SCIENTIFIC RESEARCH OF THE SCO COUNTRIES: SYNERGY AND INTEGRATION

上合组织国家的科学研究：协同和一体化

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欧亚铁路主要性能特征比较分析
COMPARATIVE ANALYSIS OF KEY PERFORMANCE CHARACTERISTICS OF EURASIAN RAILWAYS

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注释。本文对欧亚大陆最大的铁路公司的经济和运量指标进行了最新分析，这些铁路公司包括：俄罗斯铁路公司 – RZD、德国铁路公司 – 德国铁路股份公司和中国铁路公司 – 中国铁路集团。本文探讨了这些公司在经济活动领域的发展方向。

关键词：铁路、铁路运输、俄罗斯铁路、德国铁路股份公司、中国铁路集团、运输服务、关键经济指标。

Annotation. *The article presents an up-to-date analysis of the economic and volume indicators of the largest railway companies in Eurasia, consisting of: Russian Railways - RZD, German Railways -Deutsche Bahn AG and Chinese Railways – China Railway Group. The directions of development of these companies in the sphere of economic activity are considered.*

Keywords: *railway, railway transportation, Russian Railways, Deutsche Bahn AG, China Railway Group, transport services, key economic indicators.*

Rail transport plays a key role in international transportation, as the world freight turnover is 9,842 billion ton-kilometers and 4,124 billion passenger-kilometers. When converting the volume of rail transportation from conventional natural units to value units, the profit received from freight transportation by rail will amount to 28.58 trillion rubles, with 13.4 trillion rubles from passenger transportation [1]. It should be noted that the state is interested in developing its railway companies and increasing the share of railway transportation in the world market.

JSC Russian Railways is the largest state-owned company in Russia. According to various estimates, the railway industry accounts for 4% to 15% of all fixed assets in the Russian economy's production volume. The separation of JSC Rus-

sian Railways from the Ministry of Railways (MPS) in 2003 made it possible to solve the main problems of developing railway transport and mechanical engineering in the country, ensuring economic growth in the early 2000s.

In Germany, the main railway operator is Deutsche Bahn Holding. It was created on the basis of the merger in 1993 of two railway organizations of West and East Germany, and includes three divisions: “Passenger Transportation” (DB Bahn), “Infrastructure and Service” (DB Netze), “Freight Transportation and Logistics” (DB Schenker).

China Railway Group was founded through the reform of the Ministry of Railways. The company operates under the control of the Ministry of Finance of China. The company controls the railways, bridges and tunnels, passenger stations, freight stations, and the railway police department, which is formally listed as a civil service under the Ministry of Public Security of the People’s Republic of China. The main volume indicators of all three railway companies are presented in Table 1.

Table 1

Volume indicators of railway companies in 2023

Indicators	Russian Railways	Deutsche Bahn Holding	China Railway Group
Length of tracks in operation, thousand km	85.6	33.5	159
Freight turnover, billion ton-km	2636.7	74.4	3263.8
Passenger turnover, billion passenger-km	136.2	21.7	1471.7
Number of freight cars in operation, thousand wagons	196.3	15.4	710.1
Number of passenger cars in operation, thousand cars	35.3	4.4	622.3

In addition to volume indicators, for a more detailed analysis of railway transportation operators, it is necessary to analyze key economic indicators, which are presented in the form of a histogram in Fig. 1. [2,3,4,5].

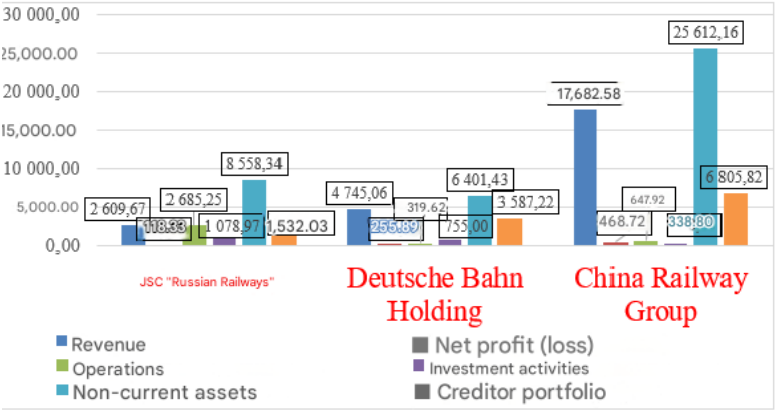

Figure 1. *Key economic indicators of three Eurasian railway companies in 2023, in billion rubles*

China Railways is the leader among the three companies in terms of revenue (RUB 17,682.58 billion), non-current assets (RUB 25,612.16 billion), but at the same time the company has a small net profit (RUB 468.72 billion) relative to the funds earned from its core business or operating activities (RUB 647.92 billion). The results of the analysis show that the company receives a significant part of its earnings from the design, construction and production of equipment for railway companies in other countries, which is a consequence of their national strategy for the "globalization" of their company. The company receives most of the funds allocated for its development not from investment activities (RUB 338.8 billion), but through a loan portfolio (RUB 6,805.82 billion), where the main creditor is the state. [4, 5].

The German railway company is inferior to the Chinese one in many indicators: revenue (RUB 4,745.06 billion), net profit (RUB 255.89 billion), operating activities (RUB 319.62 billion) and non-current assets (RUB 6,401.43 billion). The results of the analysis show that the German railway is smaller than the Chinese one in terms of operational length, number of rolling stocks, volumes of freight turnover and passenger turnover. Thus, the German company has greater investment activity (RUB 755 billion) and a smaller loan portfolio (RUB 3,587.22 billion).[3] The company spends a significant portion of its investments and government loans on upgrading its infrastructure and rolling stock, noise insulation of tracks, and promoting environmental policies.

Russian Railways has low revenue (RUB 2,609.67 billion) and net profit (RUB 118.33 billion) compared to the roads under consideration. However, it has the largest operating activity (RUB 2,685.25 billion). Thus, most of the funds are

received directly from freight and passenger transportation. Russian Railways has the largest investment activity (RUB 1,078.97 billion) and the smallest loan portfolio (RUB 1,532.03 billion), directing a significant part of its funds to comprehensive development.

It should also be noted that Russian Railways JSC wins in many key indicators against German and Chinese railways. For example, Russian Railways JSC invests a significant part of its funds in general development, while the governments of Germany and China have to issue loans and state credits for the activities of their companies. The Russian company, with a smaller number of freight cars and fewer employees, can issue 2/3 of the total freight turnover of Chinese railways.

It should be noted that JSC Russian Railways is the only company that can afford a significant range of preferences for its employees. For example, JSC Russian Railways is the most striking example of a Russian company that offers young employees under 30 an event called "Unified Adaptation Day" aimed at revealing teamwork. It is designed to help young professionals who have just graduated from university and are working in the company for the first year, form a holistic understanding of the principles of work of JSC Russian Railways, starting from the features of the transportation process and ending with social guarantees provided to young people. The event consists of three blocks:

1. Business game "My path to Russian Railways" (division into five teams: locomotives, infrastructure, traffic management, freight and passenger transportation and interaction between specialists in key areas of Russian Railways' work).

2. Corporate social services fair, where participants become familiar with the main benefits and guarantees provided to employees of JSC Russian Railways.

3. Round table with the management of the road and regional directorates (discussion of current topics for young people, including development opportunities within the company and participation in infrastructure projects) [6]. With the presented development directions, the Company may become the largest railway company in Eurasia in the future.

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多功能商品与耐用品消费质量的比较定量评估方法（以无人设备为例）

THE METHODOLOGY OF COMPARATIVE QUANTITATIVE ASSESSMENT OF CONSUMER QUALITY OF MULTIFUNCTIONAL GOODS AND DURABLE GOODS (USING THE EXAMPLE OF UNMANNED DEVICES)

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摘要。提出了一种用于多功能耐用品消费者质量的比较定量评估的原创方法，并以无人设备为例进行了考虑。证实了使用距离和 Kemeny 中位数通过消费者质量特征的组成和值来评估 BPU 对象之间的关系的可能性。结果表明，应用对象及其特征的功能完整性和重要性比较评估方法可以将具有最佳消费者质量特征和最佳信息“权重”的 BPU 分组。提出了一种用于评估和最小化耐用品制造和改造技术过程的资源强度的原创程序。该方法适用于比较评估技术过程、技术和建筑对象的消费者质量。

关键词：消费者质量、无人设备、Kemeny 中位数、资源强度、总成本、功能完整性。

Abstract. *An original methodology for comparative quantitative assessment of consumer quality of multifunctional and durable goods is proposed and considered using unmanned devices as an example. The possibility of using the distance and Kemeny median to assess the relationship between BPU objects by the composition and values of consumer quality characteristics is substantiated. It is shown that the application of the method of comparative assessment of the functional completeness and significance of objects and their characteristics allows for grouping BPUs with the best consumer quality characteristics*

and the best information "weight". An original procedure for assessing and minimizing the resource intensity of technological processes for the manufacture and modification of durable goods is proposed. The methodology is suitable for comparative assessment of consumer quality of technological processes, technical and construction objects.

Keywords: *consumer quality, unmanned devices, Kemeny median, resource intensity, total cost, functional completeness.*

Introduction. Let us first recall that "quality is a set of properties of a product, goods or service that determine its suitability to satisfy certain needs in accordance with its purpose ... the concept of quality or service includes many components ... Quality is the most important basis for differentiation of goods" (Great Economic Encyclopedia. - M .: Eksmo, 2007. - 816 p.). At the same time, it is known that the number of characteristics of consumer quality of unmanned devices (UDV) is already very large today, and with the development of the information society [1[and the widespread use of unmanned devices, the requirements for the quality of UDVs will only increase. And in such a situation, it will be very difficult to carry out both a comparative quantitative assessment of the consumer quality of UDV objects and the optimal choice of the desired UDV from a variety of comparable ones based on the criteria specified by the user (buyer, consumer).

The article proposes an original methodology for the operational comparative quantitative assessment of the consumer quality of multifunctional goods and durable goods and the optimal choice of the desired object based on the criteria specified by the consumer (buyer). 1. Fragment of consumer quality characteristics of unmanned devices. Among the many known characteristics of consumer quality, differing depending on the purpose of the UDV, we will highlight only a few of the most relevant and significant: 1) resource intensity of the technological process of production (manufacturing) of the UDV, 2) the probability of maintaining operability under each of the possible external influences, 3) speed of movement (maximum, average-cruising), 4) lifting capacity, 5) the distance that the UDV can travel without refueling, 6) maintainability (level of repair complexity, labor intensity of repair), 7) the probability of failure-free operation in a given period of time, 8) price, 9) characteristics of the appearance of the UDV, 10) labor intensity of modification, 11) energy intensity of operation, 12) noise level, 13) total cost of ownership of the UDV, 14) weight of the BPU, …

[**Note 1.** The relevance of the characteristics of consumer quality of the UDV under numbers 1, 2 and a number of others is due to the fact that and today and in the future, the consumer-user represented by the state may have an urgent need to quickly create an unmanned device * with a minimum resource intensity of the technological process for the purpose of import substitution or export [2-4], or *

to ensure the safety of the personnel servicing this device, or * to protect social facilities (hospitals, schools, ...), or simply to ensure the protection of the population of the administrative-territorial entity.]

2. Description of the proposed methodology. The methodology consists of four sections and includes numerical examples.

2.1. Ranking and grouping of UDV-objects taking into account the composition and values of consumer quality characteristics consists of the following steps:

Step 1. Presentation in the form of Table 1 of the selected group of BPUs of the same purpose for a comparative quantitative assessment of consumer quality and the optimal choice of the BPU-object needed by the consumer.

Table 1.

A group of UDV objects of the same purpose Oi, (i∈n), possessing a set of m consumer quality characteristics Hj, (j∈m)

Objects (UDV)	**Consumer quality characteristics of UDV objects**					
	H1	**H2**	**. . .**	**Hj**	**. . .**	**Hm**
O1	**H1^{O1}**	**H2^{O1}**	**. . .**	**Hj^{O1}**	. . .	Hm^{O1}
O2	H1^{O2}	H2^{O2}	. . .	Hj^{O2}	. . .	Hm^{O2}
. . .	. . .	. . .	. . .	. . .	. . .	. . .
Oi	H1^{Oi}	H2^{Oi}	. . .	Hj^{Oi}	. . .	Hm^{Oi}
. . .	. . .	. . .	. . .	. . .	. . .	. . .
On	H1^{On}	H2^{On}	. . .	Hj^{On}	. . .	Hm^{On}

Step 2. Translating the quantitative values of the consumer quality characteristics of the analyzed UDV into relative units (in relation to the average value).

As a result of implementing Step 2, it becomes possible to obtain the sums of the relative values of any subgroups of consumer quality characteristics selected by the user for each of the analyzed objects and, accordingly, to organize the UDV objects based on the sum of the relative values of the selected characteristics.

