MotionController - a model of the player's controller that contains the logic of the player's interaction with the outside world.
3. BP_ClimbObj - an object for the physical movement of the player.
4. BP_Button - the parent object of the button.
5. BP_Portal - a child of the button responsible for teleporting the player to a specific point.

Implementation of movement. The most common type of movement in virtual reality applications is teleportation. In the basic template project of virtual reality of the Unreal Engine 4 engine, there is an implemented system of teleportation, which is the main system for moving the basic project. This type of teleportation transfers the player's model to the point indicated by the player on the playing field.

This project implements a different type of teleportation. Unlike the type indicated above, the player does not control the exact position in which he will move. Moving by pressing the button object (BP_Portal) in the virtual world and has a fixed value. At the same time, during the movement itself, the image is darkened, which can significantly reduce the motion sickness effect.

The BP_Portal function, shown in Figure 1, performing the movement is called Event Button Action, and has, in addition to the Add Actor Local Off-set, which moves the player to the teleportation endpoint, the Start Camera Fade function blocks at the beginning and end of the movement, which darkens the image, returning it after the end of the movement.

To implement the player's movement in a horizontal plane with voiced steps, a solution was developed, shown in Figure 2.

A position value is read from the joystick (for Oculus) or the touchpad (for HTC Vive), which changes from -1 to 1 along the X and Y axes. This value is passed to the Moving Forward function for the Y axis and Moving

Right for the X axis. Also, these values are compared to zero, as they are read continuously, and if at least one of them is not equal to zero it changes the value of the boolean variable Is Moving to True, if both values are zero, Is Moving becomes False.

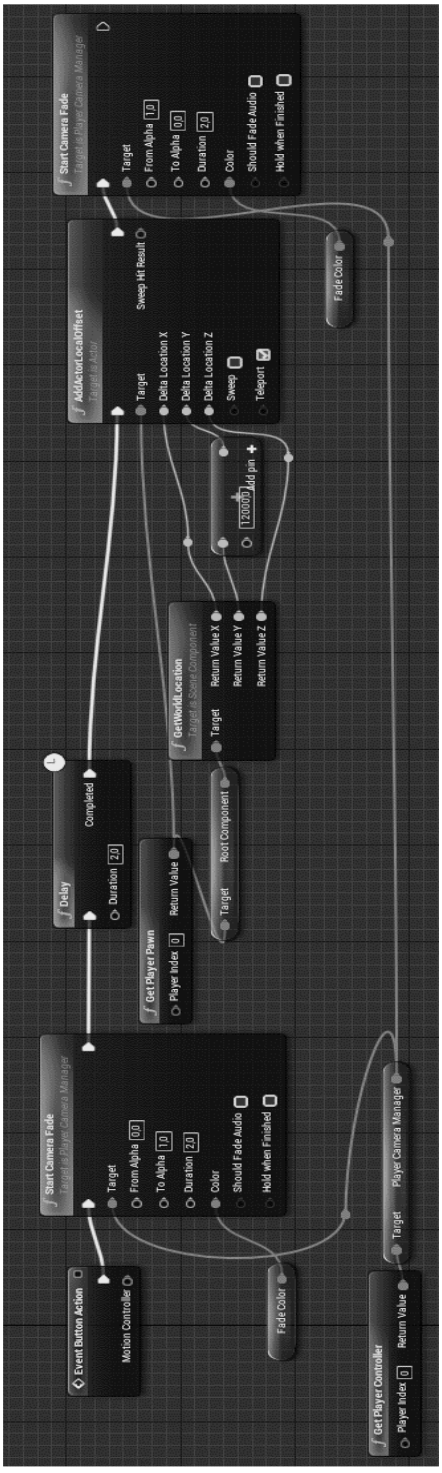

Figure 1. – Implementation of the fixed-point teleportation

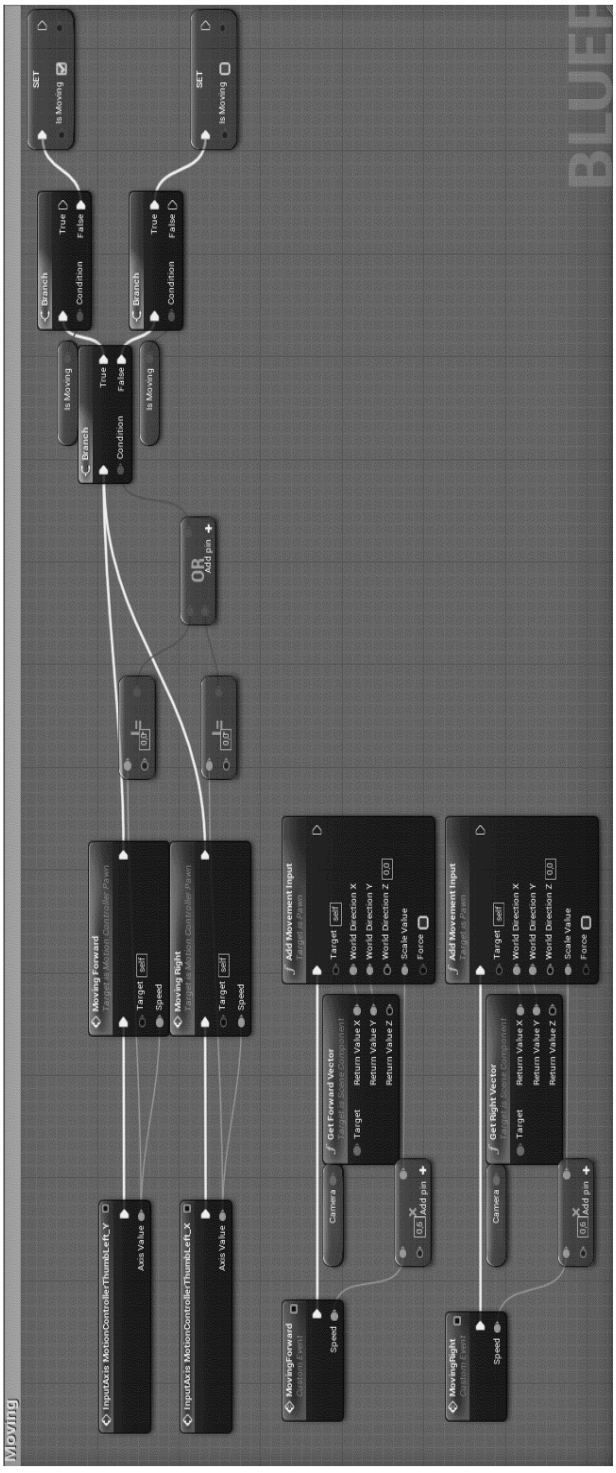

Figure 2. – Implementation of the linear movement

In functions, the values of the axes are multiplied by a constant equal to 0.6, identified experimentally as the most comfortable for this type of movement. Further, this constant, by means of the built-in Add Movement Input function, is summed up with the direction of the camera looking forward for Move Forward and right for Move Right.

At such a speed of movement, during testing, the average time of a game session before the onset of disorientation was checked. According to the testing data obtained at the first game session, the average value of its duration is 6 minutes. When repeated, the time can increase up to 30 minutes without the occurrence of a simulator disease.

Physical movement is implemented by the interaction of several modules: a controller component that stores the 3D model of the controller and its animation BP_MotionController, a component of the MotionControllerPawn player that stores all the basic user functionality, the interface that connects the player and the components with which it interacts, and a component of surfaces for vertical movement BP_ClimbObj, which stores a model of a surface primitive for vertical movement, as well as specially created material for a simplified perception of objects of that type. In addition, the BP_ClimbObj component stores the logic of movement along vertical surfaces.

The logic of such a movement is as follows: the player has two controllers, each of which interacts with an object of a certain type (a special wall for moving). At the moment the interaction begins, the entire player's model begins to move relative to the point at which the interaction of the controller and the object began, this movement occurs with the help of the controller, the model of which is fixed at the above point.

Conclusion. Any given type of movement can be used in virtual reality application. Nevertheless, it depends on the specific genre or goal of the project. And, of course, it is important to understand the effect of virtual interactions on the organism of the user. Summing up, one of the most crucial things in vr project is to choose accurate type of movement and implement it carefully.

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UDC 528.7

USE OF UNMANNED AERIAL VEHICLES WHEN PERFORMING TOPOGRAPHIC SURVEYS

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The article discusses the possibility of using unmanned aerial vehicle when performing topographic survey, data processing and accuracy. Current work is based on a practically obtained data.

Introduction. One of the most popular tasks conducted in geodesy is topographic survey and drawing up a detailed plan of the area. Such methods as tacheometry, satellite positioning in RTK mode, airplane-based surveying as well as airborne laser scanning are widely used for topographic surveying nowadays. On the other hand aerial survey using an unmanned aerial vehicle (UAV) has become a worthy alternative to the traditional aerial survey from airplanes and helicopters, and in a number of cases even ground survey.

The aim of the work is to study the UAV data treatment process using Trimble INPHO UASMaster software and to analyze the possibility of using UAVs in engineering and geodetic surveys based on practically obtained data.

Among the main advantages of UAV-based surveying compared to airplane-based one are: reduction of surveying time, less expensive cameras and other equipment, convenience of transportation of aircraft, easiness of operation and route laying, objectivity and accuracy of the results, high level of details, easiness of analysis and data perception, efficiency (the whole cycle from surveying until the final results takes several hours), environmental safety, etc. An important advantage of survey using UAV compared to satellite positioning systems in RTK mode or tachometry is efficiency for surveying of poorly built and sparsely populated areas [1, 2]. UAV-based surveying has also such limitations as weather and season dependence. But these factors significantly affect other methods of surveying as well.

As for the scale range the author [3] says that UAV-based survey is limited to the scale range 1: 5000 - 1: 1000. Since the surveying at the scale smaller than 1: 5000 is more efficient when conducted using satellite images and the surveying at the scale larger than 1: 1000 is to be combined with ground-based methods.

Methods and results. In order to go through the UAV data treatment and analysis process for the purposes of the current work 60 JPEG images obtained by a quadrocopter DJI Mavic Pro over the territory of "new building" of the Polotsk State University in Novopolotsk were used. UAV carried out a remote-controlled flight by an operator. Data set consists of 4 routes.

UAV data processing for the purpose of topography is quite a new field. But the manufacturers aimed at the development of its UAV complex are interested in creating software that is capable of solving the tasks. One of the world leaders in the UAV market is the company Trimble which is a worldwide known manufacturer of geodetic equipment as well. It also develops software Trimble INPHO UASMaster for photogrammetric processing of UAV data. The software offers a streamlined batch processing and various editing tools. UASMaster is bridging the gap between simple black-box workflows for non-photogrammetrists and photogrammetric expert workflows [4]. Among other software in the field of UAV data processing are ENVI OneButton, PHOTOMOD UAS, Agisoft PhotoScan, etc.

The general data processing sequence in the Trimble UAS Master is represented by the following main steps:

- data preparation and project setup;
- phototriangulation including extracting tie points, camera calibration, report creation;
- extraction of Digital Elevation Model (DEM): creating point cloud, editing the point cloud,
- creation of orthophoto.

As a result, 2523 tie points were automatically acquied for 60 images in UASMaster.

In total, 5 ground control points and 22 check points were used in the work. Their coordinates were obtained in field within some other student's work and accuracy of coordinates is not matter of current research. Ground control points are determined on one of the images and software automatically locate it on all the images where point appears. Then it remains to clarify its position. It is enough to measure point on 3 images.

At the next step point cloud is generated. Automatically generated point cloud has gaps which appeared in places of weak overlaps of images, areas covered with tree-shrub vegetation. Gaps in the point cloud

are shown in Figure. Such gaps may be edited manually if needed. The final result of data processing is an orthophoto.

As a result of processing in Trimble INPHO UASMaster phototriangulation including the tie points extraction, camera calibration, point cloud and orthophoto generation are performed. Assessment of orthophoto is performed by ground control and check points.

Discussion and conclusion. Visual analysis of the orthophoto shows a high-quality imaging result. The boundaries of the building, lawns, asphalt roads and a training car site located in the area are clearly visible.

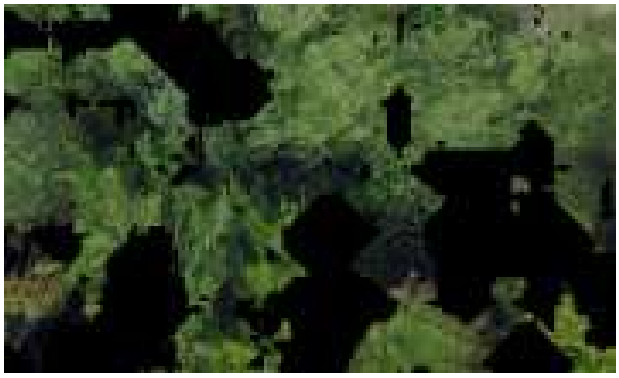

Figure. – Gaps in point cloud

Trimble INPHO UASMaster is photogrammetric software capable of processing data from various cameras. But software is quite sensitive to data features. For example, there was a problem of single camera definition for all 4 routes. The program has produced an error without mentioning the reason for the refusal for data processing, what caused some difficulties to find out the source of the error. On the other hand it helped to discover the errors within the data acquisition process. In general, it can be noted that UASMaster is a powerful software in the field of photogrammetric processing of data from UAVs.

Root mean square (RMS) errors in planned positions of check points used for orthophoto accuracy assessment have shown that it fits in general to the requirements of 1:1 000 according to surveying requirements. RMS error of vertical position was not tested. On the other hand coordinates of ground control as well as check points which were obtained within another work and their reliability must be checked as well before making final conclusion.

Nowadays, the development of the civilian UAV market, including its development for the needs of aerial photography, suffers from the lack of legal framework for the integration of UAVs into a single airspace. Unfortunately the problem of legal regulation of wider civil use of UAV nowadays is not solved completely in almost any country of the world.

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UDC 004.42

WEB APPLICATION FOR SMALL BUSINESS MANAGEMENT

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This article describes the importance of developing and implementing software for managing small and medium-sized businesses in the Republic of Belarus. The paper also has a description of the developed software, technologies used in the development process, as well as the architecture of the application.

Small and medium-sized business in the Republic of Belarus plays an important role in the socio-economic development of the country. It contributes to the formation of a competitive environment, provides growth in the production of consumer goods. Thanks to it, the service sector expands, and the economy is given additional stability. The importance of small business is also determined by its features such as the ability to quickly respond to consumer demand and quickly meet it, quickly respond to changes in market conditions and demonstrate high maneuverability. What is more, small business provides the country with many new jobs. This, in turn, leads to a reduction in the number of unemployed people.

Due to the low level of competition and strong fragmentation of the market, small business in Belarus can develop quite successfully. In every area, from the supply of household and computer equipment to the sale of food products, there is a certain growth reserve.

The business environment of Belarus is formed mainly from small and medium-sized companies. Due to the rapid growth in the number of small companies, there is a need for software for business management. Such applications allow to manage the warehouse, goods, orders, managers, customers, etc. Thus, the user can facilitate and accelerate the conduct of his business, increase sales and, accordingly, increase the level of income of the organization [1].

One of the most powerful tools in the arsenal of modern leaders are automated systems of the Enterprise Resource Planning (ERP) class. ERP class systems are a full-featured set of applications integrated among themselves that allows you to create a unified environment for automating the planning, accounting, control, analysis and management of enterprise business processes in the field of financial, inventory, production and logistics flows, accounting, personnel management, regulation of relations with counterparties, reporting, etc.

The company's resource management systems are being introduced in order to combine all the company's divisions and all the necessary functions in one computer system that will serve the current needs of these divisions. Thanks to the one-time input of data into the mutual database of the company, information can be used simultaneously by any number of users of the system, which increases the effectiveness of both planning and control, as well as ensures the coherence of actions of all parts of the enterprise and the productivity of management in general.

ERP systems with a web interface make it possible to combine geographically remote branches and divisions of the company and involve them in a single information space. Enterprise management systems allow you to create a kind of information channels that can connect the enterprise with partner companies to provide them with access to the enterprise database and exchange the necessary information. As a result of such cooperation, a single information archive is formed, which allows optimizing the supply processes, deliveries and other types of joint activities, as well as bringing the whole process of interaction to a whole new level [2].