[**Note 2.** Let us assume that some user, for example, the state, being interested in obtaining (or creating) a UDV with the highest possible values of a subgroup of characteristics selected by this user, can “recommend” several organizations (firms, design bureaus, etc.) competing in the corresponding subject area to maximize the values of the selected characteristics for this UDV.]

Step 3. Sorting in descending (or ascending, in some cases) order the relative values of each UDV characteristic

Step 4. Constructing ordering matrices in canonical form for each consumer quality characteristic of UDV objects [5-7].

Step 5. Estimating the Kemeny distance between all characteristics of UDV objects [8]. Here, the distance and the Kemeny median are used to identify UDVs with the highest possible values for the groups of consumer quality characteristics that are of interest to the user.

Step 6. Identifying UDVs that are quantitatively interconnected by the values of the characteristics of interest to the consumer-user. Estimating the degree of interconnection. Construction of relationship graphs.

Example 1. Let Table 1.1 present the results of ordering the actual relative values (in relation to the average value) of five characteristics of consumer quality Hj for six UDV-objects selected by the user.

Table 1.1.

Results of ordering the actual values of five characteristics of consumer quality of six UDV-objects.

UDV	H1		H2		H3		H4		H5	
	Actual magnitude	Rank	Actual magnitude	Rank	Actual magnitude	Rank	Actual magnitude	Rank	Actual magnitude	Rank
O1	H1 ^{O4}	4	**H2^{O5}**	5	**H3^{O6}**	6	**H4^{O2}**	2	**H5^{O6}**	6
O2	**H1^{O5}**	5	**H2^{O4}**	4	**H3^{O3}**	3	**H4^{O1}**	1	**H5^{O2}**	2
O3	**H1^{O6}**	6	**H2^{O2}**	2	**H3^{O2}**	2	**H4^{O6}**	6	**H5^{O3}**	3
O4	**H1^{O2}**	2	**H2^{O3}**	3	**H3^{O1}**	1	**H4^{O3}**	3	**H5^{O1}**	1
O5	**H1^{O3}**	3	**H2^{O1}**	1	**H3^{O5}**	5	**H4^{O5}**	5	**H5^{O4}**	4
O6	**H1^{O1}**	1	**H2^{O6}**	6	**H3^{O4}**	4	**H4^{O4}**	4	**H5^{O5}**	5

Compiled by the author

As follows from the data in Table 1.1., the spread of actual values of consumer quality characteristics for the UDV objects selected by the user is quite large. To estimate the Kemeny distances and search (based on the approximate value of the Kemeny median) for the best UDV objects by the values of the selected consumer quality characteristics, ordering matrices in canonical form were formed for each consumer quality characteristic Hj of the UDV objects and an estimate of the Kemeny distance was performed (Table 1.2.).

Table 1.2.

Kemeny distances between UDV objects depending on the actual values of consumer quality characteristics

D_{ij}	H1	H2	H3	H4	H5	Sum of distances Kemeny	Sum of squares of Kemeny distance
H1	0	8	20	24	16	∑68	1296
H2	8	0	24	20	24	∑76	1616
H3	20	24	0	8	4	∑56	1056

H4	24	20	8	0	8	∑60	1104
H5	16	24	4	8	0	∑52	912
	∑68	∑76	∑56	∑60	∑52	∑∑312	The minimum is 912

Compiled by the author

The maximum possible Kemeny distance between six objects is 30. Therefore, the minimum relative distance between the analyzed UDV objects is 4/30=0.13, and the maximum degree of interrelation between UDV objects (by ordered values of consumer quality characteristics), respectively, is 0.87 (87%).

Step 7. Optimal selection of UDV with a defining (maximum possible among the compared UDVs) value of a specific consumer quality characteristic with restrictions on the values of some other characteristics, i.e. the user-consumer can be provided with the opportunity to search for UDVs with maximum values of a particular characteristic with given restrictions on the values of other characteristics (of course, the search is possible only among existing BPUs, for example, among those presented on the market).

2.2. Assessment of the significance (information "weight") of characteristics and objects. If the user-buyer is interested only in UDV objects with maximum values of consumer quality characteristics, then it is possible to use the method of comparative assessment of the functional completeness and significance of objects and their characteristics [9-14]. Moreover, UDVs with the maximum value of the characteristic Hj, (jЄm) receive 1, and the rest - 0 (with the number of UDVs >> 10, all BPUs that fall into the first decile with the characteristic Hj, (jЄm) receive 1, and the rest - 0). In this case, only individual UDVs have the maximum value of a particular characteristic.

Let's highlight $UDV\ O_i$ and O_k (i, k =1, 2,…) and we introduce the following notations:

$P_{ik}^{(11)}$ – the number of maximum values of characteristics that belong simultaneously O_i and O_k, i.e. $P_{ik}^{(11)} = |O_i \cap O_k|$- cardinality of the intersection of sets $O_i and\ O_k$; $P_{ik}^{(10)}$ – the number of characteristics included in O_i, but absent in O_k, i.e. $P_{ik}^{(10)} = |O_i / O_k|$- cardinality of the difference of sets O_i and O_k (i, k =1, 2,…); $P_{ik}^{(01)}$ – number of characteristics missing in O_i, but included in O_k, i.e. $P_{ik}^{(01)} = |O_k / O_i|$.

Step 8. Let's construct matrices $P = \left\{p_{ik}^{(01)}\right\},\ (i,k \in \overline{1,n})$,

We transform the matrices P into logical matrices of the absorption (inclusion) ratio for the values ε_p, . $P_0 = \{p_{ik}^0\},\ (i,k \in \overline{1,n})$, the elements of which are defined as follows:

$$P_{ik}^0 = \begin{cases} 1, \text{если } P_{ik}^{(01)} \le \varepsilon_p \text{ и } i \ne k, \\ 0, \text{если } P_{ik}^{(01)} > \varepsilon_p \text{ или } i = k; \end{cases}$$

where ε - selected boundary values.

Step 9. Evaluation of the information "weight" of each characteristic of the UDV objects by calculating the values of the sum $(P_{ik}^{(01)} + (P_{ik}^{(01)})^2)$.

Example 2. Let the initial table containing UDV objects with maximum values of individual characteristics have the form of table 2.1.

Table 2.1.

General form of the initial table for comparative assessment of the composition and information "weight" of the characteristics of UDV objects

Characteristics of UDV objects	UDV objects					
	O1	O2	O3	O4	O5	O6
H1	1	0	1	0	0	0
H2	1	0	1	1	1	0
H3	0	1	0	0	0	1
H4	1	0	1	0	0	1
H5	1	1	1	1	0	1
. . .	. . .	. . .	. . .	. . .	. . .	. . .
H14	1	0	0	0	1	1
H15	1	1	0	0	0	1

Compiled by the author

To assess the information "weight" of each characteristic of the consumer quality of BPU objects, we will calculate the sum $(P_{ik}^{(01)} + (P_{ik}^{(01)})^2)$. Let's construct matrices $P = \left\{p_{ik}^{(01)}\right\}$, $(i, k \in \overline{1, n})$,

Matrix $P = \left\{p_{ik}^{(01)}\right\}$ for table 2.1 has the form:

H1	H2	H3	H4	H5	. . .	H14	H15
0	2	2	1	3	. . .	2	2
0	0	2	1	2	. . .	1	2
2	4	0	2	3	. . .	2	1
0	2	1	0	2	. . .	1	1
0	1	0	0	0	. . .	1	0
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
1	2	1	1	3	. . .	0	1
1	3	0	1	2	. . .	1	0

Compiled by the author

We transform the matrix P into logical matrices of the absorption (inclusion) ratio for the values ε_p: $P_0 = \{p_{ik}^0\}$, $(i, k \in \overline{1, n})$. When fully absorbed by the matrix P^{01} (ξ_p=0) will take the form:

H1	H2	H3	H4	H5	. . .	H14	H15
0	0	0	0	0	. . .	0	0
1	0	0	0	0	. . .	0	0
0	0	0	0	0	. . .	0	0
1	0	0	0	0	. . .	0	0
1	0	1	1	0	. . .	0	1
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
0	0	0	0	0	. . .	0	0
0	0	1	0	0	. . .	0	0

Then Matrix P^2_{01} will become equal to:

H1	H2	H3	H4	H5	. . .	H14	H15
0	0	0	0	0	. . .	0	0
1	0	0	0	0	. . .	0	0
0	0	6	0	0	. . .	0	0
0	0	0	0	0	. . .	0	0
3	0	8	1	1	. . .	0	1
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
0	0	0	0	0	. . .	0	0
0	0	6	0	0	. . .	0	0

Compiled by the author

And the sum of the matrices ($P_{ik}^{(01)} + (P_{ik}^{(01)})^2$) will allow you to obtain a comparative assessment of the information "weight" of each of the characteristics $\mathbf{H}_i$:

H1	H2	H3	H4	H5	. . .	H14	H15	$\sum H_i$
0	0	0	0	0	. . .	0	0	0
2	0	0	0	0	. . .	0	0	3
0	0	6	0	0	. . .	0	0	42
1	0	0	0	0	. . .	0	0	1
4	0	9	2	1	. . .	0	2	75
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
0	0	0	0	0	. . .	0	0	0
0	0	7	0	0	. . .	0	0	49

2.3. Calculation of the total cost of ownership of a UDV facility. Assessing the total cost of ownership of UDV facilities is an extremely relevant and rather complex task, since, firstly, a significant portion of unmanned devices are already long-term use objects and the share of such UDV facilities is constantly increasing. Secondly, obtaining the initial information for the calculations requires quite significant time, labor and financial resources. Moreover, as shown in [15], the list

of cost items is quite large and includes, in addition to the acquisition and modernization of the analyzed facility, many more items related to training, assessing maintainability, ensuring safety and operability, with obvious and hidden, direct and indirect costs. However, even approximate information on the structure and level of costs when assessing the total cost of ownership (TCO) makes it possible to analyze and correlate them with the real capabilities of a potential buyer-user. It is obvious that, for example, the repair time, labor intensity, energy intensity, and financial costs of repair depend on the skill level of the repair personnel, the design features of the BPU facility, and its repair complexity. The fact that UDV facilities have been actively used only in the last 2-3 years also indicates that it is highly unlikely that it will be possible to obtain a quantitative estimate of the values of individual cost items when calculating the TCO from retrospective reporting data. Therefore, at the first stage, it is necessary to identify an ordered set of the most significant resource cost items for a given type of UDV facility. For this purpose, it is possible to use the method of step-by-step refinement of the ranking of objects during the examination process [16], which allows preserving the known advantages of both the Delphi procedure (anonymity and the ability to familiarize oneself with the explanations provided in defense of very different answers) and the algorithm for searching for a consistent ordering of objects - the correct calculation of the median and the Kemeny distance. In turn, the joint use of both the Delphi procedure and the correct approach to ordering objects (functions, features, etc.) proposed by Kemeny allowed: *to obtain a meaningfully acceptable quantitative criterion for the justified completion of the examination - a certain value of the relative (for example, 5%) change in the total Kemeny distance is established; *to form groups of experts, focusing on the selected (depending on the degree of agreement of opinions) threshold values of the Kemeny distance and to study the reasons for the relationship between expert assessments; *to find an ordering of characteristic objects agreed upon with the members of each expert group, having calculated the Kemeny median exactly or approximately.

At the second stage, the only possible way to quantitatively assess the values of the resource intensity of the main, most resource-intensive cost items in the total cost of ownership of BPU objects is to use the expert method of step-by-step clarification of the values of the indicators with an assessment of the distribution characteristics: after all, there is simply no other way to obtain initial data for at least an approximate calculation of the TCO. Among the most important advantages of the proposed method [17, 18], we will highlight the possibility of considering objections and proposals of other members of the expert group in an atmosphere free from the influence of personal qualities of the participants, which contributes to the activation of the intellectual activity of experts. The method makes it possible to determine how the answers of the expert group participants

are interconnected, what is the degree of this interconnection, and the influence of what factors explains the presence of such an interconnection. At the same time, it provides the opportunity to use the so-called "informed intuitive judgment" of the expert specialist by creating conditions for active interaction with other specialists in areas related to various aspects of the problem under study. Moreover, direct communication between specialists is replaced by a sequence of steps, at each of which a full cycle of examination is implemented, including informing the expert specialists about the results of the previous step. Therefore, there is no negative impact on the result of the implementation of the method of the presence in the expert group of superiors and subordinates, friends and enemies, people with different reaction speeds, with different cultural and religious traditions, etc. It is extremely important to increase the accuracy of the examination results due to *feedback during the implementation of each subsequent round; *providing the expert with the opportunity to indicate three or two values of the desired indicator; *determining the probability of the indicator value falling within the specified range of values based on the results of simulation modeling and presenting the total distribution as the average (mathematical expectation) of the sum of triangular or uniform distributions of individual experts' assessments, which makes it possible to obtain the resulting distribution of the indicator values even if the experts indicate three or two values of the desired indicator and a large dispersion of the assessments. And the calculation of the statistical characteristics of the distributions (mathematical expectation, dispersion, variation coefficient, median, asymmetry, kurtosis) of histograms and distribution tables makes it possible to estimate the probability of the values of the desired indicator falling within the specified range. At the same time, identifying spontaneous groupings of experts whose assessments relative to the desired values of the indicator are close makes it possible to study the reasons for the formation of such groups.

Step 10. Identifying a group of the main, most significant costs, using the method of step-by-step refinement of the ranking of objects in the process of the examination. Step 11. Estimation of the amount of costs for each item selected in Step 10, using the method of step-by-step refinement of the values of the desired indicator with an assessment of the characteristics of the distribution law.

Example 3. Let us assume that as a result of ordering the cost items using the PURO method, labor costs (and time costs) for restoring the operability of the BPU facility turned out to be among the priority ones.

Now it is necessary, using the method of step-by-step refinement of the values of the indicator with an assessment of the distribution characteristics (PUZ-OHR), to obtain a quantitative assessment of these costs. Let us agree that 5 (five) experts will participate in the examination (this number of experts is quite sufficient to explain the features of using the PUZ-OHR method when assessing labor costs for

restoring the operability of the UDV). Table 3.1 presents the results of 3 stages of the examination.

Table 3.1.

Step-by-step assessment of the labor intensity (time) of restoring the operability of the UDV facility during the examination

Expert	Labor intensity (time) of restoring the operability of the UDV facility (man-hour)								
	Step 1			Step 2			Step 3		
	min	most probable	max	min	most probable	max	min	most probable	max
Э1	45	60	105	**55**	**60**	**95**	55	60	95
Э2	75	110	115	**65**	**105**	**115**	65	105	115
Э3	45	55	95	45	55	95	**45**	**50**	**95**
Э	55	60	90	55	60	90	**55**	**57**	**90**
Э5	50	85	100	**50**	**90**	**105**	50	90	105

Compiled by the author

*The values of the indicator changed by the expert at the next step are highlighted in bold.

Table 3.2.

Accumulated probabilities and dynamics of labor intensity of restoring the operability of the UDV facility. at Step 3.

X_{min}	X_{max}	Frequency	Probability	Cumulative probability
61.66	64.29	3	0.003	0.003
64.29	66.91	17	0.017	0.020
66.91	69.54	82	0.082	0.102
69.54	72.16	123	0.123	0.225
72.16	74.78	214	0.214	0.439
74.78	77.41	214	0.214	0.653
77.41	80.03	182	0.182	0.835
80.03	82.65	107	0.107	0.942
82.65	85.28	41	0.041	0.983
85.28	87.90	15	0.015	0.998
87.90	90.52	2	0.002	1.000

Compiled by the author

Table 3.3.

Modeling results. Cost item J. - Labor intensity of restoring the operability of the BPU facility. Steps 1-3

Parameter	Characteristics of the law of distribution of cost items J (CL_J) at each step		
	STEP 1	**STEP 2**	**STEP 3**
Variable	**$C3_J^{(01)}$**	**$C3_J^{(02)}$**	**$C3_J^{(03)}$**
Number of iterations	**1000**	**1000**	**1000**
Mean	**60.43**	**75.7**	**75.56**
Variance	**15.78**	**20.42**	**20.2**
Standard deviation	**3.97**	**4.52**	**4.5**
Variation coefficient,, $K_{var}^{(01-03)}$	0.066	0.06	**0.059**
Asymmetry	**-0.06**	**-0.21**	**0.04**
Kurtosis	**-0.12**	**-0.11**	**-0.2**
Minimum	**48.87**	**61.5**	**61.67**
Maximum	**72.1**	**86.73**	**90.5**
Modal interval	**59.43 : 61.54**	**75.28 : 77.57**	**72.16 : 74.78**

As follows from the data in Table 3.3, the assessment of labor costs for restoring the operability of the analyzed UDV facility can be completed, since the change in the value of the variation coefficient is less than the established value of 5%:

$|K_{var}^{(02)}-K_{var}^{(03)}|*100/K_{var}^{(02)}$ =1,7%<5%.

[Note 3. If we assume that over time there will be analogs of UDV-objects, using which it will be possible to approximately estimate the costs for the main items of the TIS, then in this case, with a known range of changes in the estimated cost item or a known standard deviation and a known average value of these costs, it is possible to use a truncated normal distribution and simulation modeling to obtain with a given probability the value of the analyzed costs in the TCO. (See also [15]).]

2.4. Evaluation and minimization of the resource intensity of the manufacturing (production) process or modernization of the BPU-object.

The authors previously described a sequence of steps for solving such a problem in their works [19-23]. However, here, unlike the methods previously used by the authors, it is proposed to compare not similar technological processes for the manufacture of BPU objects, but to compare the resource intensity of individual similar operations of technological processes for various purposes in other industries - in instrument making, automotive industry, in combine harvester manufacturing, ... After all, in other industries the number of similar operations can be in

the hundreds. Therefore, the probability of a successful search for an operation with minimal resource intensity increases many times over.

[Note 4. For the economy of any country, an extremely important task is to minimize the values of such a characteristic of consumer quality of a multifunctional product and a durable good as its resource intensity, i.e. minimization of time costs, minimization of labor intensity, energy intensity, material intensity and cost of the technological process of production of this product (see also [3]).]

Step 12. Evaluation of the resource intensity of the production process of the analyzed UDV object using the method of process-statistical accounting of time, labor, materials, energy, finances (PSUZ of resources) for all operations of the technological process.

Step 13. Selection and analysis of the most resource-intensive operations of the technological process of UDV production, taking into account which resources are critically important, requiring strict restrictions (these can be strict restrictions on the duration of the production process, restrictions on energy, materials or on labor costs).

Step 14. Search for opportunities to reduce the resource intensity of the selected operations by analyzing technological processes in other industries. For example, if there are limitations on the duration of the technological process and labor costs during the manufacture of a BPU object, then it is quite possible that in one of the mechanical engineering industries, performing such operations on CNC machines requires both less time and less labor costs.

Conclusions.

1. An original methodology for comparative quantitative assessment of the consumer quality of multifunctional goods and durable goods is proposed and considered using unmanned devices as an example to ensure the ability to make the optimal choice of a product with the characteristics required by the consumer.

2. The possibility of using the Kemeny distance and median * to assess the relationship between UDV objects by composition and values of consumer quality characteristics and * for the optimal choice of a UDV object with the best values of a certain characteristic among the compared objects under given restrictions on the values of other characteristics is substantiated. 3. It is shown that the use of the method of comparative assessment of the functional completeness and significance of objects and their characteristics allows for grouping BPU objects with the best consumer quality characteristics and the best information “weight”.

4. The scope of application of the methods of step-by-step refinement of object ranking (PURO) and step-by-step refinement of indicator values with assessment of distribution characteristics (PUZ-OKhR) is expanded

5. An original procedure for assessing and minimizing the resource intensity of technological processes for the manufacture and modification of durable goods is

proposed, which allows (including in the presence of strict restrictions on the use of certain types of resources) to form a continuous process of searching for operations with minimal resource intensity in different industries.

The methodology described in the article is suitable for comparative quantitative assessment of the consumer quality of technological processes, technical and construction objects.

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区域均衡发展研究的理论路径
THEORETICAL APPROACHES TO RESEARCH BALANCED DEVELOPMENT OF TERRITORIES[1]

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摘要。本文探讨了研究区域平衡发展的主要理论方法。介绍了“平衡”发展和“可持续”发展类别之间的区别。从整个社会经济系统的可持续性角度论证了地区平衡发展的必要性。

关键词：平衡发展、平衡、可持续发展、区域、社会经济发展。

Abstract. *The article examines key theoretical approaches to the study of balanced regional development. The differences between the categories of “balanced” and “sustainable” development are presented. The need for balanced development of territories is substantiated from the point of view of the sustainability of the socio-economic system as a whole.*

Keywords: *balanced development, balance, sustainable development, region, socio-economic development.*

The key guideline for the socio-economic development of the Russian Federation is to ensure the balanced development of regions and municipalities.

The problem of balanced socio-economic development of regions is currently the most discussed and is considered from various positions. In scientific literature, balanced development is often identified with the concept of “sustainable development”. However, in our opinion, sustainability is, first of all, the preservation of a given state, and balance is the observance of certain proportions in the development of socio-economic systems.

Numerous publications by Russian and foreign authors are devoted to the study of issues related to the balanced development of systems. Most of them are based

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on the works of the founders of economic thought Leontiev V., Stiglitz J., Solow R., who determined the possibility of equilibrium growth of the economy [1].

The problem of ensuring balanced socio-economic development of regions was considered in the works of Animitsa E.G., Bobylev S.N., Vlasova N.Y., Gusev A.A., Danilov-Danilyan V.I., Izrael Y.A., Pchelintsev O.S., Razumovsky V.M., Ryumina E.V., Strukova E.B., Tyaglova S.G., Ursul A.D., Chepurnykh N.V., Chistobaev A.I. and many others.

The study of the terminological apparatus of the category "balance", "balanced development" will allow us to clearly examine the essential approaches of the authors to the concepts under study.

Of particular note are the definitions of such authors as Brodskaya T.G., Semenov V.F., Belkin V.D., Balatsky E., Alymov A.N., Figurnova N.P., Mordvinov S.V., Malyshev Y.A. Balatsky E., Lapin V., as well as scientists who took part in the Hannover International Industrial Exhibition, who believe that balance should be viewed as an equilibrium. Another group of economists (Alymov A.N., Figurnova N.P.) considers balance as consistency. Another group of terms based on the feature of "balance as a proportion" arose thanks to Malyshev Y.A.

Analyzing the above interpretations, we can conclude that at the present stage in economic literature there is no consensus on what "balance" is. Most often, authors associate this concept with a certain correspondence, balance, consistency, proportion and development.

The concept of "balanced development" (the English term sustainable development, other translations include stable, harmonious, viable, self-sustaining, long-term, continuous development) entered scientific circulation relatively recently - in the second half of the 20th century. The accuracy of the translation still causes much debate, and a generally accepted version has not yet been approved.

There are more than a hundred definitions of the term sustainable development, and as A.D. Ursul notes, "there will be even more, since there is a process of understanding future development, which is in principle uncertain and multi-variant" [2]. The lack of unity of opinion in the definition and interpretation of this concept is explained by its complexity, since it includes social, economic and environmental aspects of human development, as well as the discrepancy between the views of representatives of different strata of society - scientific, political, entrepreneurial.

Endovitsky D., Sirotkina N., Goncharov A. understand balanced development of a region as "conditions for the realization of opportunities by the most effective, dominant sectors, and competitive entities of the regional economy, capable of supporting subsidized and socially significant spheres" [3].

Vorontsova I.N. understands balanced development of a region as "the process of coordinated interaction of regional economic entities aimed at achieving proportions developed through indicative planning taking into account the inter-

ests of government and administrative bodies, business, civil society institutions and corresponding target settings of regional socio-economic policy" and notes that "strategic guidelines for balanced development of a region are determined by documents regulating the development of meso- and macroeconomics in the long term" [4].

According to Yakovleva D.G., balanced development implies ensuring strategic sustainability and competitiveness of the socio-economic system of the region based on the preservation and increase of all components of the total capitalsocieties [5].

According to Starikova M.S. the balance of regional development is determined by the territory's ability to coordinate its functioning trajectory with global challenges. The transformation of regional economic systems in accordance with changes in the global market conditions, technologies, products and production methods means the proportionality of their response to external demands, and, consequently, the balance of their development. In the context of the need for import substitution, balance is considered from the point of view of the success of attempts to modernize regional production complexes to provide domestic consumers with the necessary goods [6].

The problem of balanced development of regions is one of the most debated, and even in sources related to the same historical and time period, balanced development is considered from different positions:

– most often balanced development is identified with sustainable development;

– balanced development is considered as a certain relationship between a set of factors, while various researchers have established a special diversity of factors that influence the achievement of a balanced state by the system;

- balanced development is seen as a result, target a setting that must be strived for.

From the standpoint of public administration, the balanced development of a region is associated with the problem of placing production capacities, creating economic territories with intra-territorial cooperation, with the problem of balancing the budget, and overcoming the asymmetry of regional development. It should be noted that the conceptual foundations of economic zoning were laid by N.N. Kolosovsky [7], who considered the principles of forming the prevailing types of economic activity in territorial production complexes.