Implementation of the enterprise management system makes the company's business processes more transparent, increasing its attractiveness to investors, and, therefore, allows attracting additional investments for further development of production.

The developed system is based on the client-server architecture, in which tasks or network load are distributed between service providers, called servers, and service customers, called clients. The Internet is used as a medium for client-server interaction.

MVC concept is used on the backend side – Model-View-Controller – a scheme for dividing application data, user interface and control logic into three separate components: model, view and controller. This architecture allows the software to be more flexible, so that each component can be modified independently [3]. Backend of the application is written in PHP language. Laravel was chosen as a framework because it is a free and open-source. It is intended for the development of web applications following the MVC architectural pattern and based on Symfony framework. Some of the features of Laravel are a modular packaging system with a dedi-

cated dependency manager, different ways for accessing relational databases, utilities that aid in application deployment and maintenance, and its orientation toward syntactic sugar.

MySQL is used as a database for the application. The latest version of MySQL is one of the world's most popular databases. It is open source, reliable, compatible with all major hosting providers, cost-effective, and easy to manage. Many organizations are leveraging the data security and strong transactional support offered by MySQL to secure online transactions and enhance customer interactions. The schema of the database tables is presented below (Figure 1).

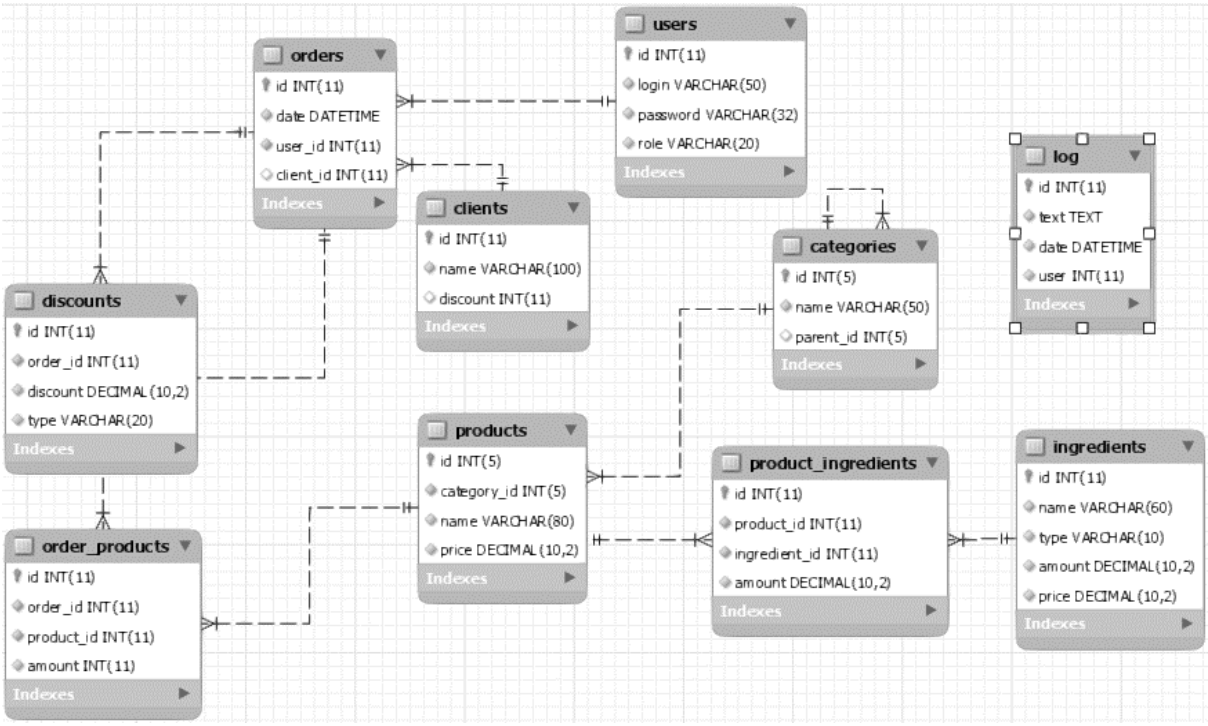

Figure 1. – The schema of database tables

React library is used for frontend. React (also known as React.js or ReactJS) is a JavaScript library for building user interfaces. It is maintained by Facebook and a community of individual developers and companies. React can be used as a base in the development of single-page or mobile applications. However, React is only concerned with rendering data to the DOM, and so creating React applications usually requires the use of additional libraries for state management and routing. Redux and React Router are respective examples of such libraries. Some of the features of React are class and functional components, virtual DOM, JSX, React hooks and lifecycle methods.

The application allows you to create and manage many manager accounts. Each user can be assigned a role or provide additional privileges that determine which parts of the application the manager will have access to.

There are 3 product types in the application, such as simple, configurable and bundled. Each product has a number of predefined and custom attributes. Configurable products consist of simple products. They are configured by one or more attributes. Bundles consist of simple and configurable products and represent packages of products that are sold together. Products can be categorized for easier search and classification. Categories can be unlimited by nesting.

The application implements warehouse management. The number of warehouses can be unlimited. Goods can be presented in various units, such as pieces, packages, grams, liters, etc. The user can also transfer products from one warehouse to another. When selling goods, products stock in warehouse decreases automatically by the appropriate amount.

One of the most important features of the application is the sales module. It allows to keep track of sales of the enterprise. Orders are formed from products and services. The customer can be either anonymous, for example in the field of catering, or included in the list of customers of the company. Customers included in the enterprise database may have discounts on products, as well as receive newsletters with useful information.

It is often necessary to be able to view sales statistics for a specific period for further analysis.
Possible use cases:

- determine which products are sold better than others;
- what goods and services sell poorly;
- track sales for a specific period, for example, day, week, month.

The created software product allows to increase the efficiency of business management of the company, increase the productivity of managers. The program does not require installation and can be used on computers, on tablets and mobile devices as well.

The application interface is designed in such a way as to achieve maximum convenience and ease of use. Even a user unfamiliar with the program will be able to quickly and easily understand it.

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UDC 004.4'22

CONVERTING SPEECH TO TEXT USING JAVASCRIPT

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This article is about the process of working with the Web Speech API. This is a very powerful browser interface that allows to record human speech and convert it to text. We will also consider the way to use it for the opposite procedure of reading lines with a human voice.

Convert speech to text. The Web Speech API is actually divided into two completely independent interfaces: SpeechRecognition for understanding human voice and turning it into text, and SpeechSynthesis for reading lines aloud with a computer-generated voice.

The speech recognition API is surprisingly accurate for the free browser feature. It recognized correctly almost all my conversations and knew which words are combined into meaningful phrases. It also allows you to dictate special characters such as breakpoints, question marks, and newlines. An example is shown in Listing 1 [1].

The first thing to do is to check if the user has access to the API and show the corresponding error message. Unfortunately, the speech-to-text conversion API is only supported in Chrome and Firefox (with a checkmark), so many users are likely to see this message.

Listing 1 - checking if the user has access to the API

```
try {
  var SpeechRecognition = window.SpeechRecognition || window.webkitSpeechRecognition;
  var recognition = new SpeechRecognition();
}
catch(e) {
  console.error(e);
  $('.no-browser-support').show();
  $('.app').hide();
}
```

Recognition variable will give us access to all API methods and properties. There are various options available, but we will only set the recognition.continuous parameter. This will allow users to speak with longer pauses between words and phrases.

Before we can use voice recognition, we also need to set up several event handlers. Most of them just listen to changes in recognition status. An example is shown in Listing 2.

Listing 2 - setting up event handlers before using voice recognition

```
try {
  var SpeechRecognition = window.SpeechRecognition || window.webkitSpeechRecognition;
  var recognition = new SpeechRecognition();
}
catch(e) {
  console.error(e);
  $('.no-browser-support').show();
  $('.app').hide();
}
```

However, there is a special onresult event, which is very important. It is executed every time the user says a word or several words in quick succession, giving us access to a text transcription of what was said.

When we write something using the onresult handler, we save it in a global variable and display it in the text area. An example is shown in Listing 3.

Listing 3 - recognition.onresult event handler

```
recognition.onresult = function(event) {

  // event is a SpeechRecognitionEvent object.
  // It stores the entire recorded dialog
```

```
  // We only need the current dialog / phrase
 var current = event.resultIndex;

  // Get the text of what was said.
  var transcript = event.results[current][0].transcript;

  // Add text to the content of our text document.
  noteContent += transcript;
  noteTextarea.val(noteContent);
 }
```

The code above is a bit simplified. There is a very strange error on Android devices, due to which everything repeats twice. There is no official solution, but I managed to solve the problem without any obvious side effects. With this error in mind, the code looks like this [2]:

Listing 4 - a simplified code from the previous listing that solves the problem of repeating the output text twice on Android devices

```
var mobileRepeatBug = (current == 1 && transcript == event.results[0][0].transcript);

if(!mobileRepeatBug) {
  noteContent += transcript;
  noteTextarea.val(noteContent);
}
```

Everything is set up, now you can start using the browser voice recognition function. To start with, you just need to call the start () method:

Listing 5 - calling the start () method to start voice recognition

```
$('#start-record-btn').on('click', function(e) {
  recognition.start();
});
```

In this case, the browser will ask users to give permission. If permission is given, the device microphone will be activated.

The browser will listen for some time, and each recognized phrase or word will be transformed into the text. The API will stop listening automatically after a couple of seconds of silence or when it is stopped manually.

Listing 6 - handling the event of pressing the stop button for converting speech to text

```
$('#pause-record-btn').on('click', function(e) {
  recognition.stop();
});
```

Convert text to speech. Speech synthesis is actually very simple. The API is accessible through the speechSynthesis object, and there are several methods for playing, pausing, and other things related to sound. There are also some interesting features that change pitch, speed, and even the reader's voice.

All that is needed for demonstration is the speak () method. It expects one argument - an instance of the SpeechSynthesisUtterance class.

Listing 7 shows all the code needed to read a line.

Listing 7 - reading text aloud with a computer synthesized voice

```
function readOutLoud(message) {
  var speech = new SpeechSynthesisUtterance();

  // Устанавливаем атрибуты текста и голоса.
  speech.text = message;
  speech.volume = 1;
  speech.rate = 1;
  speech.pitch = 1;

  window.speechSynthesis.speak(speech);
}
```

Conclusion. The article examined a method for converting human speech into text using the Web Speech API. A method for converting text into human speech by a computer-synthesized voice was also investigated.

In an era when voice assistants have become more popular than ever, a similar API provides a quick way to create bots that understand and speak human language.

Adding voice control to applications can also be a great way to improve accessibility. Visually impaired users can use both speech-to-text and text-to-speech user interfaces.

The speech synthesis and speech recognition APIs work quite well and easily handle various languages and accents. Unfortunately, at the moment they have limited browser support, which limits their use in production.

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UDC 004.4

EFFICIENCY OF USING CRYSTAL PROGRAMMING LANGUAGE FOR APPLICATION IMPLEMENTATION

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This article discusses the capabilities of the Crystal programming language and its advantages over the C and Ruby programming languages using the implementation of the Tower of Hanoi problem as an example.

Nowadays, there are many different programming languages. Some of them allow developers to write well-readable and efficient codes, while others allow you to focus on the productivity of the future product. Programming languages by type-checking are usually divided into two categories. They are static and dynamic. Static examples are C, Java, C#. Dynamic examples are Python, JavaScript, Ruby. Ruby is one of the popular dynamic interpreted programming languages.

Ruby has an operating system-independent multithreading implementation, strong dynamic typing, garbage collection, and many other features. In terms of syntax, it is close to the Perl and Eiffel languages, in the object-oriented approach to Smalltalk. Also, some features of the language are taken from Python, Lisp, Dylan, and Clu. Nowadays, Ruby is used with the Rails framework. However, Ruby has its drawbacks. The most significant drawback of Ruby is its performance. Consider Crystal programming language as a more productive alternative to Ruby [1].

Crystal is a general-purpose, object-oriented programming language, designed and developed by Ary Borenszweig, Juan Wajnerman. Crystal is statically typed and has Ruby-like syntax. The first official release of the language took place in June 2014. The language compiler was originally written in Ruby until it was rewritten in Crystal in 2013. The language is under active development. Despite the similarities in syntax, Crystal is much more efficient than Ruby to compile into machine code using LLVM, while sacrificing dynamic aspects of the language. According to the test results, Crystal shows similar performance with the C language. The language uses the Boehm garbage collector, has a macro system, it supports generics, as well as overloading methods and operators [2].

Crystal is a programming language with the following goals:

1. Have a syntax like Ruby (but compatibility with it is not a goal).
2. Be statically type-checked, but without having to specify the type of variables or method arguments.
3. Be able to call C code by writing bindings to it in Crystal.
4. Have compile-time evaluation and generation of code, to avoid boilerplate code.
5. Compile to efficient native code.

To compare Crystal performance, we take two programming languages: Ruby and C. The choice fell on these languages since Crystal is positioned as a technology balanced between these languages. To compare the performance, we implement the solution of the Tower of Hanoi problem.

The Tower of Hanoi [3] (also called the Tower of Brahma or Lucas' Tower and sometimes pluralized as Towers) is a mathematical game or a puzzle. It consists of three rods and a few disks of different sizes, which can slide onto any rod. The puzzle starts with the disks in a neat stack in ascending order of size on one rod, the smallest at the top, thus making a conical shape.

There are several approaches to the solution (recursively, a "triangular" solution, a cyclic solution). All of them give identical results. We implement a recursive solution.

The implementation of the solution in Ruby is presented in the listing below.

```
require 'benchmark'
N=20
A=Array.new
B=Array.new
C=Array.new

LOG = false
```

```
def move(n, source, target, auxiliary)
  if n > 0
    move(n - 1, source, auxiliary, target)
    target.append(source.pop)
    print "********\n#{A}\n#{B}\n#{C}\n" if LOG
    move(n - 1, auxiliary, target, source)
  end
end

def run()
  (1..N).each { |v| A << v }
  A.reverse
  move(N, A, C, B)
end

puts "\nRuby work time: #{Benchmark.measure { run() } }"
```

The implementation of the solution in Crystal is presented in the listing below.

```
require "benchmark"
N = 20
A = Array(Int32).new
B = Array(Int32).new
C = Array(Int32).new

LOG = false

def move(n, source, target, auxiliary)
  if n > 0
    move(n - 1, source, auxiliary, target)
    target << source.pop
    print "********\n#{A}\n#{B}\n#{C}\n" if LOG
    move(n - 1, auxiliary, target, source)
  end
end

def run()
  (1..N).each { |v| A << v }
  A.reverse
  move(N, A, C, B)
end

puts "\nCrystal work time: #{Benchmark.measure { run() } }"
```

Listings with solutions to the Tower of Hanoi problem in C, Crystal and Ruby are available on GitHub [4].

After starting the solutions in the selected languages, we obtain the following results (in seconds) (table 1).

Table 1. –Performance Tests (Tower of Hanoi Problem)

Language	Test 1	Test 2	Test 3	Average values
C	0.000895	0.000957	0.000955	0.000936
Crystal	0.021738	0.021611	0.013851	0.019067
Ruby	0.364303	0.359521	0.359140	0.360988

After analyzing the results, we can conclude that Crystal programming language combines, as in C, performance, and readablility, and conciseness; as in Ruby, its syntax and can be used to develop software products

for operating systems of the Unix family. As far as the minuses of this language go, they are a weak community and a small number of libraries so far.

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DEVELOPMENT OF NEURAL CONVOLUTIONAL NETWORKS IN THE WORLD AND CHILD FEATURES

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This article discusses the main directions of development of machine learning and neural networks of intelligence, the rules of teaching children of preschool and school age when working with computers and the features of the graphical application interface for children.

Very often today you can hear the phrase "artificial intelligence" in everyday life. Machine learning is a very promising area in the development of computer science - this is proved by the new expositions of enthusiasts from around the world, the algorithms of which give truly incredible results: creating poems and lyrics, although very mediocre, before creating photographs of people who never existed.

This article is aimed at describing the scale of development of neural networks in the modern world.

Machine learning. Russian programmer Alexei Prikhodko, being deaf from birth, created a system that controls a computer using gestures and translates the language of people with hearing impairment into text.