A number of authors (Davankov A.Y., Barabash D.A., and others) consider balance from the point of view of achieving equilibrium in the development of the economic, social, and environmental subsystems of the region [8]. In particular, Barabash D.A. defines balanced development as the comprehensive development of a region as a socio-ecological-economic system, in which a balance is maintained between economic growth, an increase in the standard of living (material wealth), and a reduction in the burden (harmful impact) on the environment.

Balanced regional development is based on a dynamic equilibrium between the economic, social, and natural subsystems, maintaining scientifically sound proportions (ratios) between the economic, social, and environmental parameters of the regional system, ensuring an increase in the quality of life in the long term":

In our opinion, it is necessary to distinguish between the concepts of sustainable and balanced development.

The term "sustainable development" was introduced into widespread use by the International Commission on Environment and Development (Brundtland Commission) in 1987. "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs." Sustainable development is ensured by a balance in the development of the economic, social and environmental subsystems of the territory.

Balanced development of the region is aimed at ensuring the competitiveness of the entire socio-economic system, through the uniform development of the municipalities included in it, through the efficient use of the existing resource potential.

In research work, we will proceed from the fact that balance is a state of the system in which its main parameters have an optimal ratio, contributing to the existence and development of the system. Stability is a related concept and represents the ability of the system to maintain an equilibrium state in the presence of external influences.

Thus, sustainable development of the region can be ensured only by observing a number of principles of balance.

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区域社会经济体系的现代增长点
MODERN GROWTH POINTS OF THE REGIONAL SOCIO-ECONOMIC SYSTEM[2]

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摘要。本文以区域社会经济系统为例，论证了寻找经济增长点这一主题的相关性，并介绍了国内外作者对这一主题的研究方法。
关键词：区域社会经济系统、经济增长、增长点、区域、竞争力。
Abstract. *The article substantiates the relevance and presents approaches of domestic and foreign authors to the topic of finding points of economic growth using the example of individual regional socio-economic systems.*
Keywords: *regional socio-economic systems, economic growth, growth points, region, competitiveness.*

In the current conditions of intense competition in the markets of goods, services, capital and human resources, both regions and individual municipalities of Russia need effective tools that take into account their development features. High differentiation of the level and conditions of socio-economic development in the regions of the country, territorial vastness and remoteness, refraction through the prism of regional determinants of globalization processes and management impacts of the macro level increase the relevance of searching for modern points of economic growth of individual regional socio-economic systems.

Identification of priority areas that are active points of attraction of labor and financial resources is the key to a competitive economy. Development of growth points can lead to the creation of a flexible socio-economic system in the region that quickly responds to changing conditions of the external environment. Each municipality has its own economic, natural, demographic and other growth points,

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the development of which can have a multiplier effect on the economy of the region as a whole.

The works of the French economist F. Perroux, Russian specialists T.O. Lashcheva, A.S. Molchan, V.N. Leksin and others are devoted to identifying growth points [1].

Points of economic growth are specific potentials of socio-economic development localized in space and time. The strategy of forming growth points envisages the redistribution of resources in favor of creating mechanisms of self-development in the most promising territories or industries distinguished by higher indicators of infrastructural development, material and technical provision, quality of labor resources, investment potential, i.e., the formation of unique territorial leaders specialized in their niche.

The theory of "growth poles" was formulated in the early 1950s by the world-famous French economist François Perroux (1903-1987), who proceeded from the fact that the development of the territories of each state occurs at an uneven pace [1].

Perroux defined growth poles as compactly located and dynamically developing industries and territories in which administrative, managerial, human and financial resources are concentrated. According to his theory, the growth of the country's economy in all regions does not occur uniformly; it appears at certain points, or growth poles, and then spreads with varying intensity through various channels and with a certain effect on the entire economy. In addition, territories located between the growth poles and providing transport links receive additional growth impulses due to increased freight flows and infrastructure development. Therefore, they become axes (corridors) of development, which, together with the growth poles, determine the spatial framework of economic growth for the entire region or country.

Currently, there are several approaches to defining the category of "growth point" in science [1]. For example, a growth point is recognized as an urban core that has the ability for spontaneous growth of population, economic activity and income level in the surrounding area, as well as potential growth that can form independently or through external intervention [2].

Also, a growth point (at the regional level) is understood as a city center, which, in addition to the function of providing services to the population, has a diversified industrial structure capable of constant development and improvement. The specified features of the center's development provide it with high economic activity, due to the necessary level of employment, population size and income.

A growth point can also be called a center of economic activity that is capable of independently developing to a level where there is a need to spread growth to adjacent territories and subsequently to less developed areas [3].

However, in modern conditions, a broader understanding of the growth point is widespread, which is closest to the author's opinion, associated not only with geographical characteristics, but also with functional, sectoral and institutional planes, which also influence regional development. It seems that any element of the regional socio-economic system that has signs of dominance and contributes to the development of the system as a whole can act as a growth point. This can be either an enterprise or a sector of the economy, or a specific type of activity or project that is capable of ensuring structural shifts in the regional economy in the process of self-development, stimulating the involvement of new elements in the process [4].

Thus, the points of economic growth can be:

- industries (those operating most effectively in a given territory, i.e., more promising and less expensive);
- enterprises (stable functioning or basic for the regional system);
- programs (as a regulatory instrument aimed at stabilizing the socio-economic development of the region).

Based on the analysis conducted, it can be said that the growth point is characterized by belonging to a certain industry; the presence of opportunities for accelerating economic growth; specific relationships.

Thus, a regional growth point should be understood as a set of economic entities within a certain territory that have significant potential and are capable of ensuring high dynamics of economic growth in the region. We are talking about such factors as assistance in employment, increased growth in living standards, budget security, sustainability and structural diversification of the regional economy, minimal impact on the environment, and promising specialization of the region.

In the global practice of managing growth points, the following methods are distinguished:

- organization of special (free) zones for production, trade and other purposes;
- organization of technological, scientific cities and parks;
- organization of special zones, including recreational ones;
- development of the infrastructure of territorial entities in order to increase their attractiveness;
- transfer of production to areas with cheaper resources (primarily labor);
- relocation of scientific and development centers to areas characterized by favorable environmental conditions.

Thus, we can list the main forms within which growth points are formed: special economic zones, territorial production complexes, clusters, technology parks, etc.

Thus, the main results of activating the points of economic growth are [1]:

- positive transformation of the regional economic structure;
- significant expansion of sources of financing investment processes by increasing the investment attractiveness of the region;
- ensuring the revenue side of local budgets and the consolidated budget of the region, sufficient to finance the socio-cultural sphere of the region;
- increasing the economic activity of the population, creating jobs
- places;
- promoting the strengthening and development of interregional and foreign economic relations of the region.

In the process of identifying growth points of regional development, it is necessary to take into account the processes of scientific and technical, innovative development, and the specifics of resource provision of specific territories. In this regard, it is advisable to impose such requirements as complexity, efficiency, and social orientation on economic growth points.

The effect of complexity is formed by a balanced, coordinated development of the productive forces of the region. According to A.B. Alaev, complexity implies the effective implementation of the region's specialization and its ability to carry out expanded reproduction within its territorial boundaries [1].

As for the efficiency criterion, it is important to note that the use of any factors of production and available resource potential should ensure maximum return per unit of resources involved.

The socio-cultural orientation of economic growth points is manifested in such categories as quality of life, which characterizes the level and degree of well-being, freedoms, social, spiritual and cultural development of a person. The following components of the category "quality of life" are distinguished: life expectancy and state of public health, level and way of life of the population.

The effectiveness and efficiency of the functioning of growth points is characterized by both market and socio-cultural criteria.

Economic growth points should improve the quality of life of the population in the region and promote the development of socio-cultural infrastructure. Socially oriented growth points are one of the most important factors in the development of the region, since the growth of the quality of life of people can serve as a powerful incentive to increase labor activity, a source of solvent demand, and also stimulate the formation of the middle class.

As for the methodology for identifying economic growth points for individual territories of the region, in our opinion it is necessary to conduct a study of the resource provision of municipalities. The analysis includes an assessment of the resource potential, primarily the provision of basic production assets, taking into account their quality and efficiency of use, the quality and development of the labor potential of the territory.

As for mechanisms for attracting private investment, the development of regional socio-economic systems requires coordinated application of economic and administrative methods. One of the economically and socially effective methods is the mechanism of public-private partnership (PPP).

The formation of an information society based on a creative economy and developing intangible resources requires joint efforts by regional authorities, business and civil society. The main and most effective method for implementing the concept of strategic development of regions is negotiations and organization of strategic partnership. PPP is a system of economic relations between the state (federal and regional authorities), local government, entrepreneurs, non-profit organizations, which is based on long-term public-civil-law contracts that combine the principles of competitive market management and public-state regulation. The role of non-profit organizations is the control function, as well as the participation of civil society in the economic development of the region. An important function of public-private partnership is the participation of partners in the integration scheme for the creation of a valuable final product and added value.

In practical terms, PPP is a network contract on a civil-law basis for cooperation between federal, regional and municipal authorities, enterprises and private companies, carried out with the participation and under the control of non-profit public organizations, to achieve joint socio-economic goals.

Today, the organizational and legal forms of PPP are investment partnerships, federal-regional target programs, state corporations and joint ventures, and various types of concessions.

The conducted analysis of modern growth points of the regional socio-economic system allows us to draw the following conclusions:

1) the current stage of development is characterized by increased competition between territories. The subject of rivalry is the resources necessary for socio-economic development, in particular, financial, intellectual and creative;

2) the proposed methodology for identifying economic growth points involves an analysis of potential industries – economic growth points in the region and an assessment of the resources needed to activate them. Among the necessary measures aimed at activating activities, we note the creation of infrastructure, the development of mechanisms for attracting funds from private investors, stimulating tax and budget policies and a monitoring system that provides timely feedback and the ability to adjust the chosen strategy;

3) the reduction in the volume of resources necessary for the socio-economic development of territories justifies the relevance of intensifying inter-municipal and interregional cooperation.

Thus, the formation of territorial growth points, including on the basis of public-private partnerships, allows for the implementation of the multiplicative prop-

erties of development, gives impetus to accelerated dynamics of enterprises in the industry, and also stimulates the integration of economic, cultural and social structures, the combined development of scientific research, production and education.

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区域社会经济发展管理基础

FUNDAMENTALS OF MANAGEMENT OF SOCIO-ECONOMIC DEVELOPMENT OF TERRITORIES[3]

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摘要。本文探讨了管理地区社会经济发展的各个方面，从提高利用其实际潜力的效率的角度论证了支持贫困地区的必要性。研究了各国发展贫困地区计划的经验。

关键词：平衡、发展、地区、地区、贫困发展。

Abstract. *The article examines various aspects of managing the socio-economic development of territories, substantiates the need to support depressed territories from the point of view of increasing the efficiency of using their realized potential. The experience of programs for the development of depressed territories in various countries is studied.*

Keywords: *balance, development, region, territory, depressive development.*

The Russian Federation as a whole and the Republic of Belarus in particular are characterized by significant differences in natural and climatic conditions, natural and other resources.

These and other factors determine the territorial heterogeneity of the country's economic space.

It should be noted that in Russian and foreign regional science and practice the task of leveling the development of territories and reducing differentiation to

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a certain level is not absolutized. Of fundamental importance is ensuring equal conditions and relatively equal opportunities for the development of territories, achieving the necessary social standards and quality of life of the population. The problems of territorial differentiation are constantly in the focus of attention of foreign researchers. Their works propose different approaches to the analysis and assessment of intra-regional differentiation and tools for overcoming excessive inequality and its negative consequences.

For Western countries, as well as for the Russian Federation, one of the most pressing problems is the internal unevenness of their socio-economic development, which manifests itself in the form of both regional and sectoral disproportions within the framework of a single national economy, and the growing social differentiation of society [1].

Foreign governments generally use similar approaches to implementing policies to stimulate depressed regions, which are based on developing criteria for determining priority areas of the country in terms of providing state support, preparing a package of measures, mainly financial, and mutually linking state support measures within the framework of medium-term state programs for regional development. Regional policy is currently moving away from a narrow approach to targeting specific regional problems and implementing primarily infrastructure projects. New approaches are currently being used to stimulate regional development through measures aimed at maximizing regional potential, promoting entrepreneurship and increasing the level of innovative activity, supporting educational projects and retraining the local workforce. This allows for better use of the potential of depressed regions in conjunction with the development of more successful areas of the country [2].