The developed algorithm does not need sensors and additional devices - the machine works only with the help of computer vision. The camera recognizes the hand in the frame, creates its virtual model and displays the symbol on the screen. For example, seeing a fist, a neural network issues the letter "a". In addition to the translation, the neural network moves the cursor on the screen - without using a mouse, only tracking palm movements.

The most interesting and, at the same time, very dangerous, direction of the development of artificial intelligence is the "deep fakes". This is a human image synthesis technique used to connect and overlay existing images and videos on source images or videos [1]. Researchers downloaded neural networks from one photo and audio recording, and Einstein began to give a lecture, and Rasputin sang a song to Beyoncé [2].

This example shows that all one photo may not be enough for realistic facial expressions, but if you upload a network of a collection of photographs of a person, it turns out a strikingly natural picture even in motion [3].

Designer Konstantin Zhabinsky collected 100 thousand photos of non-existent people and posted them on Google Drive. In the database, there are people with different expressions and face shapes, of different ages and ethnicity [4]. Picture 1 shows examples of such "deep fakes."

Figure 1. – Photo of people generated by a neural network

The breadth of malicious use of "deep fakes" has become so great that researchers at the University of Southern California have created a tool that can recognize a non-existent person in the video with a 96% probability. The researcher's tool overlays the movie frames on top of each other and looks for any possible inconsistencies in facial expressions and head movements. It turns out that they usually exist - otherwise it would take too much time to create one "deep fakes".

Today, neural training is used in the development of software for environmental recognition, photo information and video information. Conventionally, this area is called computer vision. However, neural training

is not limited only to pictures, it can also be used to work with audio and fingerprint data (recognition of fingerprints, voices).

Google has demonstrated a neural network that can detect disease from a skin snapshot. Fifty thousand cases from the practice of dermatologists were loaded into the neural network and taught him to find twenty-six diseases. Recognition accuracy - up to 92%.

Artificial intelligence from the OpenAI company generates texts on any of the given topics, which in content can compete with any writer. To create such a tool, one and a half billion parameters and a large database were required. The developers trained the neural essence with the help of a popular social network, from where they collected texts with high reader ratings. As a result, the laboratory refused to lay out the code and showed only a small part of it [5].

Increasingly, they are resorting to the use of mobile devices to educate children in schools or children's rooms - this can reduce the time spent on maintenance, this is a cheaper and more durable solution, but, most importantly, it can reduce the influence of a person as a teacher. However, it becomes necessary to study the negative impact of computers on the body of children and the characteristics of attracting attention to the child.

Child features. Personal computers (PCs) are a source of electromagnetic radiation. Electromagnetic radiation generated by computers, under certain conditions, can be an increased danger to children, adolescents and adults. In order to reduce the impact of the PC on the user, it is recommended to limit the time spent working on the computer, mandatory pauses during operation, etc.

When organizing the workplace of a PC user, it must be borne in mind that the minimum distance from the screen to the operator is about 50-70 cm (arm length), and the nearest workstations from the side and back walls of the monitor - at least 1.5 m, a keyboard and hands. Operators should also be located as far away from the monitor as possible.

The room where the PC is installed must be equipped with protective grounding (grounding) and a bipolar outlet (with a grounded contact) connected to an electric mains with an industrial frequency of 220 V and a frequency of 50 Hz.

Priority and safest when using are liquid crystal monitors that are part of the PC.

According to experts of the Republican Center for Hygiene, Epidemiology and Public Health (ГУ РЦГЭиОЗ), the duration of continuous work on a computer for children of different ages should be as follows:

- 5 years - no more than 7 minutes;
- 6 years - 10 minutes;
- 7-9 years - 15 minutes;
- 10-12 years - 20 minutes;
- 13-14 years - 25 minutes;
- 15-16 years - 30 minutes.

In addition, between classes, if they involve a longer stay of the child in front of the screen, it is necessary to take breaks of at least 10 minutes [6].

Light and bright shades, cause positive emotions. It is proved that a good, high spirits can be created using also the color of ivory - light with a golden hue, light beige, and pale blue color [7].

Children are interested in bright colors. Many different studies were carried out, which showed that in childhood, a child changes its preference for colors many times. Most children under ten years old adore red, pink or yellow colors. As soon as the child is ten years old, he can already love the blue color with all its shades.

According to studies, girls prefer pink, lavender, purple flowers. Boys prefer dark and blue colors [8]. Figure 2 shows color schemes for children with graduation by gender.

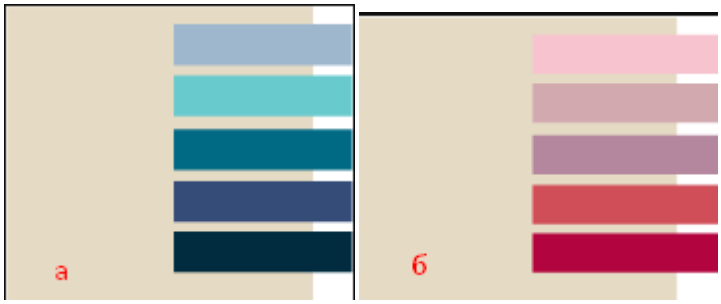

Figure 2. – Color preferred for children (a - boys, b - girls)

If the application is designed for children of any gender and age, the optimal solution for this is an interface that would satisfy all color requests. Figure 3 shows a color palette for children of any gender.

Figure 3. – Color preferred for children (a - boys, b - girls)

Conclusion. This article discusses the features of teaching children when working with computers, as well as some aspects of choosing a color scheme for the interior or graphical application interfaces.

This article discusses the main ways of development of neural networks in the modern world. The result of this article can be considered as the potential for the development of computer science.

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AN EFFECTIVE STRUCTURE FOR NEW DATA INTERCHANGE FORMAT

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Most modern web applications use two JSON and XML data structures for data transfer. They both have a lot of advantages, among which:

- Code readability.
- Ease of creating a data object on the server side.
- Ease of processing data on the client side.
- Easy to expand.
- Debugging and correction of errors.

However, it is worth noting that JSON is used much more often in new applications, XML received a large part of the audience at a time when it was at the peak of its popularity. JSON has taken the lead, crowding out XML more and more for the following reasons:

- JSON has a simpler grammar, only 30 patterns versus 90 for XML, which provides a simpler implementation and further debugging.
- JSON has significantly less code redundancy. For example, two arrays are shown in Table 1 with lists storing the same information:

Table 1. – Comparing JSON and XML volume

JSON	{
	"users": [
	{
	"name": "Alice",
	"age": 20
	},
	{
	"name": "Bob",
	"age": 46
	}
	]
	}

XML	<users> <user> <name>Alice</name> <age>20</age> </user> <user> <name>Bob</name> <age>46</age> </user> </users>

In the Table 1, the main drawback of XML is clearly visible compared to JSON, all its field names are duplicated in the opening and closing tags, and in the array, each element is additionally wrapped in an additional tag.

This redundancy of XML was the main reason for switching to JSON. However, JSON also has enormous redundancy. The format has a lot of unnecessary designs and here are the most obvious ones:

- Keywords may be repeated many times.
- Keywords are in double quotation marks.

• The colon and the value separate the keyword.
• If this is not the end of the object, then you need to set a comma after the value.
• Arrays and objects are surrounded by brackets.
• Lines must also be inside quotation marks.
• Numbers are written in a string, which also adversely affects their size.

It is also worth noting that JSON and XML have a readable form only in a formatted version, when transferred, they are cleaned of extra spaces and hyphens, losing this quality.

Considering all these shortcomings, a new data structure was designed. The structure is represented in binary form.

To solve the problem of repeatability of keywords for each, a unique id of two bytes will be set and the entire list of keywords will be located at the beginning of the message. Before each word, its id of two bytes and the length (also 2 bytes) of the keyword in bytes will be written in order to know which piece of the message to take next as a keyword. Before all this list there will be the first 2 bytes storing the total length of the list of keywords. Thus, long key glories will be recorded only once, and then in the main structure they will be recorded using id which occupies only 2 bytes.

Next, after the list of keywords, the main data structure will go. Any data will begin with its type occupying 1 byte. In the structure, I highlighted the following data types:

• Object - after the type, the total number of bytes that this object occupies should be indicated. This value will occupy 2 bytes. And then the data inside the object will go as a list. All of them will have a key id in front of their type.

• Array - repeats the structure of the object, only you do not need to specify id before the type, all objects will be numbered from scratch during parsing.

• Integer - will always occupy 4 bytes, so after the type you do not need to specify its length.

• Fractional number - will have a double representation and a length of 8 bytes, which also makes it unnecessary to specify the length.

• String - after specifying the type, you must specify the total number of bytes that this string occupies.

All this will provide the structure with the same flexibility that JSON has, but will deprive it of enormous redundancy. Now all field names are repeated once at the beginning of the structure, to determine a field in an object, you only need to indicate the id of the name, which takes only 2 bytes, its type (1 byte) and, if it is a string, array or object, the length of the value. As a result, we get that to declare a field, only 3 or 5 bytes are needed, not counting the value itself. At the same time, in JSON, to define a field, you must specify its full name, which can take unlimited length, the name must be in quotation marks, each of which takes one byte, followed by a colon, which takes another byte, and if the value is a string, an array or an object, that value should still be in quotation marks or brackets (depending on type) which will add 2 more extra bytes. As a result, we have fixed 3 or 5 bytes in the new structure, when in JSON we have a field name occupying at least 1 character (byte) and the same 3 or 5 bytes for additional formatting.

The main drawback of the structure is its complete unreadability. But since JSON is transmitted in an unformatted form, before working with it, it is formatted into a convenient structure. My structure can easily repeat JSON so that when working with it can be parsed in JSON and when passing back. This will allow people to easily work with it and transfer data with minimal redundancy.

It is also worth noting that there is a scenario in which my structure is more redundant - this is the case when the data does not have fields with the same name. However, it must be taken into account that such data, as a rule, are not large and the losses will be negligible. This structure is aimed at reducing redundancy during the transfer of large amounts of data, and these are usually arraying with repeatedly repeating objects that have a similar structure, and therefore the fields will be duplicated many times. Savings in the transfer of such structures will greatly exceed losses in the transfer of small objects, which will positively affect both the transmission speed and the amount of traffic.

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ROLE OF THE WEB PORTFOLIO IN INCREASING COMPETITIVENESS OF UNIVERSITY GRADUATES

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This article discusses the role of compiling a personal portfolio and its impact on improving the competitiveness of university graduates for their future work.

The Republic of Belarus on May 15, 2015 at the Conference of Ministers of Education of the Member States of the European Higher Education Area (Yerevan) became the 48th participant in the Bologna process - the process of convergence and harmonization of education systems in Europe to create a single European space for higher education.

The priority tasks of the Bologna process are the creation of a European higher education space designed to stimulate the competitiveness of the European higher education system and its attractiveness, as well as create opportunities for students' mobility and their further employment [1].

This process poses the most important task for any university, (including the educational institution "Polotsk State University") the preparation of a competitive and sought-after specialist in the labor market.

As practice shows, in several countries there is a decrease in the quality of education at the first stage due to the introduction of shortened training periods. Many graduates do not fully meet the requirements of employers: universities graduate with general ideas about professional activity, in most cases students are not ready for operational inclusion in this field of activity [2]. Traditional forms and methods of training students do not contribute to the optimization of the formation process of such components of a professional culture.

In fact, the leading form of organization of training is the subject system, in which the student usually solves the tasks of a particular academic discipline, usually without connecting them with the leading goal of higher education - the formation of professionalism [3].

Self-realization in the field of professional activity requires specific personal work, and its implementation, of course, must be taught. It follows that the task of designing an educational system that provides the student with a real opportunity to get an idea of the key competencies of a professional should be considered by pedagogy with a hight priority.

Today, in the context of the implementation of new educational standards, the university should provide not only the process of developing specialist competencies, but also tracking and presenting the results and achievements of its activities to the future employer. One of the modern technologies for preparing a student for future professional activity, which allows him to effectively plan and evaluate the process and the results of his training, is the technology of compiling a portfolio that is rapidly developing in foreign higher education.

Compiling a portfolio of students in such a system separates teaching, training and assessment as much as possible by organically integrating these three components into the educational process, which allows you to combine a quantitative and qualitative assessment of student abilities by analyzing a variety of educational and cognitive products. This system encourages not only assessment, but also self-esteem and self-esteem of students, as well as self-analysis and self-control of the student. And the portfolio itself is aimed at the cooperation of the teacher and the student in order to assess the achievements, efforts and progress in learning. And the portfolio itself is a form of continuous assessment in the process of continuing education, which shifts the emphasis from the hard factors of traditional assessment to the flexible conditions of an alternative student assessment [4].

"Portfolio" in the broad sense of the word is a way to record, accumulate and evaluate the individual achievements of a student over a certain period of his studies. The portfolio is actively used in foreign education systems, which classify it as "authentic" individualized assessments focused on new forms of student assessment. This allows teachers to consider the results achieved by the student in a variety of activities: educational, creative, social, communicative and others, and is also an important element of a practice-oriented approach to education. In a foreign tradition, a portfolio is defined as "a collection of student work and results that demonstrates his efforts, successes and achievements in various fields" [5].

Portfolio is one of the conditions for increasing student motivation, the formation of reflection skills. According to E. S. Polat, a portfolio is a tool for self-assessment of a student's own cognitive, creative work, reflection of his own activity [5].

Based on the foregoing, a web service is being developed in the training system for future highly qualified personnel to host an online portfolio.

For universities in the Republic of Belarus, this topic is more relevant than ever, which is why the main task is to develop a web service that would help students in compiling their future portfolio. You can observe the prototype of the developed web service in Figure 1

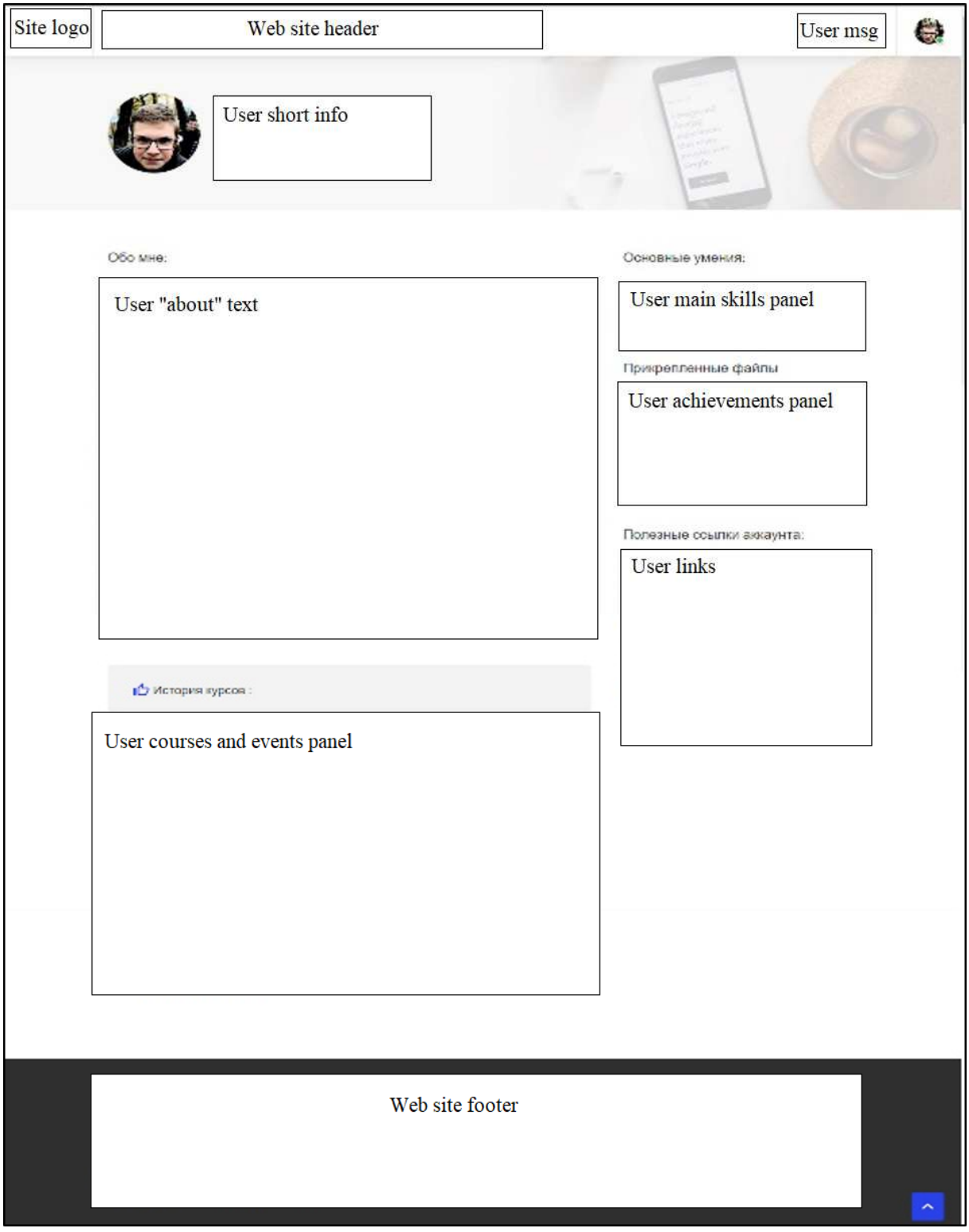

Figure 1. – The prototype of the developed electronic student portfolio

The developed web service encourages students in developing the ability to solve professional problems at a fairly high level - which, of course, is a key competence of a specialist. Thus, the formation and development of a key competency for a graduate of a university requires a special organization of a web service that fully complies with the requirements described for it. In Figure 2, you can see the class diagram of the product being developed.