States, seeking to provide targeted support to depressed regions, pursue not only social goals, i.e., equalization of the income level of the population living in backward regions. Currently, depressed regions are considered as a source of economic growth due to the presence of a significant amount of unused or inefficiently used resources. In this regard, support for depressed regions is considered not so much an element of social policy, but as an element of the policy of stimulating economic growth in the country [3]. The new paradigm of regional policy is based on market mechanisms and is aimed at stimulating endogenous growth through the maximum use of the resources of depressed regions and synergy with the resources of other regions. If earlier the policy of state support was aimed at attracting investments in backward regions and subsidies to investors or new companies, now state aid is aimed at developing the competitiveness of local companies, creating regional clusters and exchanging knowledge between local companies, primarily small and medium-sized enterprises, in order to promote innovation. At the same time, countries strive not only to expand the supply of

resources in a depressed region, since this is not enough to qualitatively accelerate the growth of the region and catch-up development in relation to more developed territories. State policy is focused on finding synergies in the use of available and attracted resources in the region based on the use of innovations, stimulating various subjects of the market process in this region, as well as ensuring synergy of the resources of the backward region with other regions of the country [4]. At the same time, countries strive for a certain decentralization of the management of regional policy, transferring powers to specially created regional organizations subordinate to the government.

In the Russian Federation, a mechanism for regulating and activating the development of municipalities has been formed, based on the use of a wide range of methods and tools within the framework of regional and other types of state and local socio-economic policy. At the same time, many of the existing programs to support territories are not directly aimed at achieving a balance in intra-regional development. For this reason, the efforts made do not bring the desired effect, in particular, the rate of reduction of socio-economic inequality remains insufficient, which creates threats to the sustainable development of regions. Issues related to a comprehensive assessment of the unevenness of the socio-economic development of municipalities and the justification of the choice of methods for regulating intra-regional differentiation depending on the characteristics of different types of territories and the conditions in which they are developed remain unresolved. It should be noted that at present, mechanisms for more efficient use of the existing potential of socio-economic systems are acquiring particular importance.

The characteristics of the development of socio-economic systems are: stability, sustainability, balance. The potential of the socio-economic system and the characteristics of its functioning are determined by the concepts of competitiveness and security.

Competitiveness is a dynamic state of the potential of a socio-economic system in which it is higher at the moment of manifestation (use) than in the compared socio-economic systems of the regions.

Security is a state of potential of a socio-economic system in which no internal or external influences can lead to its significant reduction during use.

Stability is a state of potential of a socio-economic system in which the process of its reduction does not occur under any conditions (internal and external influences).

Sustainability is a state of the potential of a socio-economic system in which the process of its growth occurs under any conditions (internal and external influences).

Thus, the characteristics of regulation of the socio-economic system reveal their true essence through the manifestation and assessment of potential.

The problem of increasing the efficiency of using the potential of the Russian economy is obvious to all interested parties. The main issue is finding ways to increase the efficiency of using the potential of the socio-economic system. There is no consensus among economists on this matter, but some prerequisites are widely recognized.

Systemic transformations include increasing the role of small businesses in the economy, which can provide sustainability, stability and flexibility to the economic system.

The most promising path is the gradual displacement of imported products from the market and support for local producers.

In addition to the structural problems of industry, there is another, no less important problem concerning the competitiveness of industrial production systems.

The lag in the field of informatization and automation of production, which began in the 1970s, was supplemented in the 1990s by problems of a slowdown in the reproduction cycle.

The system of depreciation reproduction was practically lost at most enterprises of a number of industrial sectors. Along with technical problems, financial and economic problems have also accumulated. Thus, the industry of Russia has encountered problems of "anti-crisis" investments - to achieve high rates of development and create a competitive economy in this area, funds are needed not only for growth, but also to eliminate today's problems (the so-called "reanimation" investments"). In the absence of financial resources, this leads to one thing - the reproduction of production systems reduced in capacity.

The growth of the system's potential a priori sets the possibilities for economic growth.

At the same time, actual economic growth depends on the realization of potential in specific conditions, i.e., situational factors largely influence the indicators of potential use. But all other things being equal, systems with greater potential are more competitive. The problem of managing potential growth rests on the implementation of a number of investment projects that arise as a response to the interests of economic system entities.

The main tasks of potential use management can be divided into two large groups:

- increasing the efficiency of using the existing potential of the region's socio-economic systems;
- growth of potential.

Both of these problems are solved by a combination of two groups of factors:

- removal of restrictions on the use of existing potential;
- development of the system's potential.

It is obvious that for territorial-industry systems with low in-house potential and limited ability to attract external resources, budgetary support is necessary.

The management subsystem of the territory, which is represented by various bodies making management decisions (including the administration and its departments, the management of individual enterprises, etc.), influences the resources of the territory, facilitating their transformation into some final result. At the same time, the potential capabilities of the territory enter the resource system, and the final result of resource use is determined at the output. In modern conditions, it is necessary not only to know, but also to be able to manage the potential and development of the territory (region, municipality). The goal of any territorial economic system can be considered its effective development.

Analysis and generalization of conceptual approaches of various researchers of regional economic theory allows us to conclude that in order to understand and identify processes of resource use in regional economics, it is necessary to analyze such parameters as quantity of resource (i.e. volume of availability in the region for the needs of the production process), quality of resource (i.e. share of some of its part, maximally adapted for use in the production process), level of resource reproduction, as well as efficiency of resource consumption.

By intensification of their use, we will understand a process aimed at increasing the results of economic activity of the region through the high-quality use of regional resources.

Based on an understanding of the essence of the process of resource use, as well as the requirements for constructing a regional system of intensive resource use, we can assert that in the matter of intensifying the process of resource use, their basic properties are of the utmost importance, allowing us to understand the degree of possible inclusion of the region's resources in such a system: quantity, quality, reproduction and efficiency.

Thus, increasing the efficiency of using existing potential is one of the key methods (mechanisms) for leveling the development of the territory.

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海关和交通基础设施是区域发展的一个因素
CUSTOMS AND TRANSPORT INFRASTRUCTURE AS A FACTOR IN REGIONAL DEVELOPMENT

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摘要。揭示了海关和交通基础设施对区域发展的影响，影响经济和社会生活的各个方面。主要影响领域及其预期结果在三个关键方面框架内考虑：经济、基础设施和创新。海关和交通基础设施的效率由本文提出的许多关键因素决定。概述了公私伙伴关系（PPP）在海关和交通基础设施发展中的作用。本文还关注海关和交通基础设施发展的创新方面，这最终有助于为该地区创新集群的形成和吸引高素质专家创造有利条件。

关键词：海关和交通基础设施、交通枢纽、区域发展、公私伙伴关系。

Abstract. *The influence of customs and transport infrastructure on regional development is revealed, affecting various aspects of economic and social life. The main areas of influence and their expected results are considered within the framework of three key aspects: economic, infrastructural and innovative. The efficiency of customs and transport infrastructure is determined by a number of key factors that are presented in this article. The role of public-private partnership (PPP) in the development of customs and transport infrastructure is outlined. The article also pays attention to the innovative aspect of customs and transport infrastructure development, which ultimately contributes to the creation of favorable conditions for the formation of innovative clusters in the region and the attraction of highly qualified specialists.*

Keywords: *customs and transport infrastructure, transport hubs, regional development, public-private partnership.*

Introduction. The Sustainable Development Goals of the Russian Federation are defined by the Order of the Government of the Russian Federation dated

14.07.2021 No. 1912-r "On approval of the goals and main directions of sustainable (including green) development of the Russian Federation" [11] and provide for the need to ensure national interests in the sustainable development of the economy, civil society and the state in order to achieve an increase in the standard and quality of life of the population, observance of the constitutional rights and freedoms of man and citizen. In the context of achieving this goal, special attention is paid to ensuring a balance between the economic, social and environmental dimensions of sustainable development, which, among other things, should provide for the need to ensure the appropriate development of the transport industry. The transport industry is extremely important for the development of the public economy, since it provides services for domestic, export-import and transit transportation of goods and passengers. Transport is also an integral part of the general state economic policy and ensuring the country's defense capability. At the same time, the transport industry is a basic indicator of the level of socio-economic development of the state on an ecological basis in terms of ensuring the quality of life of the population, a favorable environment for economic growth and development of entrepreneurial activity, environmental protection, etc.

Issues of improving the relationship between customs and transport infrastructures in the field of cargo transportation are extremely relevant, since the sustainable development of the country and ensuring the necessary standard of living of the population are basic values. In addition, for our country, which has faced challenges of a sanction nature, solving problems related to the construction of an effective customs and transport infrastructure is one of the primary and most important steps towards preserving its statehood.

Materials and methods of research. Customs and transport infrastructure is a complex and multifunctional complex, acting as one of the key drivers of economic progress in the region. Its impact on the regional economy is characterized by multifacetedness and penetrates into all spheres of economic activity. This infrastructure is not limited to physical objects, but includes a number of interconnected elements that form a single system for ensuring foreign economic activity and logistics operations.

The efficiency of this system largely determines the potential of the region in the field of international trade, investment attractiveness and overall economic competitiveness. In the modern conditions of globalization and increased interregional competition, the role of customs and transport infrastructure as a development factor is of particular importance, becoming one of the priority areas of regional economic policy [5, p. 40].

Customs and transport infrastructure is a complex, multi-level system that combines various objects and technologies that together ensure the smooth functioning of foreign economic activity and international cargo transportation. This

system plays a key role in the development of the regional economy, facilitating the integration of local markets into global supply chains.

The fundamental element of this infrastructure are customs points and terminals. These facilities can be described as a kind of "gate" of international trade, through which the flow of goods crosses state borders. Modern customs complexes are equipped with advanced technologies for inspection and identification of goods, which significantly speeds up customs clearance processes and increases the efficiency of control [7, p. 36].

No less important is the role of transport hubs of various types. Airports, ensuring the prompt delivery of high-value and urgent goods, seaports, which are key hubs for large-tonnage transportation, and railway stations, allowing for large-scale cargo transportation over significant distances, form the backbone of the transport component of the infrastructure. Their interaction and integration create the basis for optimizing logistics routes and increasing the efficiency of cargo transportation.

Logistics centers act as coordination hubs, uniting various types of transport and providing comprehensive management of commodity flows. These multifunctional complexes not only provide cargo storage and handling services, but also serve as a platform for optimizing supply chains, which ultimately helps reduce logistics costs and increase the competitiveness of the regional economy [9, p. 61].

Warehouse complexes, being an integral part of the customs and transport infrastructure, provide temporary storage, sorting and preparation of goods for further transportation. Modern warehouse systems are characterized by a high level of automation, which allows optimizing inventory management and control over the movement of goods, thereby increasing the efficiency of the entire logistics chain [14, p. 128].

In the era of digital transformation, information systems and technologies are of particular importance. They permeate all elements of the customs and transport infrastructure, providing electronic declaration of goods, management of logistics processes, real-time cargo tracking and data exchange between all participants in foreign economic activity. The introduction of these technologies helps to increase the transparency and efficiency of customs and logistics operations. Integration of all the above components into a single, well-functioning system allows for the formation of an effective customs and transport infrastructure. Such infrastructure not only stimulates the development of the regional economy, but also significantly increases the investment attractiveness of the region, creating favorable conditions for foreign economic activity and strengthening positions in international markets [4, p. 56].

Customs and transport infrastructure has a complex impact on regional development, affecting various aspects of economic and social life. To systematize

this impact, it is proposed to consider the main areas of impact and their expected results within the framework of three key aspects: economic, infrastructural and innovative. This information is presented in Table 1 [6, p. 117].

Table 1

The impact of customs and transport infrastructure on regional development

Aspect of influence	**Directions of impact**	**Expected results**
Economic	Stimulation of foreign trade activities	Growth in export and import volumes. Attracting investments. Increasing capital inflow into the region. Creation of new jobs. Reducing unemployment. Increasing tax revenues. Growth of the regional budget revenue.
Infrastructure	Development of the regional transport network	Increasing transport accessibility. Modernization of existing infrastructure facilities. Improving quality and throughput. Creating new logistics routes. Optimization of cargo flows
Innovative	Implementation of modern technologies in the field of logistics and customs clearance	Increasing efficiency and speed of operations. Digitalization of processes. Reducing administrative barriers and costs

The analysis of the data presented in Table 1 allows us to conclude that the customs and transport infrastructure has a multifaceted impact on regional development processes.

From an economic point of view, it acts as a driver for increasing international trade volumes, stimulates the inflow of capital investment and contributes to the formation of additional vacancies, which together strengthens the economic potential of the territory.

In the context of infrastructure transformations, significant transformations of the transport complex are observed, leading to the optimization of logistics operations and an increase in their efficiency. The innovative component opens up prospects for the introduction of advanced technologies and digital solutions, which can serve as an impetus for progress in related sectors of the economy and strengthening the competitive position of the region at the national and international levels.

Consequently, the improvement of the customs and transport infrastructure can be considered as a multifunctional mechanism that helps to activate regional

economic growth and increase the attractiveness of the territory for potential investors.

The efficiency of the customs and transport infrastructure is determined by a number of key factors, each of which makes a significant contribution to the overall efficiency of the system:

1) firstly, the territorial location of the region plays a primary role. Proximity to state borders, sea routes or major transport arteries significantly increases the potential for infrastructure development. Regions with a favorable geographical location have a natural advantage in forming effective logistics chains [12, p. 165];

2) the second important aspect is the condition and capacity of infrastructure facilities. Modern, well-equipped customs terminals, warehouse complexes and transport hubs help to accelerate the turnover of goods and optimize cargo flows. Investments in the modernization and expansion of infrastructure facilities directly affect their productivity;

3) the third factor is the degree of involvement of regional infrastructure in international transport corridors. The higher the level of integration, the more opportunities open up for the region in the field of international trade and logistics. Participation in global transport networks allows attracting additional cargo flows and investments;

4) the fourth aspect concerns the optimization of customs procedures. The introduction of electronic document management, preliminary information systems and automatic release of goods significantly reduces the time for customs clearance. This, in turn, accelerates the movement of goods and increases the attractiveness of the region for participants in foreign economic activity;

5) finally, the fifth key factor is the level of competence of employees involved in the customs and transport sphere. Highly qualified personnel are able to effectively solve complex problems, promptly respond to changes in legislation and apply advanced technologies. Continuous training and advanced training of personnel is the key to the successful functioning of the entire system.

A comprehensive review and consideration of all of the above factors allows us to identify the strengths and weaknesses of the customs and transport infrastructure of the region, as well as determine priority areas for its further improvement [1, p. 66]. Balanced development of all components contributes to the formation of an effective and competitive system that meets the modern requirements of international trade and logistics.

Customs and transport infrastructure faces a number of challenges and prospects in today's rapidly changing world. First of all, it is worth noting the need for constant modernization in the context of rapid technological progress. This includes the implementation of advanced digital solutions to optimize customs procedures, the integration of artificial intelligence and machine learning into risk

management systems, and the development of blockchain technologies to improve the transparency and security of transactions. In order to systematize the multifaceted aspects of the development of customs and transport infrastructure, let us turn to a visual representation of the key challenges and prospects. The proposed Figure 1 reflects four main transformation vectors: digital renewal, reconfiguration of logistics routes, optimization of safety and efficiency, and greening of transport operations. Within each area, priority tasks and innovative approaches are identified that form a holistic picture of strategic guidelines in the context of global changes. This visualization allows not only to structure information, but also to clearly demonstrate the relationship between various aspects of infrastructure modernization [10, p. 665].

Another important aspect is adaptation to changes in global supply chains [2, p. 168]. In this context, the development of alternative routes and methods of cargo delivery, the creation of multifunctional logistics hubs to diversify risks, and the strengthening of regional cooperation to overcome global challenges are of particular importance. An equally important task is finding a balance between economic efficiency and ensuring security. To achieve this goal, it is necessary to introduce innovative methods of non-invasive cargo inspection, develop preliminary information and risk management systems, and improve mechanisms for interdepartmental and international cooperation.

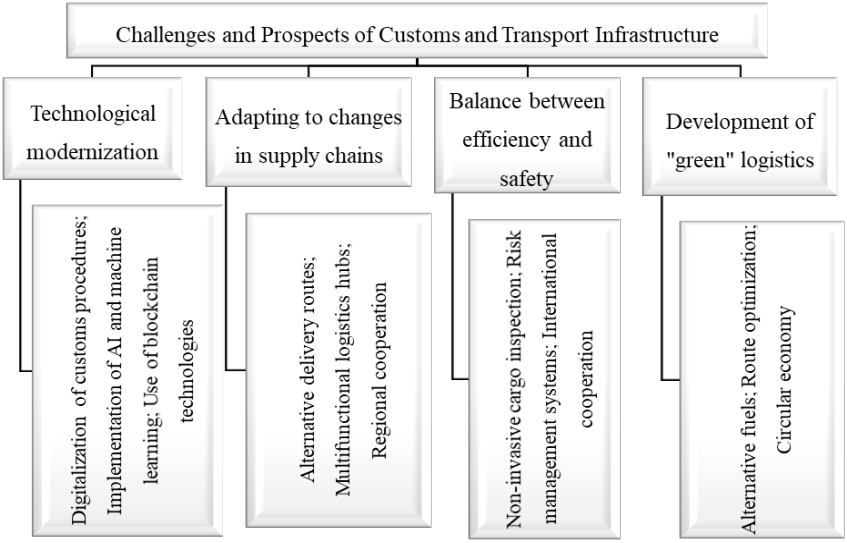

Figure 1. *Challenges and Prospects of Customs and Transport Infrastructure*

Finally, in light of the growing concern about environmental issues, special attention is paid to the development of "green" logistics and environmentally friendly technologies. This area includes stimulating the use of alternative fuels in the transport sector, optimizing routes to reduce the carbon footprint, and introducing circular economy principles into waste management at infrastructure facilities.

Thus, customs and transport infrastructure faces a range of complex tasks, the solution of which requires innovative approaches and close cooperation of all stakeholders. Successful overcoming of these challenges opens up broad prospects for increasing the efficiency of international trade and strengthening the economic potential of regions.

The role of public-private partnerships (PPP) in the development of customs and transport infrastructure is difficult to overestimate. This mechanism of interaction between the public sector and business opens up new horizons for the modernization and expansion of infrastructure facilities that are so necessary for the effective functioning of international trade [8, p. 71].

To clearly demonstrate the structure of public-private partnership in the sphere of customs and transport infrastructure, let us turn to Figure 2, which reflects the key principle of PPP – a balanced distribution of roles and responsibilities between the public and private sectors [13, p. 18]. This distribution not only illustrates the contribution of each party, but also emphasizes the importance of their joint work to achieve optimal results in the development of infrastructure projects.

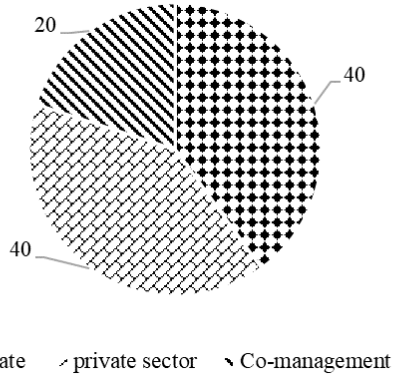

Figure 2. *Distribution of roles in PPP, %*

First of all, PPP is a powerful tool for attracting private investment in infrastructure development. In conditions of limited budget resources, private capital becomes the most important source of financing large-scale projects. This could be the construction of new customs terminals, the modernization of port facilities

or the creation of modern logistics centers. Attracting private investors not only reduces the burden on the state budget, but also promotes the introduction of innovative technologies and advanced management practices.

Another key aspect of PPP is the joint development of development strategies. Combining the public sector's expertise in regulation and supervision with the practical experience and market vision of private companies allows for the creation of more effective and viable infrastructure development plans. This approach ensures that the interests of all stakeholders are taken into account and contributes to the formation of a more flexible and adaptive strategy that meets both current needs and long-term development prospects for the industry.

An equally important aspect of PPP is the optimization of the distribution of risks and benefits between the partnership participants. Well-structured PPP agreements allow for the distribution of risks so that each party is responsible for those aspects of the project that it can manage most effectively. For example, the state may assume risks associated with changes in legislation or the political environment, while the private partner will be responsible for operational and financial risks. Such distribution not only increases the overall sustainability of projects, but also creates incentives for each party to maximize their contribution to the success of the enterprise.

Moreover, the PPP mechanism contributes to increased transparency and efficiency in the management of infrastructure facilities. Private sector participation often leads to the introduction of stricter reporting and quality control standards, which has a beneficial effect on the overall level of project management.

However, the implementation of PPP projects in the field of customs and transport infrastructure is associated with a number of challenges. Among them are the need to harmonize the interests of the state and business, ensure fair distribution of profits, and maintain a balance between commercial goals and public interests. Overcoming these challenges requires careful consideration of the legal and financial aspects of the partnership, as well as ongoing dialogue between all participants in the process [15, p. 21-23].

Conclusion. In conclusion, it is worth noting that the successful implementation of PPP projects in the field of customs and transport infrastructure can not only improve the efficiency of international trade, but also become a catalyst for economic growth, creating new jobs and stimulating the development of related industries. Thus, public-private partnership is a key factor in the modernization and development of infrastructure necessary for the successful integration of the country into global economic processes.

The role of customs and transport infrastructure in the development of the region is difficult to overestimate. It is a key factor stimulating the comprehensive development of the territory, exerting a significant impact on the economic,

social and innovative spheres. Continuous improvement and maintenance of high efficiency of this infrastructure is becoming a prerequisite for strengthening the region's position in the global economy.

A well-developed customs and transport system creates fertile ground for economic prosperity. It not only attracts new investment flows, but also stimulates local businesses to expand their activities. Optimization of logistics chains, achieved thanks to modern infrastructure, leads to a decrease in operating costs and an increase in the profitability of regional enterprises. Moreover, high-quality customs and transport infrastructure opens doors to international markets for local producers, while facilitating access to global resources and innovative technologies. The importance of this infrastructure for the social sphere is also great. Its development is accompanied by the emergence of new vacancies, the improvement of the qualifications of local personnel and the improvement of transport accessibility, which directly affects the standard of living of the population. In addition, the modernization of customs and transport infrastructure often entails the development of related industries and a general improvement in the quality of services in the region, which also contributes to the improvement of the social climate.

The innovative aspect of developing customs and transport infrastructure cannot be ignored. The introduction of advanced technologies in the field of customs clearance and logistics not only optimizes work processes, but also stimulates the development of the local IT sector, research centers and educational institutions. This creates favorable conditions for the formation of innovative clusters in the region and the attraction of highly qualified specialists. It is important to emphasize that the improvement of customs and transport infrastructure is a continuous process that requires constant efforts and financial investments. In the context of a dynamically changing global economy and rapid technological progress, regions need not only to maintain the existing infrastructure in working order, but also to actively modernize it, introducing innovative solutions and adapting to the changing demands of business and society [3, p. 760]. To summarize, it should be noted that an effective customs and transport infrastructure is not just a technical element of regional development, but a strategic asset that can significantly enhance the competitive advantages of a region both at the national and international levels. Therefore, investments in its development should be considered as long-term investments in the future of the region, capable of bringing multiple returns in the form of sustainable economic growth, increased social well-being and acceleration of innovative progress.

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论二十世纪五六十年代苏联批发贸易的组织
ON THE ORGANIZATION OF WHOLESALE TRADE IN THE USSR IN THE 50S AND 60S OF THE XX CENTURY

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摘要。本文展示了批发贸易的作用，分析了苏联 50-60 年代批发贸易存在的问题，强调了批发组织结构的变化。作者提出了批发贸易的主要任务：提高对商品范围和质量的要求，为零售贸易网络提供支持。特别关注了批发贸易的新形式及其实施细节。

关键词：批发和零售贸易、商业合同、质量检验、批发交易会、流动商人、邮购贸易。

Abstract. *In the article, the author shows the role of wholesale trade, analyzes its problems in the 50-60s in the USSR, highlights changes in the structure of wholesale organizations. The author formulates the main tasks of wholesale trade: increasing requirements for the range and quality of goods, providing assistance to the retail trade network. Particular attention is paid to new forms of wholesale trade and the specifics of their implementation.*

Keywords: *wholesale and retail trade, business contracts, quality inspection, wholesale fairs, traveling merchandisers, mail order trade.*

At present, despite the difficult conditions for international trade, it continues to develop, taking into account the experience of its development, as well as within the country in previous years.

After the end of the Great Patriotic War, the leadership of the USSR faced the task of providing the population with essential goods. Having solved this problem by the beginning of the 50s, in the 60s attention was paid to the development of trade in order to meet the growing needs of the population of our country. For this purpose, on August 8, 1960, the Central Committee of the CPSU and the Council of Ministers of the USSR adopted a resolution “On measures to further improve trade” [1, p. 551]. It devoted significant space to issues of improving the organization of wholesale trade.

The resolution noted that trading organizations poorly studied consumer demand, did not exert the necessary influence on industry in organizing the production of high-quality goods and in an assortment that meets the needs of the population, made mistakes in determining the quantity of goods needed for sale to the population, in distributing the delivery of goods to different regions of the country.

The resolution indicated ways to eliminate existing shortcomings and improve wholesale trade and industrial work.

A fundamentally new decision was that the Councils of Ministers of the Union Republics were to systematically, taking into account changes in demand from the population, implement measures to expand the range and improve the quality of goods, and in cases where trading organizations could not sell goods due to limited demand and they accumulated in the trading network, the Councils of Ministers of the Union Republics were to ensure the replacement of the production of such goods with new ones that were in demand by the population. This was to put an end to the dispute between industry and trade. Industrial workers were obliged to respond to changes in demand and make appropriate amendments to the plan for the release of goods.

At the same time, the resolution placed even greater responsibility on employees of trading organizations for drawing up applications and orders for the production of goods.