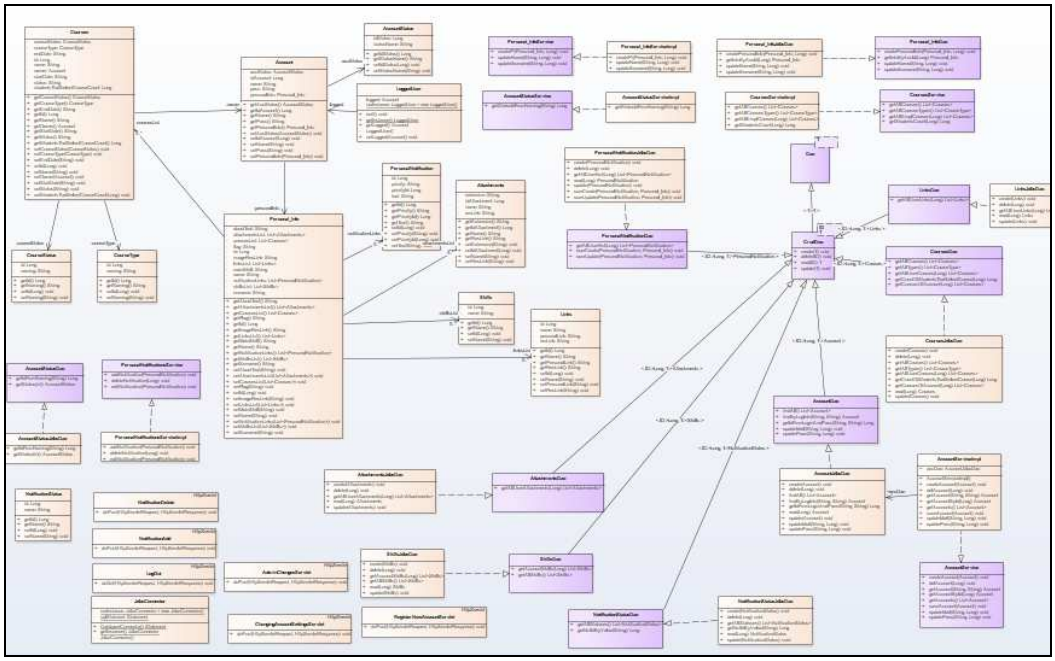

Figure 2. – Prototype system requirements

In turn, the main expected effects of the introduction of a new system of compiling a portfolio of university students will have a positive impact on the organization and effectiveness of the educational process, motivating and encouraging students' activity related to the acquisition of professional knowledge and skills, their participation in scientific work, in competitions, student scientific conferences what will be the first step of the student on the path to his future success. In more detail, the main functions of the portfolio are presented in Figure 2.

Figure 3. – Key student portfolio features

Acquiring greater independence in learning, students need advice, the help of a teacher more than in his direct leadership, management. In the process of classroom and extracurricular independent activities, students

determine and formulate goals and objectives of independent work, develop action algorithms necessary for implementation, analyse the results obtained, generalize and systematize them, drawing conclusions [6].

In addition, in the process of completing educational or professional tasks, the student develops his own style of communication with colleagues or teachers. Thus, the student demonstrates the degree of formation of their own competence, i.e. readiness and ability to professional activities [7].

The portfolio should contain sections reflecting the formation of general cultural and professional competencies, presenting the achievements and results in mastering the student with professional knowledge, skills and abilities; ability to design your professional growth. The content of the sections should reflect the achievements in educational, professional and research activities. Forming communicative and leadership qualities, organizational abilities, managerial skills, abilities to resolve conflict situations, work in a team, make collective decisions, bear responsibility for the implementation of decisions made. What should be provided due to: participation in psychological trainings on the formation of competitiveness of specialists; meetings with employers; participation in creative contests, sports competitions, military-patriotic work; implementation of projects of family, environmental, patriotic, religious, legal and other areas; participation in various forms of student self-government, volunteer work, work on the presentation itself.

Conclusion. In conclusion, it can be noted that the electronic portfolio is undoubtedly an important project at any stage of a person's formation, regardless of the degree of education received, because during the development of a portfolio he comprehends his first achievements, realizes his capabilities and forms his own attitude to the results. The introduction of such systems in the educational system contributes to the growth of competitiveness and the students' own development as future highly qualified personnel.

A portfolio, being a form of a complete and diverse view of a graduate, determines the educational rating of a future specialist and can be used by an educational institution as additional information about a student when summing up educational, research, social and creative activities, employment, issuing recommendations for admission to master's programs , graduate school, etc.

The use of the portfolio ensures the construction of plans for professional self-education, stimulates the activity of students in obtaining additional education, participation in university, city, federal, international competitions, competitions, conferences, social practices, etc.

Thus, the integrated use of these means of assessing educational results in the process of forming a student's portfolio is an effective innovative technology that allows you to best combine the needs of the educational process and scientific activity at a university, to form a craving for creative and scientific self-realization and comprehensive development of the personality of students in the process of learning.

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CLEAN ARCHITECTURE FOR ANDROID APPLICATIONS

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The article describes the features of developing a mobile Android application using a clean architecture. A set of tools for software implementation of this approach was proposed.

Introduction. The architecture of the application is the most important aspect in software development - it must be reliable, stable, flexible in testing, easy to expand and change. At the same time, the architecture should be understandable for developers with different levels of knowledge and experience to ensure ease of maintenance.

Clean acchitecture. When using pure architecture the entire application code is divided into levels that adhere to one rule: the internal level does not need to know anything about the external. The internal level contains business logic, and its external implementation, depending on the platform. This approach should also meet other requirements:

– independence on tools. Architecture should not rely on the existence of any library. This allows you to use with minimal cost to change the implementation of business logic [1];

– database independence, business logic should not be tied to specific databases [1];

– independent of any external agent, business logic should not know anything about the interaction in external data sources [1].

The figure shows the various levels and components of the architecture and their interaction.

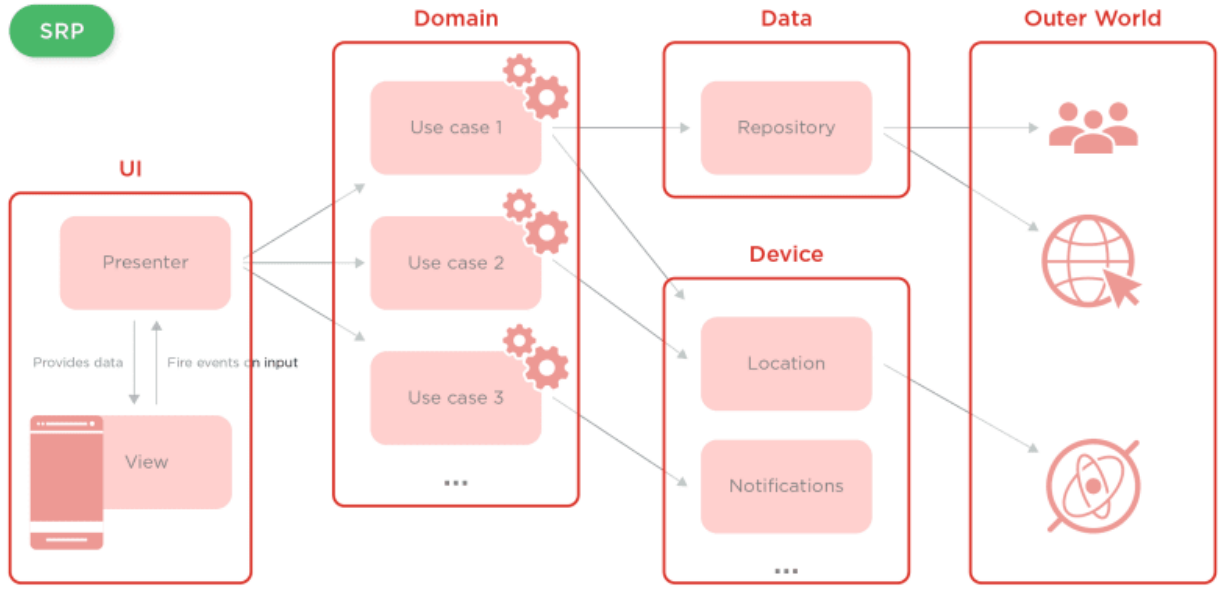

Figure. – Components of clean architecture

Presentation level:

– for this layer MVP (Model VIew Presenter) pattern is selected, using of MVVM is also possible;

– view is an implementation of the passive view pattern and provides a set of interfaces that must be implemented by components from the Android SDK (Fragment, Activity, Adapter, Custom View) [2]

– presenter is the intermediary between the user interface and business logic. It must be platform independent to improve code testability [2];

– frameworks JUnit and Mockito for testing. Esspresso is also used for integration tests.

Domain level:

– contains use cases, which are the most primitive parts of the business logic of the application for maximum simplicity and the possibility of their further reuse;

– frameworks JUnit and Mockito for testing.

Data level:

– the repository pattern is responsible for the interface on which use cases from the domain level can receive the necessary data [3];

– implementation of caching is also possible at this level;

– frameworks JUnit, Mockito and Robolectrick for testing.

Device level:

– Contains implementations of platform-dependent functionality: notifications, sensors, various managers, and so on.

Communication between layers, navigation:

– dependency injection using Dagger 2 framework;

– data flow between layers using RxJava framework;

– Cicerone framwork for navigation;

Conclusion. The features of using clean architecture when developing applications for Android mobile devices were described. A set of tools for implementing this approach is proposed. This architecture is flexible in support, easy to test and very convenient when working in large teams with specialists of various levels.

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UDC 004.9

ECONOMIC COMPONENT OF DEVELOPMENT OF THE WEB SERVICE FOR THE SUBMISSION OF ANNOUNCEMENTS, IMPACT ASSESSMEN OF THE INFORMATION ENVIRONMENT ON THE ECONOMY

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The article provides information on the economic part of developing a web application for posting ads. The information on the main stages of application development, types of work and their economic component is also provided.

The methodology for designing information systems describes the process of creating and maintaining software in the form of a life cycle. The life cycle of software development is a period of time that begins from the moment when a decision on the need to develop a system is made and ends when it is completely out of use by all users. The software is the end product of the system development process.

Traditionally, the following main stages of the software life cycle are distinguished:

- requirements analysis and design (task setting, obtaining technical specifications, development of specifications, development of decision algorithms);
- implementation (coding of the designed system);
- testing and debugging (checking the program for compliance with all the requirements for it, identifying defects);
- acceptance by the customer and revision (final acceptance tests, correction of identified errors).

At the stage of analysis and design, drawing up a specification of the requirements for software is one of the most important goals. Without this, it is impossible to proceed to the next steps. Components should be described with such precision that would allow their implementation to begin. Because of its importance, this work is considered as a separate phase and takes about 20% of the time allotted for the completion of the thesis (2.5 weeks).

At the implementation phase, a software code is compiled which is based on the software project created at the design stage. The division into components creates the prerequisites for the division of labor, i.e. when the team of programmers is involved in coding systems. Its implementation takes 7 weeks (58.33% of the allotted time).

The testing and debugging phase is essentially a system reliability check, where the main goal is to find out if the created system meets the user's requirements. This stage implies a series of tests designed to identify errors in the implementation of the project. If the latter are discovered, they must be corrected. This stage is allocated 12.5% of the time, i.e. 1.5 weeks.

At the final stage: the stage of sending the application to the customer, acceptance tests are carried out. Based on the results of these tests, the customer can voice some wishes, make minor adjustments, according to which the system should be finalized. At this stage, the remaining week of working time is allotted.

A graphical representation of the proportion of time spent for each of the stages of developing a web service for submitting ads in total is presented in Figure 1.

Types of work

In addition to dividing the life cycle into stages and phases, eight types of work can be distinguished that are performed in the process of creating a software product:

1. Requirement analysis and planning. It ensures the development of specifications, analysis and modification of functional, technical, and interface requirements.
2. Designing products. It includes the definition, specification, analysis and modification of the hardware and software architecture of the project program and database.
3. Programming. Detailed design, coding, autonomous debugging and integration of individual program components, as well as programmer work planning, database development, documentation of individual components and organization of programming at the component level.
4. Planning for debugging.
5. Verification. The process of checking the correctness of requirements, debugging products and acceptance tests.
6. Project management. Project planning and control, control and regulation of contracts, communication with users.
7. Quality control. Development and control, standard and technical checks of software tools and development processes.
8. Documentation. Development and adjustment of user manuals and operators.

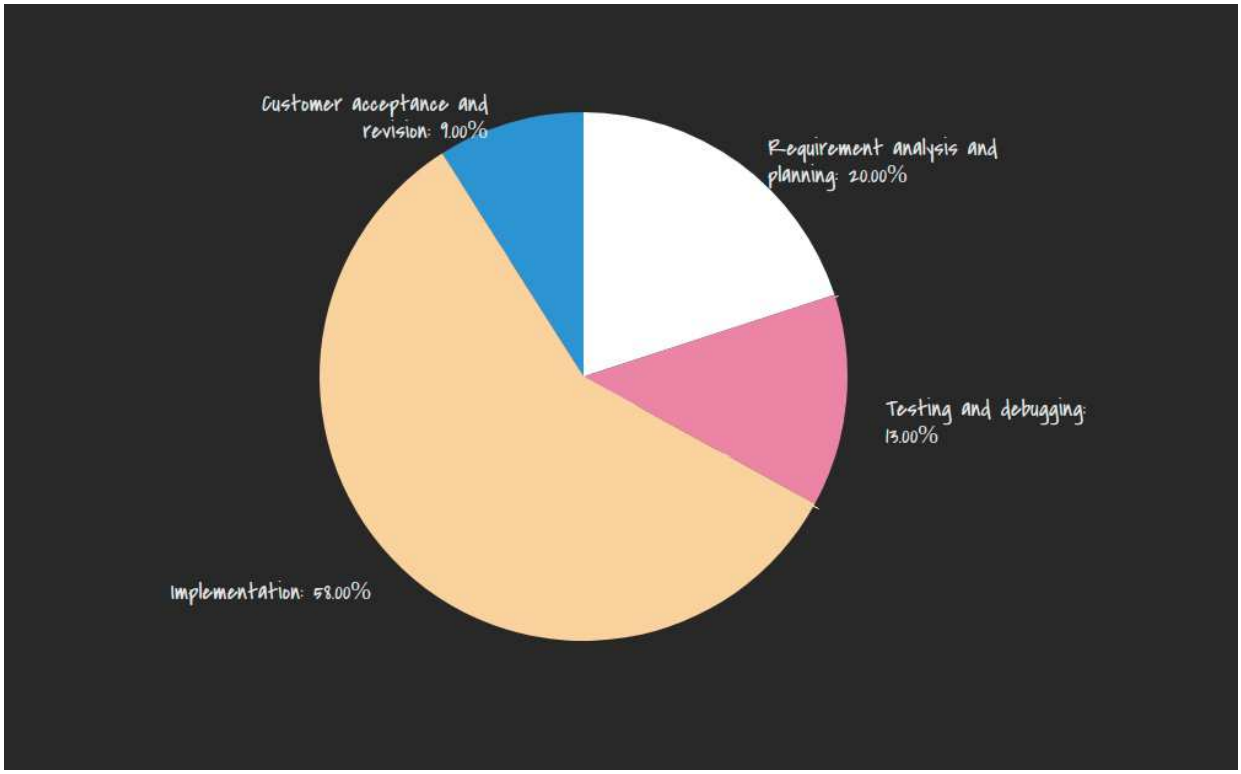

Figure 1. – Diagram of the distribution of time during project development

The division of the software life cycle into stages, phases and stages, as well as a more detailed description of the work performed during their development, production and operation, is necessary for a detailed determination of the costs required for these purposes.

Product costing

Assessing the cost of software and determining the economic effect of the developer involves the preparation of cost estimates, which, according to the Decree of the Ministry of Economy of the Republic of Belarus, the Ministry of Finance of the Republic of Belarus and the Ministry of Labor and Social Protection of the Republic of Belarus dated on 10.30.08, No. 210/161/151 "About the main provisions on the composition of costs included in the cost of production (work, services) " includes the following cost items:

1. Electricity - since the product is an application, when it is developed, computers that consume electricity are used;
2. Materials and components - consumables spent on creating a product;
3. The basic salary of executing agents is the cost of issuing salaries to employees working on a project;
4. Additional salary - the cost of paying premiums, risks, holidays, etc.
5. Deductions for social needs - the costs of tax fees, to the fund for protecting the population, insurance, etc.
6. Depreciation - contingency costs;
7. Costs for special equipment - costs associated with the acquisition of specialized equipment;
8. Other direct costs - the costs of preparing and acquiring various kinds of information.

The impact of cost items on the final cost of a product can be seen in the diagram shown in Figure 2.

According to the diagram presented in Figure 2, we can conclude that the main costs of the product being developed, regardless of the development time, are the payment of wages to employees.

The customer pays the developer the full amount of the costs of the project, including profit. After paying taxes from the profit, the developer remains at the disposal of the net profit from the project. Due to the fact that the software is developed for a single object, net profit can be considered as the economic effect of the developer from the implemented software.

The sale price of products is formed on the basis of the planned cost of production, all types of established taxes and profits, as well as the quality, consumer properties of the products and market conditions.

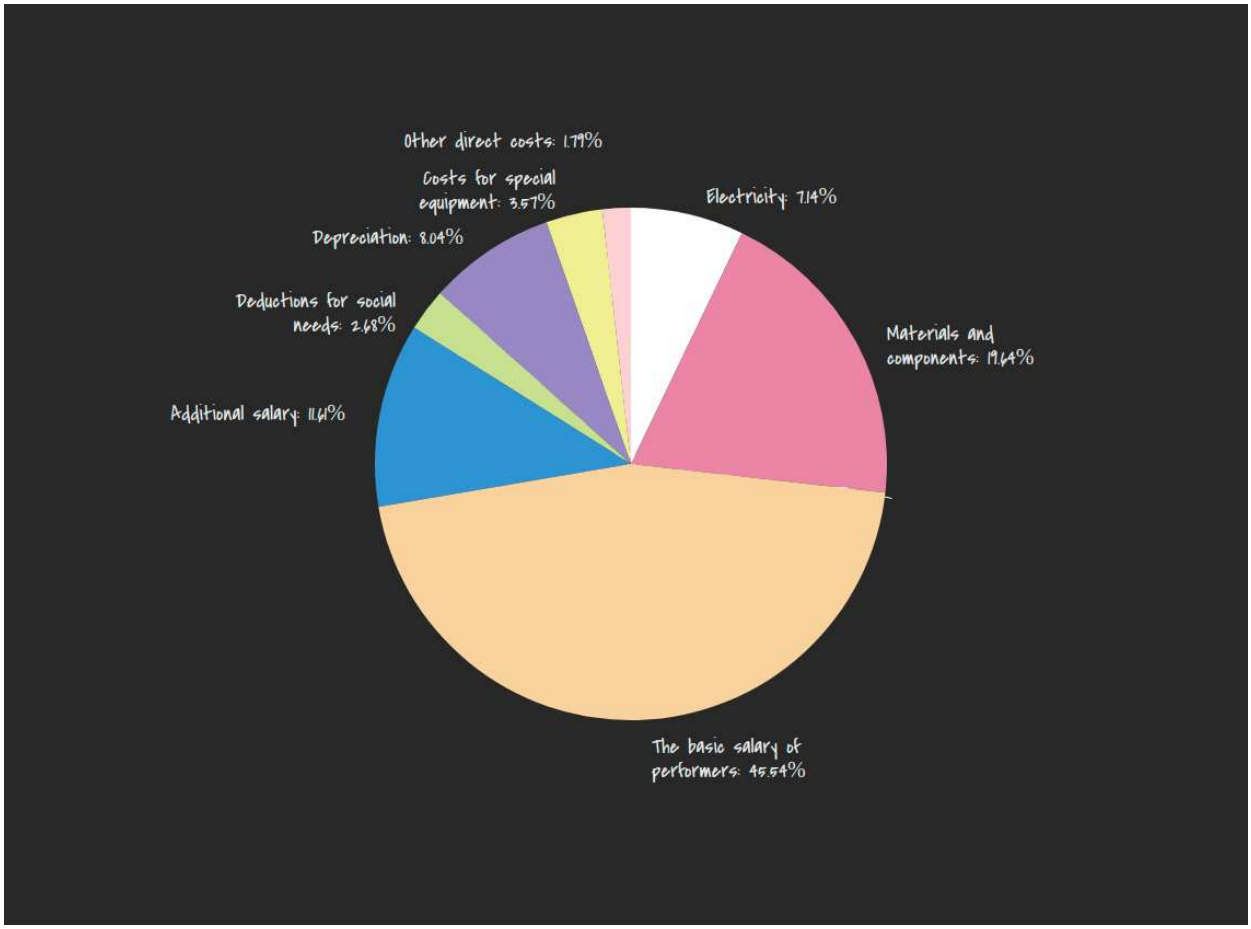

Figure 2 .- Cost structure for the development of a training application

Conclusion

Thus, the cost of electricity will reach 50.67 (rubles), materials and components - 32.6 (rubles), the base salary of executing agents - 3600 (rubles), additional salary of executing agents - 360 (rubles), deductions for social needs - 1370 , 16 (rubles), depreciation - 39.68 (rubles), other direct expenses - 180 (rubles), expenses for special equipment - 0 (rubles)

Thus, the cost price of this software was fixed to 5633.11 (rubles), and the selling price including VAT 7773.69 (rubles)

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UDC 004.223.2

MAIN ASPECTS DESIGNING A WEB APPLICATION FOR WORKING WITH PATIENT'S MEDICAL DATA

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The article presents the main aspects of architectural features for the design of protected medical information systems. The algorithm of technology of distribution of access rights to medical information is considered. The principles and technologies for designing data storage interfaces are considered.

Keywords: information technology, medical information system, data encryption, data security.

Introduction. At the moment, many health care institutions use paper document circulation to store outpatient patient database in the Republic of Belarus. This approach, since the development of information technologies, has been significantly inferior in effectiveness to electronic medical systems for storing and processing patient medical data. In this case, electronic systems have a number of advantages [1]:

- Quality improvement of management of medical, administrative and financial activities in a healthcare organization through the comprehensive introduction of an electronic medical file and an electronic voucher, provision of additional electronic services for automatic self-service for patients;
- Reduction of time required for medical paperwork by obtaining ready-made data from databases and computer input;
- Reduction of time required to report and provide a roster of services based on automatically generated templates;
- Medical staff optimization of the health care institutions;
- Provision of an operational control over the performance evaluations of the clinic, examination of the medical care quality by logging data and preparation of the reporting sample;
- Enhancement of the information reliability about the indicators of treatment and diagnostic work and financial activity using methods of cryptographic protection of information;
- The throughput increase of healthcare institutions by reducing the time spent working with the outpatient file and other documents, and as a result – the reduction of queues;
- Provision of telemedicine opportunities for communication between the doctor and the patient, altogether with a consultation between doctors.

These criteria undoubtedly prove the effectiveness of these systems, as well as the relevance of their development and implementation of such information systems in the health care system.

Based on the above characteristics and requirements of the system, the functional structure of the developed software was designed. It consists of the following subsystems:

1. User authorization subsystem. It is responsible for granting the access rights to data for the current user in accordance with the role, authorization in the app.
2. User profile configuration subsystem. It is responsible for changing the doctors' personal data.
3. Subsystem for working with information. It is responsible for information searching, extracting the necessary information in accordance with a specific request, and conveniently displaying information based on filters for various criteria using the graphical interface.
4. Subsystem for working with a pharmaceutical storehouse. It provides the ability to select a medicine on the basis of symptoms and contraindications. Management and tracking of the information about the status of medicines in the warehouse.
5. Data editing subsystem. It provides the administrator with the ability to edit information about doctors and medical institutions in the app.

Means of problem solving. The basis of the developing system is the ability to store, accumulate and process data. Also, in this case, medical data must be stored in a strictly systematic form based on the rules of maintaining medical records and have a clear interrelation.

Based on this data a relational database is to be used to store entities and the SQL query language to build the database. In this case, using a relational database will allow to formally and unambiguously determine the limitations of the database integrity in terms of its conceptual scheme.

Since medical data is strictly regulated it is advisable to use official documents for drawing up outpatient medical records during system development [2], and present a separate list of the type of examination or data collection as a separate entity associated with the patient.

Obviously it is important to form some architecture when implementing an app. In this case, the MVC pattern is suitable for interaction with the database. It represents an interaction of 3 elements: model, view, and controller [3]. A model is some data that describes a subject area and some operations can be performed on it. This information can be also provided to the user on the graphical interface.

The view is this very graphical interface. Through this interface users of the system will send data to the controller to perform the task. The controller in turn implements some algorithms to get data from the view, process it and send it back.

Also, one of the advantages of such systems is the ability to transmit information in the form of a streaming video message. The implementation of this functionality will allow to conduct video consultations and examinations, which will undoubtedly reduce the time for patient care allowing to unload health care institutions. To implement this system, we will use WebRTC technology.

This is a technology that allows Internet applications to capture video and audio media streams optionally without resorting to intermediary services and protocols. The set of standards that WebRTC technology includes allows data exchange and teleconferencing in node-to-node mode[4].

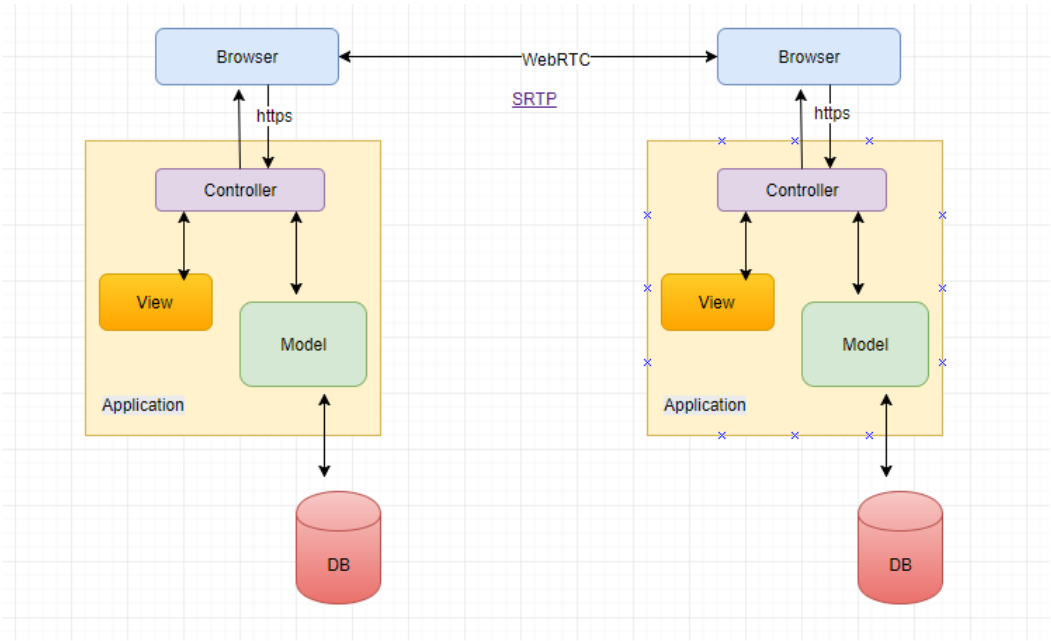

Figure 1. - General architectural scheme of the web application for working with the patient's medical outpatient data

Based on the fact that this system is designed to store confidential patient data it is necessary to develop a system of authentication and cryptographic protection of data.

To provide authentication a user entity in the database with different types of roles, such as patient, doctor, administrator etc. should be created while dividing the access levels to the algorithms for working with data according to the actual level of access to medical documentation. Also, the separation of rights to use algorithms should be implemented both at the database level, through the role editor and through the controller, using verification at the coding stage.

The following technologies are used for secure data transmission over the Internet:

- The HTTPS Protocol is a standard for data transfer between different machines, which defines what should act as a signal for the start of transmission, how data is designated and so on. In this case, data is encrypted using the SSL Protocol, which makes it problematic not only to intercept but also to obtain confidential information[5].
- The SRTP Protocol is a real-time Transport Protocol (RTP) extension profile that appends additional security features such as message authentication, privacy, and listening protection. This Protocol will be used when transmitting video messages [6].
- The AES cipher is a symmetric block encryption algorithm. This type of encryption will use the same symmetric key. This is the best option for the system being developed, since such systems are also protected by legal agreements on non-disclosure to individuals. The encryption method used will be used to encrypt sensitive data at the database level.

Interface design. In this application the process of creating an application interface is used for direct interaction between the application and the database combining all the necessary information to output directly to the application. The interface is created by adding the necessary components and then configuring them. The interface of any application has components that allow the program to interact with the user.

This web application is planned to be developed using the Java programming language and the Spring Framework web development framework. It follows that web interface development technologies must be compatible with these technologies, while providing all the features of modern interfaces.

The application being developed by its structure and basic needs should provide opportunities for working and presenting a large amount of data that could be dynamically generated when the user acts. When analyzing tools for creating a web interface, several technologies were identified that are well suited to these goals:

JSP (JavaServer Pages) is a technology that allows web developers to create content that has both static and dynamic components. A JSP page contains two types of text: static source data that can be formatted in one of the HTML, SVG, WML, or XML text formats, and JSP elements that construct dynamic content. In addition, JSP tag libraries as well as EL (Expression Language) can be used to embed Java code in the static content of JSP pages[7].

JSF (JavaServer Faces) is a framework for web applications written in Java. It serves to facilitate the development of user interfaces for Java EE applications. Unlike other MVC frameworks that are managed by queries, the JSF approach is based on the use of components. The state of user interface components is preserved when the user requests a new page, and then restored if the request is repeated. [8]

Since both technologies support the ability to work with dynamic data, the choice of JavaServer Pages technology was given because its support is most intensive and this technology is more compatible with the Spring Framework due to working through Servlet.

It was also decided to add the ability to adapt the interface for the application being developed. There was Bootstrap for this.

Bootstrap is a free set of tools for creating websites and web applications. Includes HTML and CSS design templates for typography, web forms, buttons, labels, navigation blocks and other web interface components including JavaScript extensions.

Bootstrap uses modern developments in the field of CSS and HTML, so it is necessary to be careful supporting older browsers. [9]

Interface design. When developing the interface, a tab structure was used for ease of use – information is logically divided into tabs, which simplifies its search, does not clutter the main page and does not lead to the need to create additional forms and also reduces the time for loading other pages.

The main information about patients is stored in tables, over which it is possible to perform actions after selecting the appropriate data. This structure is the most simple and understandable for users with different levels of personal computer ownership. The use of standard controls allows you to minimize the learning time to work with the application and styling them with Bootstrap templates allows you to improve the appearance and attractiveness of this application.

The ability to download and view medical media data on the page was also used. This was done on the same pages where the patient data is selected. This approach is implemented using dynamic JSP data loading (figure 2).