The main task of wholesale trade was to continuously deliver goods to retail enterprises by the fastest and cheapest routes in such a range and quality that would meet consumer demands, and thereby in every possible way contribute to the fulfillment of the established plan for retail turnover [2, p. 5].

In connection with the reorganization of industrial management, as well as the expansion of the rights of the Councils of Ministers of the republics, the structure of wholesale organizations also changed.

Wholesale trade in the RSFSR in the 50s and 60s was carried out by Russian offices of the Ministry of Trade of the Republic, wholesale organizations of Rospotrebsoyuz, as well as some sales bodies of the State Planning Committee of the USSR and the RSFSR and industry. The share of wholesale organizations of the Ministry of Trade of the RSFSR was about 60%.

Commercial work was understood as a complex of all operational wholesale work, starting with the study of consumer demand, the formation of industrial orders to the delivery of goods to retail trade organizations and assistance in their sale.

In order to provide industry with qualified orders and avoid miscalculations, wholesale organizations had to systematically study the demand for goods and be able to reasonably determine not only the current but also the future need for goods. The study of demand for goods and the patterns of consumption development had to be placed on a scientific basis.

To a certain extent, the result of insufficient study of consumer demand was the growth of inventory balances. From 1963 to 1965, the turnover of goods in the Russian Federation as a whole increased by 15%, and inventory balances in the retail trade network increased by 34% [3, p.4].

The following examples show what ignorance of demand and market conditions led to: wholesale organizations sharply reduced their orders to industry for galoshes, samovars, electric irons, meat grinders, umbrellas, and axes. This subsequently led to interruptions in the trade of these goods.

The main shortcoming of orders submitted to industry was often poor knowledge of the actual needs of the population for individual goods. Trading organizations were easily influenced by random market factors and made unjustified adjustments to orders; at the same time, orders for scarce goods were given in amounts significantly exceeding the need, and for sufficient goods - below the actual need.

In 1958, large balances of bicycles, scooters, radiograms and radio receivers accumulated in retail and wholesale. After prices were reduced and trade on credit was organized, sales increased, but the refusal of trading organizations from these goods in 1959 led to the fact that in 1960 in a number of regions there was a shortage of bicycles, scooters, radiograms and radio receivers.

The question arose about the correct accounting and analysis of inventory balances, both in retail and wholesale warehouses. Until the 60s, very little was done to study the balances, and this had a negative impact on uninterrupted trade.

An important condition for the influence of wholesale links on industrial enterprises were business contracts. However, many wholesale organizations treated the drafting of contracts formally, did not specify the order of delivery of goods, and delayed the conclusion of contracts for a long time. For example, the Penza bases of Rostorgodezhda, Rostekstiltorg, Rosgalantereya did not conclude contracts for 1960 with the local city industrial trade until April and avoided coordinating the range of goods.

The Ministry of Trade of the RSFSR made a decision to grant the right to retail organizations not only to enter into direct contracts with enterprises located in a given region, territory and autonomous republic, but also to place orders for goods directly with industrial enterprises [4, p. 1].

One of the ways to improve wholesale trade and move from office methods of distributing goods to commercial work was to hold wholesale sales fairs.

For a number of years, the Ministry of Trade held republican fairs for the sale of household goods, haberdashery and cultural goods. At republican fairs in the fall, annual contracts were concluded between wholesale bases and purchase and sale, goods of local industry were sold, as well as surplus goods available at retail. At the autumn fair of 1959, wholesale and retail organizations of the RSFSR sold various goods for 36 billion rubles and purchased for 30 billion rubles [5, p. 13].

The development of industry, technical progress in the national economy, and increased demands from the population contributed to significant changes in the range of consumer goods.

Every year more and more new products made of new materials, new models, and more advanced designs were put on sale. Industry developed and released new types of refrigerators, washing machines, televisions, and many new brands of watches [6, p.2].

However, some enterprises continued to produce goods of outdated designs, from outdated materials. The struggle to update the range was decisive in the development of trade turnover, maintaining the interest of buyers in goods. And this was one of the main tasks of wholesale organizations.

An equally important issue in organizing wholesale trade was the constant control over the quality of goods.

In 1959, the Quality Inspectorate of the Ministry of Trade of the RSFSR stopped accepting goods from 972 enterprises producing food and industrial goods. In the first quarter of 1960, acceptance of goods was stopped from 413 enterprises.

The State Quality Inspectorate established back in the second quarter of 1959 that the Rosobuvtorg base in Bashkiria was accepting low-quality footwear from the Sterlitamak shoe factory. The more than 20 thousand pairs of leather footwear stored in the base's warehouses were not checked by any of the base's employees; some of the footwear had been lying idle at the base since December 1958 due to the fact that it was of low quality and sewn using outdated styles and models. Many Rosbakaleya offices - Belgorod, Kabardino-Balkaria, Amur, Primorsky, Irkutsk, Bryansk and others - did a poor job of ensuring the quality of confectionery products [7, p. 29].

All this led to the overstocking of the trade network with slow-moving goods. To fight for high quality goods, to increase the demands on industrial enterprises and wholesale bases - this was the main task of trade in the 50-60s.

One of the main issues of operational work of wholesale offices and bases was ensuring uniform supply of goods. There were many shortcomings in this matter. Some workers justified the unevenness of supplies by referring to the changing trade situation, to large excess stocks of goods in trading organizations.

When it came to sufficient goods that were supplied in bulk, the issue was limited to the timely and careful fulfillment of contracts by suppliers for the sale of such goods and their timely delivery to the places of consumption.

But there was a large group of goods of complex assortment – garments, woolen, linen fabrics, the delivery of which in the 50s was planned for the territories and regions. Therefore, a proposal was put forward to stop planning them for the regions and to switch to wholesale sales. As for some products, the demand for which was not yet fully satisfied, for example: high-quality garments, women's

woolen drapes, certain types of men's and women's footwear, the Ministry of Trade and wholesale offices were to continue to control the uniform delivery of these goods to each region.

Wholesale bases and offices did not always take into account the peculiarities of demand at the local level and did not make the corresponding adjustments to the range of goods sent to the retail network. For example, in the Kemerovo Region, Boston was a popular woolen fabric, and the demand for it was not satisfied. Meanwhile, Boston was in low demand in Moscow and a number of other cities at the same time. Therefore, it would be logical to increase sales of Boston in places where there was demand for it by reducing sales of Boston in Moscow and other cities.

In February 1960, 25 out-of-town artels participated in the Kemerovo fair, selling goods worth 14 million rubles. Meanwhile, in Moscow, Vladimir, Gorky and Kemerovo there were wholesale bases of Rosgalantereya and Roskulttorgo, whose responsibilities included interregional deliveries of goods, purchasing goods in other regions, and selling goods from local factories [8, p.2].

At the same time, there were many facts indicating that a number of wholesale bases had not established permanent business relations with bases in other areas.

Wholesale bases and offices were obliged to free industry from searching for buyers. But often the bases refused to take goods from certain industrial enterprises because of poor quality, outdated style of the model, and factories, cooperatives, instead of listening to the demands of the market and improving the quality of goods, began to bypass the wholesale bases and engage in sales and search for buyers themselves [9, p.19].

Wholesale trade was supposed to promote the development of retail trade. The relationship between wholesale and retail could not be limited to the sale of goods. Employees of wholesale trade and, first of all, wholesale bases were supposed to assist the retail trade network in organizing the sale of goods of their nomenclature.

In December 1959, over 50 stores were inspected in Krasnoyarsk Krai and it was established that each of them was missing 8 to 40, and in some cases up to 87, types of goods that were available at that time in the local Roskhoztorg, Rosgalantereya and Roskulttorg databases. At the time of the inspection, 11 to 50 types of cultural goods were not available in stores in the city of Kuibyshev. The same situation was noted in the Ulyanovsk, Sverdlovsk and Tula regions.

The absence of goods in the retail network, despite their availability at the bases, indicated a low level of commercial work in retail and wholesale trading organizations [10, p. 2].

In the late 1950s, a form of wholesale sales of goods through traveling commodity experts was practiced. In this regard, the experience of the Voronezh base

of Roskulttorgo is interesting, the commodity experts of which accepted orders for goods directly in stores. The commodity expert talked to sellers and customers in the store, clarified their complaints, studied demand and took into account offers. The new form of trade significantly increased the sale of goods, as well as the culture of trade. If specialized store No. 2 of the Voronezh city industrial trade ordered 120 items of goods for a total of 438 thousand rubles in the base for the whole of September 1959, then with the new form of wholesale trade, in one day on November 10, the same store ordered 120 items of goods for 240 thousand rubles.

However, it should be noted that with the introduction of a staff of dedicated commodity experts, many base managers, their deputies, department heads and senior commodity experts have sharply reduced their visits to trading organizations and stores.

Even with well-established wholesale trade, the bases might not have a particular product. In this case, mail order sales helped. Practice showed that the creation of mail order departments at centralized bases in Moscow and Leningrad, where large masses of goods were concentrated in a wide range, helped to sort goods in stores in a timely manner [11, p.26].

Rosgalantereya was one of the first to use this form of trade. Then Roskulttorg and Roskhoztorg organized a parcel base. However, the parcel form of wholesale trade should not be considered as independent. It was rather an auxiliary form and performed the functions of sorting goods for stores located not only in remote areas, but also in the central regions.

A common form of commercial work of trading bases was their participation in sales exhibitions and buyers' conferences held by department stores or specialized shops. Wholesale bases had to accumulate goods for them, attract representatives of industry to monitor the progress of sales of individual goods [12, p.22].

With the help of sales exhibitions and buyers' conferences, the opinions of buyers about the products were revealed; trade was activated, conditions were created for wider sale of products.

In 1960, the Kuibyshev base of Rostekstiltorg participated in nine trade shows, five of which were held at enterprises and in workers' clubs. The Voronezh base of Rostekstiltorg, together with trade organizations, held 25 trade shows, the Chelyabinsk base - 18 trade shows and 10 buyers' conferences [13, p.22].

An important element of commercial work was control over the activities of retail organizations and assistance to them. This involved control over decentralized purchases, which were carried out by trades and or in other areas of the country. Control over retail was not limited to checking the availability of a particular product in stores; wholesale bases took part in organizing retail trade, in servicing customers, and sought to expand the network of specialized stores and increase sales of a particular product [14, p.55].

This article formulates only some of the issues of organizing wholesale trade. Wholesale offices and bases had to constantly work on expanding the range and quality of goods, ensuring a uniform supply of goods to trading organizations in accordance with the demand of the population.

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从 2D 到 3D——平面设计和品牌塑造的新发展
FROM 2D TO 3D - THE NEW EVOLUTION OF GRAPHIC DESIGN AND BRANDING

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引言。技术创新推动了品牌设计从二维到三维的转变，从而带来了视觉创新和传播策略的转变。本文探讨了3D设计如何提高品牌认知度、增强竞争力和优化用户体验。它研究了传统平面设计的局限性，分析了与AR/VR结合时的空间构造、光影效果和沉浸感，并确认了其提高市场影响力和公众认知度的能力，讨论了采用的障碍以及如何克服这些障碍，并展望了未来的新兴趋势。本文的结论是，3D设计为品牌推广提供了新的途径和传播工具。

关键词：平面设计、3D设计、品牌推广、视觉传播、品牌标识、设计语言、数字化转型、创新设计。

Introduction. *Technological innovations have driven the shift in brand design from 2D to 3D, resulting in visual innovation and transformation of communication strategy. This article examines how 3D design can enhance brand recognition, strengthen competitiveness and optimize user experience. It examines the limitations of traditional graphic design, analyzes spatial constructions, light and shadow effects and immersion when combined with AR/VR, and confirms its ability to increase market impact and public awareness, discusses barriers to adoption and how to overcome them, and looks at emerging future trends. The article concludes that 3D design provides a new avenue and communication tool for branding.*

Keywords: *graphic design, 3D design, branding, visual communication, brand identity, design language, digital transformation, innovative design.*

1. The evolution of graphic design—visual transition from 2D to 3D

1.1 Images in graphic design

The origins of graphic design: Initially, the drawings were simple and depicted animals, but over time they became more complex and showed full-fledged stories from the lives of people and deities. Drawings were applied to the walls of caves with dyes of mineral, animal or plant origin [2].

With the invention of the printing press and the industrial revolution, graphic design gradually became an independent art form and is widely used in the business world.

Graphic design plays a vital role in branding, creating a unique brand image through elements such as color, font, typography, and imagery. Color conveys emotion and meaning, and influences consumer perception and behavior. Designers need to choose the right colors according to the brand positioning and target audience to increase brand recognition and appeal.

Fonts and typography play a key role in graphic design, and different styles convey different atmospheres. Designers need to choose the right fonts and typography according to the characteristics of the brand and target audience to enhance brand personality and readability. Images—one of the most intuitive elements of graphic design. By carefully selecting and processing images, designers can create works with a strong visual impact, attracting consumers' attention and conveying the core values of a brand. In short, graphic design plays a central role in branding.