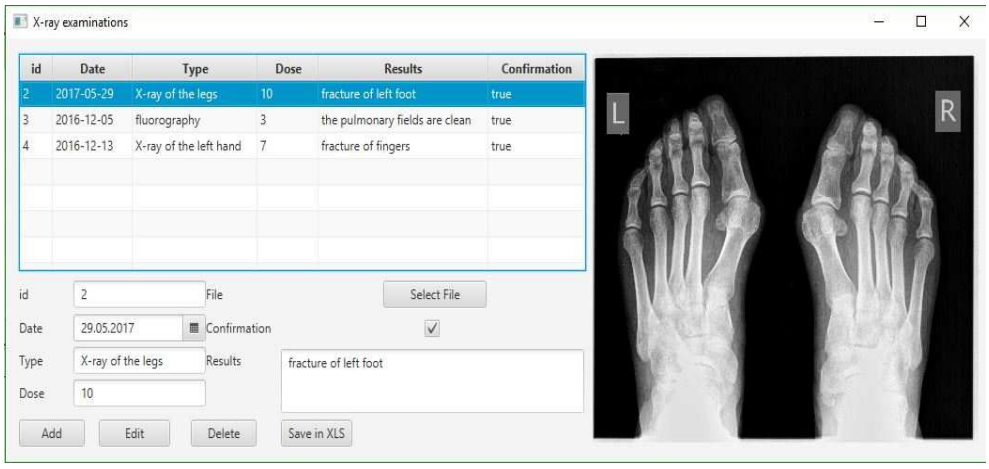

Figure 2. - An example of an interface with an image of the Blob type

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UDC 004.021

DESIGNING OF THE DATABASE FOR MOBILE APPLICATION

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The goals and principles of database designing for mobile application with different technologies are considered in the paper.

Introduction. It is hard to imagine a good client-server application without a developed database. It allows you to conveniently store large amounts of information not on a user's device, but on a remote server, which can provide these data upon request from the application.

This paper is aimed at describing the database for the developed application and its design methods.

Main section. The purpose of data modeling is to provide the developer with a conceptual database schema in the form of a single model or several local models that can be relatively easily mapped to any database system.

The most common data modeling tool is entity-relationship diagrams (ERDs). With their help, objects (entities) that are important for the subject area, their properties (attributes) and relationships with each other (relationships) are determined. ERDs are directly used to design relational databases.

ERD notation was first introduced by P. Chen and was further developed by Barker. The IDEF1 methodology developed by T. Ramay is based on the approach of P. Chen and allows you to build a data model equivalent to the relational model in the third normal form. Currently, based on the improvement of IDEF1 methodology, a new version has been created - IDEF1X methodology.

An entity is a real or imagined type of object, information which should be stored and accessible. In diagrams, an entity is represented as a rectangle containing the name of the entity. In this case, the name of the entity is the name of the type, and not of a specific instance of this type.

A relationship is an association of two or more entities. This association is always binary and can exist between two different entities or between an entity and itself (a recursive relationship). In any connection, two ends are distinguished (in accordance with the existing pair of connected entities), on each of which the name of the connection end, the degree of connection end (how many instances of this entity are connected), the binding of the connection (i.e. whether any instance of this entity should participate in this regard).

To implement the application, it is necessary to establish all the relationships between the entities: it is necessary to consider the entire information system in aggregate and determine the mutual influence of the entities.

The relational model represents the database in the form of many interrelated relationships (tables) that are used to store information about the objects represented in the database.

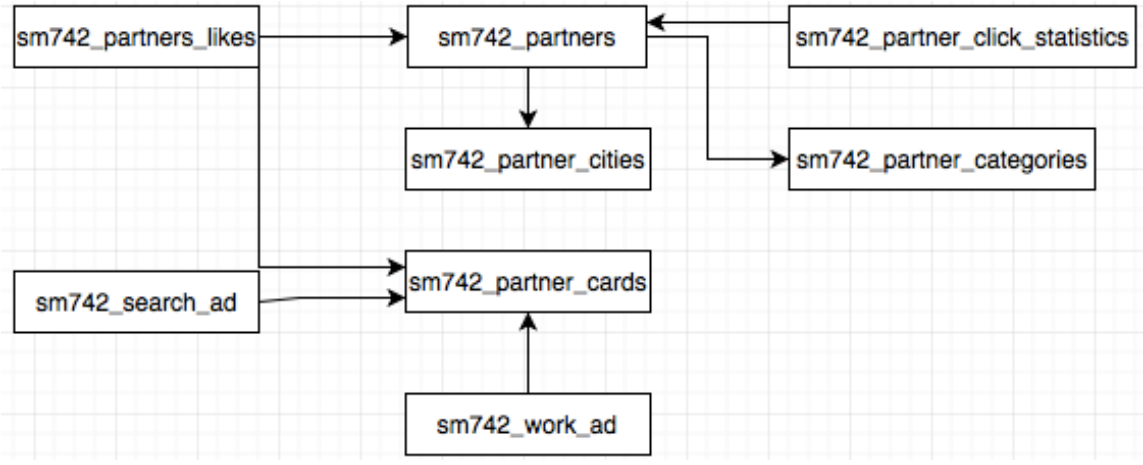

Figure 1. - Example of conceptual database schema

In accordance with the entities highlighted above, a set of necessary database tables is defined, which is presented in Table 1.

Table 1. – List of database tables

Table name	Description
Partners	List of all partners
Partner_Cities	List of all cities
Partner_Categories	List of all partner's categories
Partner_Click_Statistics	User click statistics on partner pages
Partners_Likes	Partners ratings
Partner_Cards	List of all users
Search_Ad	List of ads from music groups
Work_Ad	List of job vacancies

An important advantage of databases is the ability to store grouped data in different tables and establish relationships between these tables by means of keys and the subsequent combination of these data into a single database. This allows to reduce the redundancy of the data that is stored, to simplify the organization of requests for their receipt.

The primary key serves as an integrity constraint within the same table for identification, since primary key field cannot be repeated or be empty. An important condition is that each table can contain only one primary key.

To organize relationships between two or more tables, secondary keys are used. They serve as constraints on the integrity of the relationships of several tables, because the subordinate table cannot refer to nonexistent records of the main table (which allows the construction of integral data models).

There are three connections types between the tables:

– «one-to-many»,
– «one-to-one»,
– «many-to-many».

«One-to-many» connection is the most popular connection type for relational databases. To ensure referential integrity, a foreign key is created in the child table through which a link to the child table is organized. A prerequisite is that the foreign key must match the primary key of the parent table by the composition of the fields.

It is also very important to choose a database management system. There are a lot of different DBMS's:

– MySQL;
– SQL Server;
– SQLight;
– PostgreSQL;
– MongoDB

These databases are different, have their own advantages and disadvantages. It is convenient to use the MySQL DBMS to develop the presented database, since it is open and free, and also supports many types of data required during development.

Conclusion. The paper examined the main goals and principles of modeling the database for mobile application. Besides, the main entities of the designed database were considered.

UDC 004.921

AR TECHNOLOGIES IN ANDROID APP DEVELOPMENT

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Augmented reality have undergone considerable improvement in the past years. In spite of the numerous techniques and hardware devices, the crucial breakthrough have come with the spread of intelligent mobile phones. Mobile devices have limited hardware capabilities, which narrows down the scene analysis methods. An augmented reality application to create stickers for social media is considered in the paper.

Introduction. Augmented reality (AR) is a scientific field which has been well known for many decades. As early as in 1993 one issue of the Communications of the ACM was dedicated to the new emerging field of augmented reality and related ubiquitous computing. One of the significant contributors was Mark Weiser from Xerox Palo Alto laboratories. In [1] and few related articles, the key problems for this field were formulated. A significant number of them are still unsolved and augmented reality is still far from being a common tool.

Almost two decades later, in 2002, Billinghurst and Kato published a paper [2] that summarized state-of-the-art of the collaborative augmented reality and in a broader view the completely augmented reality. The gist of this paper is formulated in the conclusion: «Despite early promising results, a lot of research work needs to be done before collaborative AR interfaces are as well-understood as traditional telecommunication technology». This description could have been applied to most of the AR applications. One of the obvious reasons was lack of special hardware – helmets, binoculars, etc.

However, with the introduction of cell phones equipped with a camera, a completely new tool evolved. Now, a cheap common device is able to present a scene composed of real-word image and different artificial objects. Such presentation looks very natural. In a few years, it is obvious that the adoption of mobile augmented reality by common users is much faster than the adoption of previous applications (see [3], [4] and many others). This trend is clearly shown in Fig. 1 that presents normalized global search requests for «augmented reality» keywords. The exact reason for the 2009 boom will be explained later.

In spite of the significant amount of research in the field of AR, there is still a discussion about an optimal approach to the recognition of a real-world scene. In other words, an approach to identify where the user is and what is there in front of him. The following section briefly describes frequently used approaches to the problem. We will focus primarily on mobile AR applications.

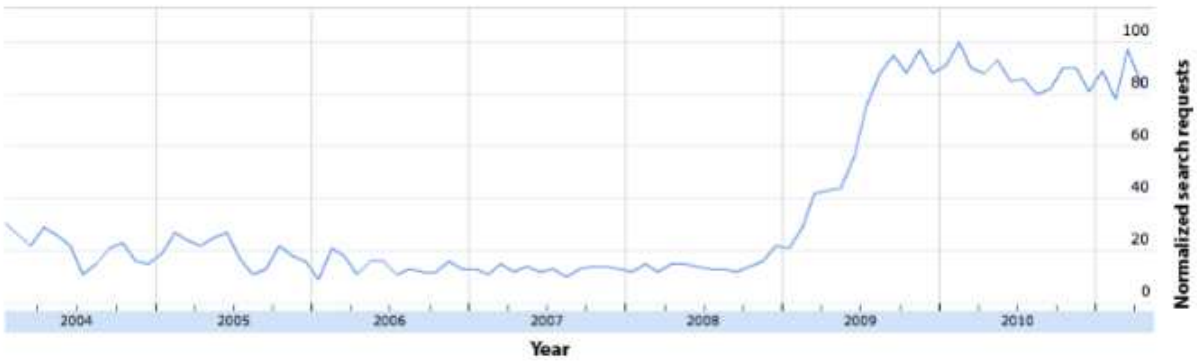

Figure 1. - Google search request for augmented reality between 2004 and 2011. The y-axis shows search requests normalized to range from 0 to 100. This number represents a fraction of highest search activity. The normalization method can be found on Google Search Insights web page.

Related research. In this section, the augmented reality technology and related technology required for the design and implementation of an augmented reality based application will be discussed.

As part of Virtual reality field, augmented reality is a system where virtual worlds are combined with virtual reality made by computer graphics. Augmented Reality is divided into two types: Marker-based Augmented Reality and Markerless Augmented Reality. The Marker-based Augmented Reality augments an object by using a special marker to easily calculate its coordinates. Its Resource libraries include the ARtag, ARToolkit, which pro-

vides the calculation of a fast and accurate coordinate while making a real-time augmented reality system. The Markeless Augmented Reality does not use a special marker. Instead it uses the information of the objects in the image to augment the object. This method detects the image's 3D object's corners and then uses the original form of the object as the object's augmented position.

Android is a mobile OS, made on Linux Canal technology. It has various APIs through which application can be made using Java and X.M.L. Through these, API's Android has interoperability in that the mobile device can be applied to other various devices and sensors. Compared to the conventional computers environment, mobile devices have higher mobility and portability which is an advantage, but there is the limitation of user input and the output of the result, which is a disadvantage. However, a mobile device has a camera, G.P.S, gyro sensor, etc. Therefore, it can use various information related to a user's location, that is, the user's current location, direction and degree of inclination, send this information to the server, get other various additional information through the APIs, and display it on the user's device.

When displaying information on an augmented reality screen, there are basic problems/limits faced including rendering, information congestion, human factor etc. Information congestion is an information-reading problem caused by the increase in information. Due to this, there is a need to maintain important data and the information filtering technic to reduce the amount of information. Information filtering's main elements include the following: user's goal, the relationship between that goal and each object, user's position, etc. Rendering deletes/removes the real objects and does real rendering too. To improve visibility, the Human Factor is used and it comprises delay, adaptation, tiredness and eye tiredness, etc.

Design and implement. Creating funny and cool stickers and making meme stickers for WhatsApp have never been so easy and quick. In implemented sticker maker app for Android, one can easily create and cut out their own stickers using their personal photos or any other photo they have in their library. The process to make a cool sticker is as simple as choosing a photo, making necessary crops, add any desired element or text to the sticker, and export the final result to any social network one wants. So, if one uses WhatsApp a lot and is already tired of default sticker packs and other available meme stickers each pack can be filled with up to 30 funny stickers and memes.

Sticker maker app for Android comes with a clean and neat design and the interface is so user-friendly that one will be able to create a funny meme sticker even if they are totally new to the concept of photo editing or creating stickers. The high-quality graphics, smooth animations, range of different customization tools, the option to create endless sticker packs, easy to use editing tools, and intuitive interface, make this sticker maker app the #1 choice when it comes to finding the best editing app to create stickers for WhatsApp and other social messaging applications.

While there are so many other photo editing apps to create one's own sticker packs, there are just a few reasons why we believe this photo editor app to create personal sticker packs, can easily become one's best tool to make unique memes and stickers:

One. It is super user-friendly and the intuitive interface designed to ensure one would get used to the whole process of making a sticker without having to worry about going through a complex procedure.

Two. The wide range of available funny elements to add to the stickers along with the unlimited customization options (such as changing the font, color and resizing photo) make sure one can easily create unique sticker packs with no limitations.

Three. Not only one can export their personal sticker packs and memes to WhatsApp, but they can also share the created stickers to any other apps and social messaging services.

And since the entire features of this sticker maker app are available for free, there is no harm giving it a try and explore the features for oneself.

Conclusion. In contrast with the current augmented reality technology, this paper has detailed analysis, research. The testing and exploration of augmented reality technology has been carried out. The augmented reality-based app considered in this paper is made up of the combination of virtual objects, the real world, and sensor data received from sensors.

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REFLECTOMETER WITH SPECTRAL SEPARATION OF SIGNALS

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The characteristics of a reflectometer with spectral separation of the signal are studied. The measurements and parameters of the optical fiber in the operating wavelength range of 1550 nm are analyzed. The perspective of the use of the study results in telecommunication systems for servicing fiber optic communication lines is considered.

The relevance of the study is explained by the need to improve the quality of fiber optic transmission systems in response to the increased data transmission traffic and lack of optical fibers in the fiber optic backbone network.

When measured with a spectrometric reflectometer, the main parameters of the optical fibers that affect the signal transmission are evaluated:

1. Attenuation of the optical fiber.

The attenuation coefficient is a = aa + ad + aat + ac + ai, where

aa и ad are attenuation coefficients, caused by losses in the absorption and dissipation of light energy;

aat is attenuation coefficient, caused by impurities in the optical fiber;

ac is additional (cable) losses, caused by twisting, deformation and bending of the optical fiber;

ai is loss of infrared absorption.

Losses in optical fiber occur due to the two processes of absorption and scattering. Absorption is determined by the properties of quartz, which is the main material for the manufacture of high-quality optical fibers. Scattering is highly dependent on the wavelength as well as manufacturing technology and composition of optical fiber.

In measurements, a reflectometer with spectral separation is easily defined by macro-bends (fiber bends with a radius less than the minimum allowable radius). In this case, additional losses occur, significantly affecting the total attenuation of the optical line.

With a change in the operating wavelength, attenuation in the cable in dB/km changes (table 1), which causes a change in the reflectogram angle.

When comparing losses at three wavelengths of 1310 nm, 1490 nm, and 1550 nm, macro-bends give greater attenuation at a longer wavelength. 1550 nm macro-bends are best defined.

The difference is particularly noticeable for multimode fibers.

Table 1. – Attenuation measurement

Wavelength	Requirements G.652.D, type A	Requirements G.652.D, type B	Requirements G.652.D, type C
1310 нм	≤ 0.34	≤ 0.33	≤ 0.35
1550 нм	≤ 0.21	≤ 0.19	≤ 0.21
1625 нм	≤ 0.24	≤ 0.22	≤ 0.23

2. Dispersion and bandwidth of the optical fiber.

The dispersion results both in limiting the transmission bandwidth over the cable and in reducing the length of the regeneration section.

When light travels through an optical fiber there are significant limitations. The signal at the receiving end is blurred and distorted, and the longer the line, the more distorted the transmitted signal is.

The parameters of frequency band ΔF and transmission distance L are interdependent.

The ratio between them for short lines is

$$\Delta F / \Delta F_x = L_x / L$$

where values with index x are required, without it are specified.

In long lines, in which the process has already been established the following quadratic law of the ratio applies:

$$\Delta F/_{\Delta Fx} = \sqrt{Lx}/_{L}$$

3. The propagation coefficient, the transmission speed of optical fiber, and wave resistance depend on the fiber length. The greater the length of the fiber, the worse the signal is to noise ratio. The ratio of the average optical radiation power of the signal to the average optical radiation power of the noise in the frequency band of the optical channel is expressed in dB.

Optical signal to optical noise ratio is one of the most important characteristics of fiber optic communication lines, determining the quality of information transmission, maximum transmission distance, the stability of the signal.

It has been found that the reflectometer signal level is more than 29 dB; the spectra of adjacent channels expand to a critical level of more than 0.8 nm. When the power is less than 29 dBm the traffic quality does not deteriorate, and the power of the backscattered radiation meets the specified value.

Studies have shown that the reflectometry method with frequency division by wavelength provides measurement accuracy of more than 99%, allows to quickly determine the location of fiber damage, performs quality control during emergency operations, monitors unauthorized access to the fiber optical highway.

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UDC 004.42

ANALYSIS OF INTERNET PORTAL DEVELOPMENT

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The article presents the results of the analysis of Internet portal development. The World Wide Web is an ever-evolving network that has gone far ahead of its concept in the early 1990s, when its creation was determined by specific tasks. High-tech experiments at CERN (The European Particle Physics Laboratory, known today as the owner of the Large Hadron Collider) produced an incredibly large amount of data that was too large to be disseminated among the participating scientists scattered around the world.

Introduction. Currently, the main source of information is the Internet. As information grows in size and complexity, we are faced with increasing content and user management challenges. Be it a seller of certain goods and services or the head of a large corporation, they need to create an Internet portal in order to conduct their work efficiently and bring information from diverse sources together in a uniform way. We will also focus on creating corporate Internet portals [1].

Main part. Portals are a class of software systems for which the terminology and classification have not been fully developed yet. You can find various definitions of the concept of "portal" and its software implementations that are different in functionality.

The following definitions are most commonly found in the literature:

1) a portal is an integrated and personalized web-interface for users to access information, applications and means of cooperation;

2) a portal is a tool for managing intellectual property, e.g. various kinds of information and data. The portal brings information from diverse sources together in a uniform way, i.e. organizes, categorizes and personalizes it in order to present it in the right way, at the right time, in the right place;

3) portals are websites that are focused on specific audiences and communities and provide content aggregation, i.e. the delivery of information to the appropriate audience; collaboration and community support services (employees, customers, shareholders); services and applications giving access to the target audience.

Let us compare a Web site with a portal. A Web site is a set of logically interconnected pages accessible through a Web browser via HTTP; a portal is a Web site that has a wide range of functions. Portals provide the user community with expanded functionality and centralized access to the necessary information and services.

Portals can be classified according to various criteria. In the classification below the main criteria are the portal topics, target audience, tasks solved by the portal and the technologies used (Fig. 1).

According to the topic criterion, portals can be divided into horizontal and vertical.

Information and thematic content and functions of the horizontal portal are aimed at a wide range of users. On the Internet, such portals are called mega-portals (Yahoo !, Yandex, etc.), because they provide information (weather, news, etc.) and functions (search for sites, sending e-mail, etc.) useful to almost all web users.

Vertical portals provide a complete list of the necessary information and functions for a specific and narrow circle of users. An example of industrial vertical portals can be portals for insurance, automotive, etc.

If the target audience of the portal is not be limited, the portal is open, otherwise the portal is closed. Open portals are available to a wide community of users. Most often, such portals are placed on the Internet. Closed portals provide access to a limited circle of users [2].

User registration in such portals usually goes through the verification stage, when the right of the person registered to access the portal is confirmed by authorized persons. This type usually includes portals located in corporate networks of organizations. They are intended for company employees and are known as B2E portals.

According to the target task criterion, the portal can be focused on the performance of one or more tasks. Several classes of portals can be distinguished, and each portal can be assigned to one or more classes:

1) Analytical portals allow decision makers to receive and create reports.

2) News portals deliver updated content on a specific topic or group of topics.

3) Business process support portals implement specific functions and support specific processes and applications, e.g. B2B, B2E, or B2C portals.

4) Collaboration portals provide users with virtual space for coordination and collaboration.

5) Solution search portals are designed to attract experts to solve problems. To do this, the portal keeps track of users and their competencies, which allows you to select experts in specific areas of knowledge, find them and use their expertise in solving problems.

6) Document management portals.

7) Portals for managing structured information.

8) Knowledge management portals. They are called upon to help the company make better use of its explicit and implicit knowledge by managing knowledge at each stage of its life cycle - at the stages of identification, creation, storage, distribution and use.

9) Portals-catalogs organize available information resources and search for the necessary resources.

10) Portals-electronic markets connect sellers and buyers with each other, providing specific information about markets, goods and services.

11) ASP portals (ASP, Application Service Provider) are designed to provide services to other companies, that is, they are B2B type portals. They provide an opportunity for client companies to lease both goods and services.

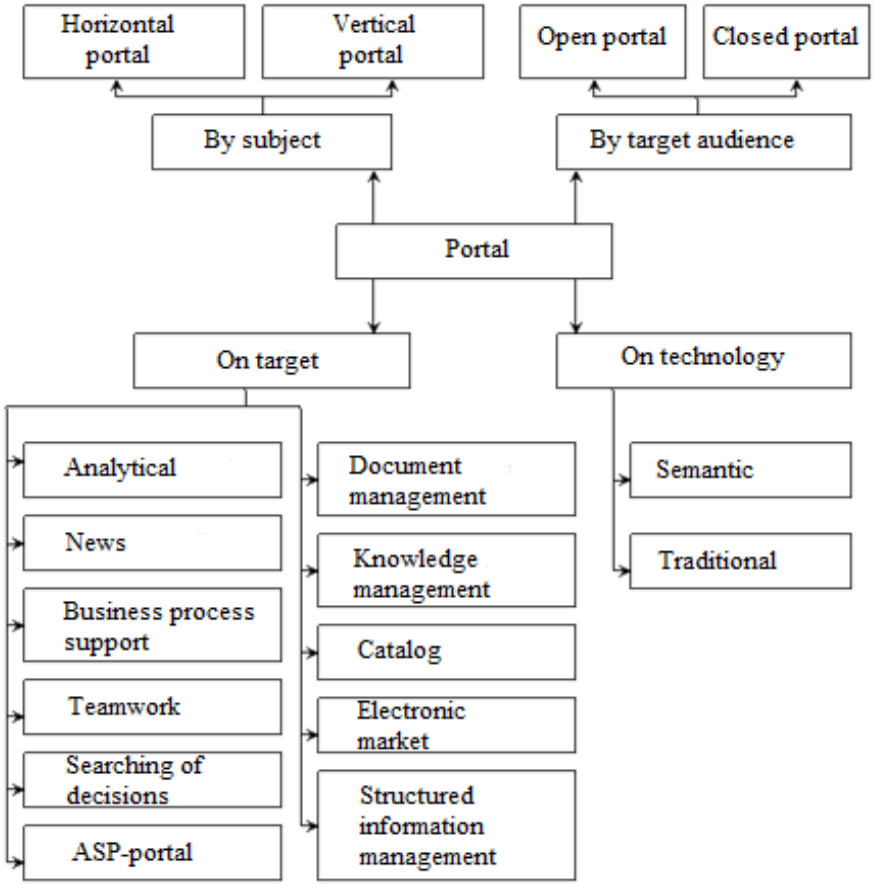

Figure 1. – Portal Classification

According to the technologies used criterion, portals can be divided into traditional and semantic. In traditional portals, information is processed regardless to its semantics.

Semantic portals are a new class of portals that contain a knowledge model of a certain subject area and use it to process information based on semantics. In addition to traditional technologies, actively developing semantic technologies are used to implement such portals.

The approaches, technologies and standards used both within the framework of the portal infrastructure and in the implementation of its functional modules are common. This allows us to describe the generalized architecture of the portal, covering the potential functionality.

At the user interface level, a thin client (Web browser) is used that can visualize the presentation of information described in HTML. To use some functionality of the portal, the user can use some other client applications (for example, email client, RSS client, etc.).

To implement the portal infrastructure, there are a number of widely used technologies and application servers. The most common application servers include software products such as Microsoft IIS, Apache HTTP

Server, Oracle Application Server. Relational databases are used as data storages, accessed using OLEDB, ODBC, JDBC, etc. Such programming technologies as ASP, ASP.NET, PHP, JSP and others are used. The visual presentation is described in HTML, which is interpreted by the user's web browser.

Although the approaches to the development and implementation of portals can be considered sufficiently developed in terms of methods and the technologies used, there is an objective need for their development. This need is justified by the development of telecommunication technologies that make information more accessible, as well as an objective increase in the volume of information.

The portal is such an information system (IS) that provides the user community with unified access to the information space, and therefore the problem of improving the quality of information processes is especially relevant. One of the approaches to solving this problem is the transition to the semantic level in the collection, processing, accumulation, storage, retrieval and dissemination of information. This approach is being developed within the framework of the Semantic Technologies area [3].

Conclusion. An Internet portal is a website that provides the Internet user with various interactive services that operate within the same website. Horizontal, vertical, mixed and corporate Internet portals can be distinguished. A corporate Internet portal is a complex designed not only for advertising goods and services, but also for the effective organization of the company's internal and external information space. In its most general form, a corporate portal is understood as a link between the end user and the internal information base. Representing a company on the Internet is essential for business development. The main goal of creating corporate Internet portals is to increase the profitability of the business. When creating corporate Internet portals, the main emphasis is on the convenience of obtaining information, on maintaining various levels of information acces. When developing such portals, technological platforms of major software manufacturers are used. The most popular technology platforms are Oracle, IBM, Microsoft, SAP.

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THE STUDY OF THE CHARACTERISTICS OF THE 3G ANTENNA FROM CHANGES IN THE MATERIAL OF THE CONDUCTOR

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The article presents the design results of a GSM antenna depending on the material of the conductor. In connection with the development of electronic devices and communication systems, there is a need for GSM antennae. The use of antennae in radio systems allows increasing the capabilities of radio communication systems, radar systems, since the amount of information that is transmitted per unit of time is directly proportional to the signal frequency band; it also allows for high noise immunity of communication channels and improves accuracy in assessing the relative orientation of moving objects.

Introduction. An antenna is a device for radiation and reception of radio waves. [1]

The shape, size and design of antennae vary depending on the length of the emitted or received waves and the antenna destination. Antennae are used in the form of a piece of wire, combinations of such segments, reflective metal mirrors of various configurations, cavities with metal walls in which slots are cut (a slot antenna), spirals of metal wires and others. [2]

A GSM antenna is the most common antenna with a fairly narrow radiation pattern in the horizontal and vertical planes. An antenna consists of a set of elements: an active vibrator and several passive vibrators, one of which is a reflector, and the others work in the mode of directors. Reflectors weaken the radiation in the rear direction, directors amplify the signal in the right direction. All vibrators are parallel and lie in the same plane, which determines the polarization of the antenna. Such an antenna is called a "wave channel" antenna or a "Uda-Yagi" antenna. [3]

Main part. The calculation of the antenna allows us to obtain only approximate results, since it is necessary to take into account many interrelated factors (the length and thickness of vibrators, the distance between them), and is associated with cumbersome calculations. Therefore, most often antenna design, selecting all their sizes experimentally, adhere to the following rules:

1) for a given operating wave λ, calculate and set the length of the active vibrator 2l taking into account the shortening Δl

2) set the length of the reflector 2 lp by 5 - 10% longer than the length of the active vibrator, and the distance between the vibrators is about 0.2 λ;

3) using the field indicator, measure the field strength E_O (towards the active vibrator) and E_180 (towards the reflector), and adjusting the distance dp between the vibrators and the length of the reflector achieve the minimum ratio E_180⁄E_O. for a system of two vibrators;

4) add a director, the length of which 2l_q is set shorter by 10 - 15% of the active length, and the distance a_d to the last is about 0.2 λ, and the minimum ratio E_180⁄E_O is achieved by adjusting the specified dimensions. For a system of three vibrators (this may require a slight adjustment of the reflector);

5) add successively second, third, etc. directors and make similar adjustments.

The shape of the radiation pattern (DN), the standing wave ratio (CWS) and the reflection coefficient (S11) are calculated for the frequency from 1.92 GHz to 2.17 GHz, the material is copper. The antenna has a directional radiation in the direction of 0 °, in the direction of -180 ° there is a reverse low radiation of the radiation pattern as shown in Figure 1. The antenna has good matching properties in the frequency range from 1.99 GHz to 2.17 GHz (Figure 2). The reflection coefficient from the input decreases from 0 dB at 1.92 GHz to -10.4 dB at 2.17 GHz, at 2.045 GHz, the reflection coefficient is -6 dB.

The shape of the radiation pattern (DN), the standing wave ratio (CWS) and the reflection coefficient (S11) are calculated for the frequency from 1.92 GHz to 2.17 GHz, the material is aluminum. The antenna has directional radiation in the 0 ° direction and is more directional. In the direction of -180 °, the backward radiation of the beam is observed (Figure 4). In the frequency range from 1.98 GHz to 2.17 GHz, good matching properties are observed (Figure 5). The magnitude of the reflection coefficient from the input decreases from -3.9 dB at a frequency of 1.92 GHz to -4.58 dB at a frequency of 2.17 GHz. At a frequency of 2.045 GHz, the reflection coefficient is -4.3 dB (Figure 6).

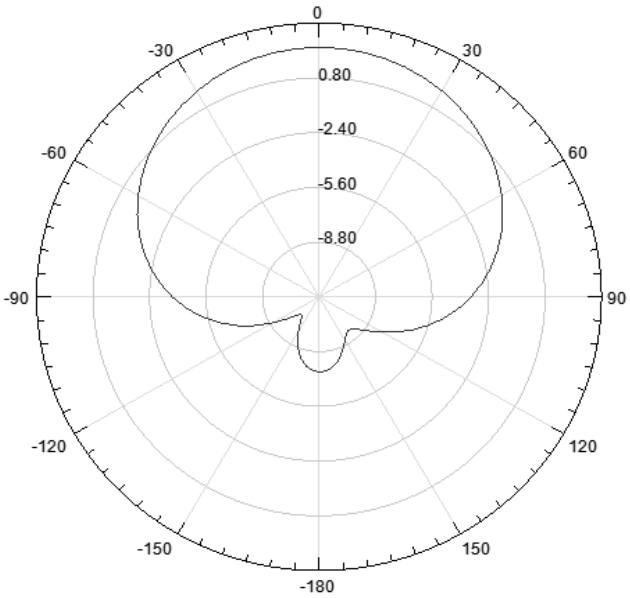

Figure 1. - Antenna pattern (copper)

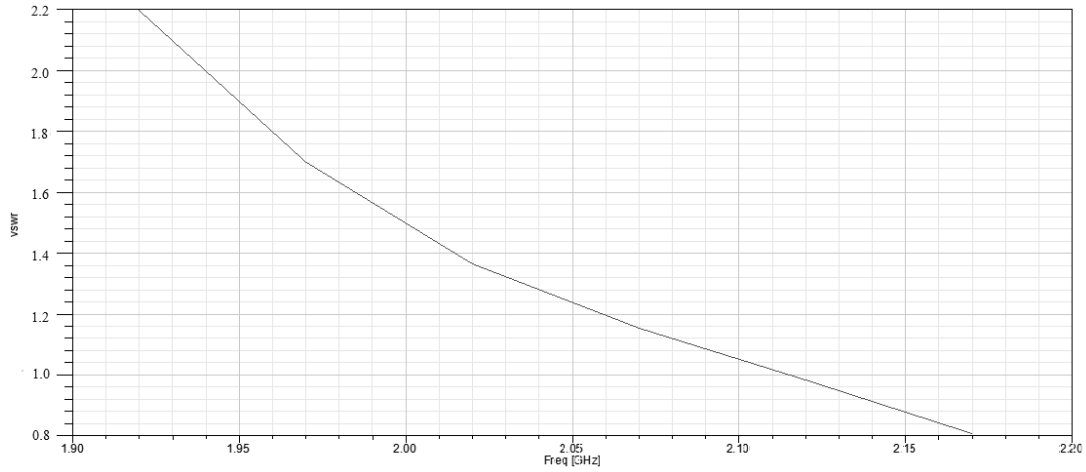

Figure 2. - Antenna standing wave ratio (copper)

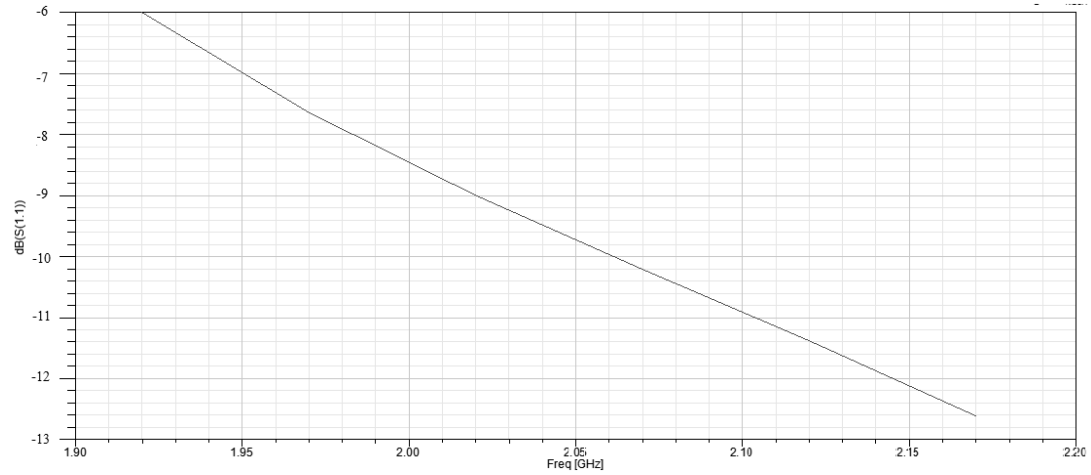

Figure 3. – S_{11} antenna parameter (copper)

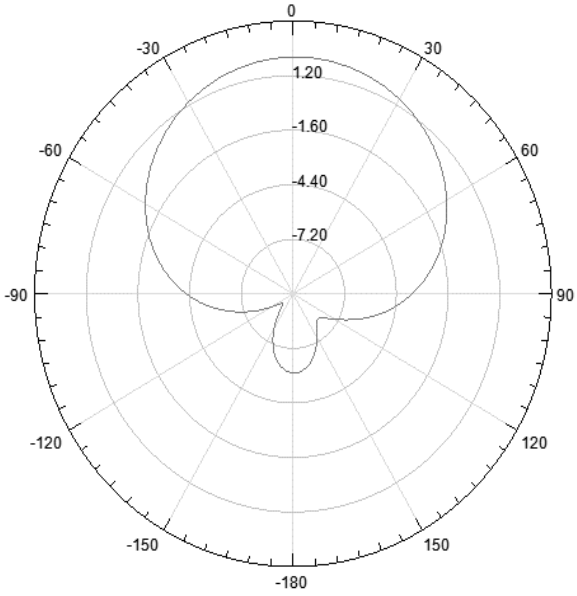

Figure 4. - Antenna pattern (aluminum)

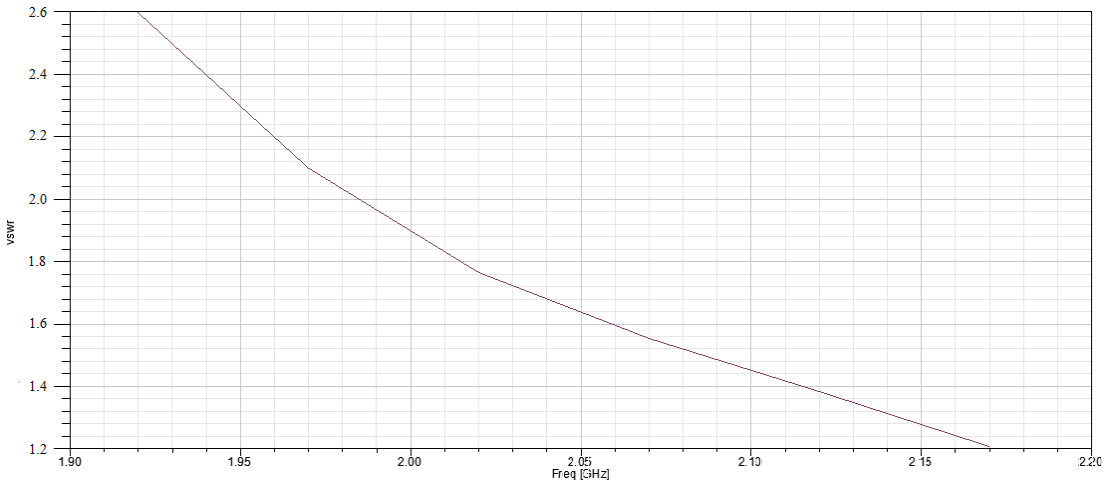

Figure 5. - Antenna standing wave ratio (aluminum)

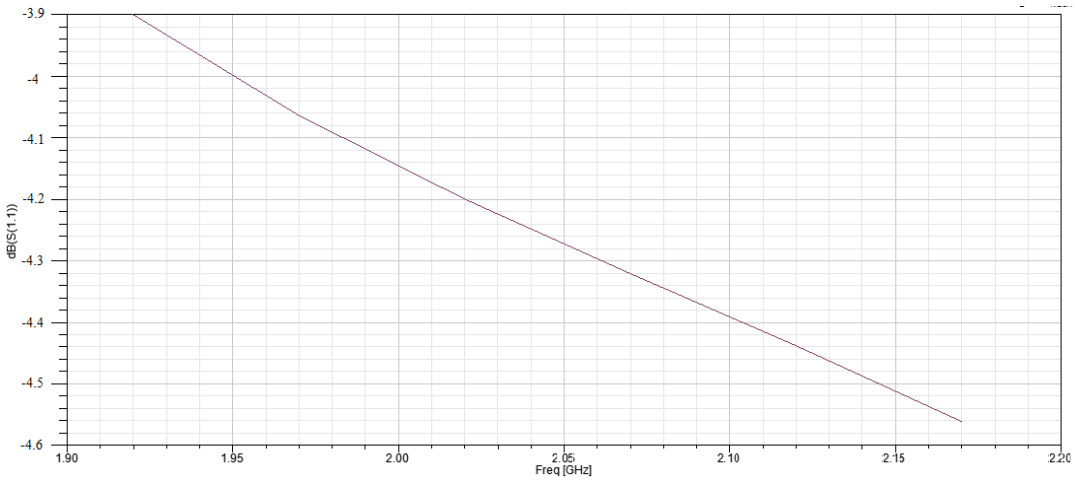

Figure 6. – S_{11} antenna parameter (aluminum)

Conclusion. In connection with the development of radio-electronic devices and communication systems, there is a need for GSM antennas. The use of antennae in radio systems allows you to increase the capabilities of radio communication systems, a radar, as the amount of information transmitted per unit of time is directly proportional to the frequency band of the signal; it also allows for high noise immunity of communication channels and improves accuracy when assessing the relative orientation of moving objects. A change in the material of the conductor affects the radiation pattern, its width and back radiation, as well as the SWR and reflection coefficient. From the data obtained, the optimal characteristics were shown, the material is cooper.

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UDC 004.223.2

«SMART RECIPE BOOK» APP

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The article discusses an application for storing recipes with the function of counting calories and selecting the optimal dishes. The analysis of the technologies used to develop this application is carried out. The relevance of the development of this application is considered.

Introduction. Currently, a large number of people are switching from paper to electronic media. The popularity of using electronic media is determined not only by the convenience of adding and storing information, but also by the presence of additional functions for processing large amounts of data. Electronic storage is not limited to professional use, it is also popular in everyday life, for example, in the form of notebooks.

Along with information technology, sports and healthy nutrition are actively popularized, which makes the introduction of information technology in the field of a healthy lifestyle relevant. At the moment, a large number of applications for sports, calorie counting and menu compilation are being created, which confirms the relevance of the created application.

The Smart Recipe Book app is convenient data storage, as well as a tool for creating a useful and tasty menu, and selecting dishes based on users' physical characteristics.

This article is aimed at describing the database, its design methods and the technologies used to create the developed application.

Main section. Designing a software product begins with designing the database needed to store all the application information. In accordance with the subject area and purpose of the application, the database stores information about users, recipes, products, cooking technologies and the values of proteins, fats and carbohydrates (PFC), both for recipes and for individual users, based on their physical characteristics.

Database development is performed using data modeling. The purpose of data modeling is to develop a conceptual database schema in the form of one model or several local models that can be relatively easily mapped to any database system. The most common data modeling tool is entity-relationship diagrams (ERDs). Using ERD, the DFD data storage devices are detailed, diagrams are documented, informational aspects of the business system are documented, including the identification of objects, entities, the properties of these objects — attributes and their relationships with other objects (relationships).

Entity is a set of instances of real or abstract objects (people, events, states, ideas, objects, etc.) that share common attributes or characteristics. Each entity must have a unique identifier. Each entity instance must be uniquely identified and distinguished from all other instances of this entity type. Each entity must have some properties:

- a unique name;
- one or more attributes that either belong to the entity or are inherited through communication;
- one or more attributes that uniquely identify each entity instance.
- any number of relationships with other model entities.

Relationship is an association between entities in which each instance of one entity is associated with an arbitrary (including zero) number of instances of the second entity, and vice versa.

An attribute (Attribute) represents a type of characteristic or property associated with a variety of real or abstract entities - objects (people, places, events, states, ideas, objects, etc.). An attribute instance is a specific characteristic of an individual element of a set. An attribute instance is determined by the type of characteristic and its value, called the attribute value. An entity instance must have a single specific value for the associated attribute [1].

In the course of the analysis of knowledge and database development, the main entities were identified, which are described below.

The Dish essence describes dishes that can have a large number of recipes, characterized by name, type (for example: soup, salad), belonging to the national cuisine of a country, type of event for which this dish is being prepared (for example: breakfast, New Year).

The recipe essence describes one of the possible recipes for a particular dish, characterized by its name, number of servings, calorie content, attachment to a specific dish.

The Products essence describes the products characterized by the name, calorie content and PFC indicators.

Ingredients essence describes the ingredients of a recipe characterized by the number of grams and linked to the recipe and product.

The technology of preparation eesence describes the steps for preparing the recipe characterized by the description, duration, number of action.

The user entity contains the usernames and passwords of users registered in the application.

The User's characteristics essence describes the parameters of the user (weight, height, age), BJU indicators for the user, the required number of calories and the date the characteristics were added.

Favorite recipes essence describes recipes that the user liked and is characterized by priority.

Based on the selected basic entities, we distinguish under the entities to the main entities:

For the Dish entity, we distinguish the entity by type, event type, and national cuisine.

For the Recipe entity, select the type of recipe for the entity.

For the Technology of cooking essence, we select an action for the essence.

To implement the application, it was necessary to establish all the relationships between the entities: it was necessary to consider the entire information system in aggregate and determine the mutual influence of the entities.

The relational model represents a database in the form of a set of interrelated relationships (tables) that are used to store information about objects represented in the database.

One of the most important advantages of relational databases is that it is possible to store logically grouped data in different tables and specify the relationships between them, combining them into a single database. Such data organization allows us to reduce the redundancy of stored data, simplifies their input and organization of queries and reports.

In each database table, a primary key may exist. The primary key is understood as a field or a set of fields that uniquely (uniquely) identify an entry. The primary key should be minimally sufficient: it should not contain fields whose removal from the primary key will not affect its uniqueness.

To organize relationships between two or more tables, secondary keys are used. They serve as constraints on the integrity of the relationships of several tables, because the subordinate table cannot refer to non-existent records of the main table (which allows the construction of integral data models).

There are three types of relationships between tables:

– one-to-many,
– one-to-one,
– many-to-many.

One-to-many relationships are the most common for relational databases. To ensure referential integrity, a foreign key is created in the child table through which a link to the child table is organized. A prerequisite is that the foreign key must match the composition of the fields with the primary key of the parent table [2].

The primary and foreign keys of the relationships of the designed database are presented in table 1.

Table 1**. -** Primary and foreign keys of relations

№	Table name	Primary key	Foreign key
1	Dish	IDDish	IDTypeOfDishes, IDNatianality, IDEventType
2	TypeOfDishes	IDTypeOfDishes	-
3	NationalCuisine	IDNationality	-
4	EventTypeDishes	IDEventType	-
5	Recipe	IDRecipe	IDDish
6	Products	IDProduct	-
7	Ingridients	IDIngridient	IDProduct, IDRecipe
8	TypeOfRecipe	IDTypeOfRecipe	-
9	RelRecipeType	IDRel	IDRecipe, IDTypeOfRecipe
10	CookingTechnology	IDTechnology	IDRecipe, IDAction
11	Action	IDAction	-
12	User	IDUser	-
13	UserFeatures	IDFeatures	IDUser
14	FavouriteRecipe	IDFavouriteRecipe	IDRecipe, IDUser

MSSQL 2014 was used to create the information database. To create the application, the Microsoft Visual Studio 2017 development environment was used.

To create the application, C # was chosen. C # is a programming language that combines object-oriented and context-oriented concepts. C # belongs to a family of languages with C-like syntax, of which its syntax is closest to C ++ and Java. The language has strict static typing, supports polymorphism, operator overloading, pointers to class member functions, attributes, events, properties, exceptions, comments in XML format [1].

MSSQL Server was used to create the database due to its good compatibility with the selected programming language and ease of use.

Connection to the database was carried out using the Entity Framework, this framework provides quick and easy connection to the database and convenient work with it using the built-in functions. Entity Framework presents a special object-oriented technology based on the .NET framework for working with data. If traditional ADO.NET tools allow you to create connections, commands and other objects for interacting with databases, the Entity Framework represents a higher level of abstraction, which allows you to abstract from the database itself and work with data regardless of the type of storage. If at the physical level the programmer operates with tables, indexes, primary and foreign keys, then at the conceptual level that the Entity Framework offers, he already works with objects [2].

To ensure the functionality and ease of use of the information system, an application was created that allows you to add new recipes, add, delete, edit information about yourself, about your favorite recipes, display information about recipes and select the best dishes for each application user.

When creating databases, one of the important tasks is to ensure data integrity. Integrity (from the English integrity - intactness, inviolability, safety, integrity) - is understood as the correctness of the data at any time. But this goal can be achieved only within certain limits: the DBMS cannot control the correctness of each individual value entered into the database. To do this, there are a number of tools that help the developer minimize the possibility of violating the integrity of the database data: triggers, checks («check»), uniqueness («unique»), etc. A trigger is a stored procedure of a special type that is automatically executed when a given event occurs [3].

In this application, triggers are also used to automatically calculate the calorie content of dishes and user characteristics. Table 2 summarizes the main uses of constraints and triggers.

Table 2. – Table Constraints and Triggers

№	Table name	Description
1	Ingridients	When adding a new ingredient, the calorie content of the whole dish is recalculated
		When adding a new ingredient, the UNIQUE restriction applies to the combination of the recipe and the product
2	Recipe	When a recipe is deleted, all tables associated with it are deleted
3	CookingTechnology	When adding new technology, the calorie content of the entire dish is recalculated depending on the action
4	UserFeatures	When changing weight, age and height, the values of PFC and calories are recounted
5	RelRecipeType	When adding a new type of recipe, the UNIQUE restriction applies to the combination of recipe and type

In addition, to ensure data integrity, there are triggers for adding, deleting and modifying tables.

Using Windows Forms, an intuitive and easy-to-use user interface was created.

Conclusion. The developed application meets all the requirements of the subject area, the tables of the created database meet the requirements of normalization, which ensures the integrity and consistency of information.

The most suitable and modern programming languages and development environments were used to create the application.

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