1.2 Limitations in Graphic Design

In the era of information explosion, brand communication faces challenges and new opportunities. The diversification of consumer aesthetics and the development of digital technologies have made obvious the limitations of traditional two-dimensional design, making it difficult to demonstrate three-dimensionality and product details. 3D modeling technology allows for the visual reproduction of the shape of objects, providing an immersive effect, increasing professionalism and trust in the brand image, and the 3D interactive environment created by new technologies such as AR and VR stimulates user curiosity and encourages participation in the brand story. Virtual try-on, online customization and other functions bring brands and consumers closer together. Multi-sensory stimulation of 3D content is more likely to evoke emotional resonance.

With the advancement of technology, 3D design has become an important part of modern brand communication. In the area of social media and digital advertising, 2D design has limitations in terms of effective communication, interaction and user engagement. Compared to multi-dimensional or interactive forms of design, its capabilities are limited. As user expectations for content increase, a single 2D visual presentation may not be able to meet the needs of modern consumers who seek new and unique experiences, which will negatively affect the effectiveness of brand communication and the formation of user loyalty.

1.3 The Rise and Growth of 3D Design

3D design technology, which is based on 3D modeling and rendering, is leading the revolution in brand design. Volumetric images open up a new world where realism and depth of perception are achieved through the use of various technologies. The ability to represent graphics in three-dimensional space has radically changed the understanding of visual content, providing users with unique opportunities to immerse themselves in images [1].

The use of 3D technology allows us to present brand logos, product displays and even the entire brand image to the world in a more voluminous and vivid form, which significantly increases brand recognition and its competitiveness in the market.

In today's era of personalization and differentiation, 3D design has become a new trend that many brands are eager to adopt due to its unique creative expression and wide customization capabilities. It can not only satisfy consumers' demand for freshness and experiences, but also help brands stand out in the fierce market competition and create a unique brand image. Therefore, mastering and applying 3D design technology is essential for any company that wants to make a breakthrough in branding.

2. The impact of 3D design on branding

2.1 Visual Benefits of 3D Design

Apple has created a unique brand identity through three-dimensional design, as exemplified by the iconic Apple logo. Simple and easily recognizable, it is recognizable not only in two dimensions but also in three dimensions. For example, the Apple retail store design, with the illuminated Apple logo hanging above the entrance to a huge transparent glass cube, cleverly integrates the brand image with the structure of the building, creating a futuristic shopping experience. In addition, the packaging of Apple products itself is also simple and sophisticated, such as the embossed logo on the iPhone box, which not only reflects the brand's premium positioning but also increases brand awareness for users when they open the box.

2.2 Brand identity creation and 3D design

Market research shows that over 70% of consumers are more satisfied with products with 3D design, especially in the technology, automotive, and fashion sectors. Smartphone brands like Apple and Huawei have increased their market share by enhancing aesthetics and user experience with 3D design. The Tesla Model S has earned praise for its sleek design and innovative interior layout, which has helped fuel the growth of the electric vehicle market.

According to the survey, 65% of respondents believe that 3D design is more likely to inspire car purchases, with 80% of young people saying so. The clever use of 3D design can increase product recognition and help businesses stand out

in the competitive marketplace. Nike's use of 3D printing technology in the Air Max series of athletic shoes to reduce weight and improve comfort has been well received. Ikea uses virtual reality technology to create an immersive shopping experience and drive sales. 3D design has become an important trend in product design, satisfying consumers' aesthetic needs and providing business value. Businesses should actively embrace 3D design to remain competitive.

2.3 3D design and emotional connection with the brand

With 3D design, brands can present their products and concepts in a more vivid and three-dimensional way, and this innovative form of display not only attracts the attention of consumers, but also gives them a new visual experience. 3D design makes the brand image more expressive and allows it to stand out from the competition, thereby deepening the memory of consumers about the brand. At the same time, 3D design can be personalized according to the different preferences and needs of consumers, so that they feel the attention and respect of the brand towards them, and therefore increase their loyalty to the brand and emotional identity. In addition, 3D design can be interactive, allowing consumers to participate in the brand story, so that they become part of the brand's communication, this feeling of participation and sense of belonging will further deepen the emotional connection between consumers and the brand.

3. Innovative use of 3D design in brand communication

3.1 Cross-platform applications and multi-story presentation of 3D projects

3D design significantly increases brand effectiveness and improves engagement on social media and mobile apps. Strengthen your brand image with 3D website design and engage users with VR/AR technology. Traditional media becomes more persuasive with 3D design. Proper use of 3D design can significantly increase brand influence and establish its position in the market. In the context of digital transformation, 3D design plays a crucial role in creating striking product presentations and increasing conversion. Mastering and applying 3D design technology is the key to brand success in the digital era.

3.2 Applying Branding to Augmented Reality (AR) and Virtual Reality (VR)

AR/VR technologies enable brands to create immersive experiences that enhance consumer engagement. For example, Nike's use of AR technology to launch a virtual shoe try-on service and IKEA's use of AR technology for home furnishings have greatly enhanced the shopping experience and stimulated consumer creativity, opening up new avenues of engagement for brands and increasing their appeal and competitiveness in the marketplace. In the future, more brands are expected to embrace these technological innovations to revolutionize their marketing and service approach.

4. Technical Problems and Solutions in 3D Design

4.1 Technical difficulties

3D design requires creativity, artistry, and the use of complex techniques. The modeling stage requires the use of professional software to accurately perceive the shape, structure, and details of objects, as well as the use of tools and techniques such as polygonal, surface, and solid modeling. Rendering determines the realism and visual effect of the final image and requires an understanding of the concepts of ray tracing, global illumination, and texture mapping, as well as the skills to use them. Animation adds dynamic elements, making the work vivid and attractive, and requires the use of techniques such as keyframe animation, bone snapping, and physics simulation, as well as control of timing and tempo.

The process of creating a 3D model can be carried out in many ways. Everything depends on the goals, deadlines, complexity of execution and other features of production. Usually the main stages of preparation of 3D graphics are: modeling, textures, animation and rendering itself [3].

4.2 The evolution of 3D design tools and platforms

In the field of 3D design, designers use a wide range of software to improve productivity and work quality: Blender, a powerful open-source 3D modeling software, is a versatile solution for cost-effective and flexible requirements; Cinema 4D is known for its intuitive interface and powerful rendering capabilities for motion graphics and visual effects; Maya, the industry standard, has a rich set of features and is the preferred choice for large-scale projects and complex scenarios. Work more efficiently with shortcuts and scripting technologies, such as Blender shortcuts and MEL or Python scripts in Maya.

Cloud computing technology has made a significant contribution to the development of 3D design software, making it much easier to work with large-scale models through powerful computing and storage resources. In addition, artificial intelligence, especially machine learning algorithms, is increasingly being used in the field of 3D design, which can automatically generate design solutions, providing designers with a rich source of inspiration [4].

Conclusion

3D design plays a crucial role in the visual expression of a brand, bringing new experiences, deepening the image and enhancing competitiveness. It creates unique symbols and images that connect the brand with the emotions of the consumer. 3D design enhances the brand's personality and provides unlimited opportunities for brand differentiation. At the same time, it improves user experience and provides an immersive effect by visually displaying product features through VR, AR and other technologies. By promoting emotional resonance, 3D design touches the hearts of users and evokes empathy, increasing loyalty and word-of-mouth effect. In the future, 3D design will combine with developing technologies

to promote automation and intelligence. Designers need to constantly learn new technologies and have the ability to think creatively and collaborate across boundaries. As technological advances change rapidly, future research can focus on a deeper understanding of the long-term impact and potential risks and challenges of 3D design.

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标志的数字化转型：从静态符号到交互式媒体
DIGITAL TRANSFORMATION OF SIGNS: FROM STATIC SYMBOLS TO INTERACTIVE MEDIA

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引言：在数字时代，标志设计正在经历前所未有的变革。传统上，企业仅使用静态的视觉符号来传达品牌理念、文化和价值观。随着数字媒体技术的发展，互动对象和审美观念。消费者发生了深刻的变化，标志设计也开启了新的阶段。将静态文本或标志转化为交互式多媒体已成为标志设计的方向。

关键词：符号、标志、品牌、互动性、动态性、数字化转型、互动媒体。

Introduction. *In the digital era, logo design is undergoing unprecedented changes. Traditionally, companies used only static visual symbols to convey brand philosophy, culture, and values. With the development of digital media technologies, interactive objects, and aesthetic concepts. Consumers have undergone profound changes, and logo design has also opened a new stage. Transforming static text or logos into interactive multimedia has become the direction of logo design.*

Keywords: *symbols, logo, branding, interactivity, dynamism, digital transformation, interactive media.*

1. The evolution of logos: from traditional symbols to digital forms

Over the long history of human civilization, logos (or logos) as an important medium for transmitting information have undergone a process of evolution from simple to complex and from static to dynamic. This process not only reflects the progress of human society and technological development, but also deeply reveals the key role of logos in cultural heritage, business exchanges and social identity.

1.1 Logo of the era of traditional symbols

The origins of logos go back to ancient times. People created symbols on rock paintings and stone carvings to distinguish tribes, record events or express beliefs. These simple images had deep cultural meaning and important social functions, becoming part of early civilization. As society developed, logos evolved from primitive symbols to more complex and sophisticated forms. paintings, decorating buildings, dishes, flags and other objects. Such logos reflected not only identification functions, but also the aesthetic taste of the craftsmen. The Industrial Revolution accelerated the development of logo design technologies. The invention of printing allowed them to be mass produced and distributed, making logos an important part of advertising, packaging, and branding. During this period, they became a tool for business competition, and their designs became more creative and attractive.

1.2 The relationship between traditional graphic symbols and modern logo design.

Logos are mass communication symbols with strong symbolic meaning, conveying specific information in a short image. Traditional graphic symbols serve as mediators of information transfer and can be integrated into modern logo design. These symbols have a conventional meaning and meet the requirements of modern corporate logo design. Totemic colors and symbolic graphics are close to the corporate image recognition system, reflecting corporate individuality and cohesion.

Traditional graphic symbols usually use metonymy to convey beautiful meaning, and modern logo design also uses this technique to transform abstract concepts into vivid images.

In modern logo design, traditional graphic symbols have the following characteristics:

Cognitiveness: revealing the main characteristics of things. For example, the Bank of China uses ancient coin samples as its logo to accurately reflect the characteristics of financial institutions.

Restrictions: the influence of cultural characteristics and audience groups. For example, German designers need to understand the historical significance of potatoes when using potato materials. White elephant radiators are popular in Southeast Asia because white elephants are considered auspicious objects, but they are not popular in Europe and the United States.

Variability: changes in time and space. For example, the inscriptions on the oracle bones are transformed from records of fortune telling into symbols of the Yin and Shang era, conveying memories and ideas of ancient times in logo design.

These characteristics make traditional graphic symbols an important source of inspiration for modern logo design, promoting innovation and design development.

1.3. Logo changes in the digital age

With the rapid development of computer technology, digital technology has gradually penetrated into the signage field. Digital signage is no longer limited to the traditional two-dimensional plane, but has expanded to three-dimensional space, dynamic images, interactive capabilities and other dimensions.

The popularity of the Internet and the widespread use of mobile devices have further accelerated the process of signage digitization. Nowadays, people can access and share identity information anytime and anywhere via mobile devices such as mobile phones and tablets. Due to this immediacy and interactivity, logos play a more important role in brand promotion and information dissemination.

2. Interactive and dynamic logos: key features and benefits

2.1. Key Features of Interactive and Dynamic Logos

- **Humanized**

Compared with traditional logos, interactive and dynamic logos take the "human" factor into account. They not only focus on the audience's cognitive style, habits, and behavior patterns, but also explore and satisfy the physical and mental needs of the audience through dynamic effects and interactive design. For example, the dynamic logo of the Norwegian Nordkyn website is updated in real time based on weather data. When you hover over it, detailed weather information will be displayed. This design not only reflects the consideration of the audience's real needs, but also conveys humanistic care for the website.

- **Confession**

Dynamic logos, from a deconstructive point of view, emphasize visual complexity, richness and originality, allowing each brand to have relatively independent characteristics, which greatly increases the uniqueness and recognition of the logo. Compared with static signs, which are confined to a one-dimensional visual space, dynamic signs move freely in multidimensional spaces such as sight, hearing and touch. A wider creative space stimulates the diverse development of dynamic signs.

- **Interactivity**

Interactive and dynamic logos break the limitations of traditional static logos in terms of creative space. In addition to the traditional visual space, they also open up auditory, tactile and other spaces, enriching the interactivity of dynamic logos. For example, modern interactive technologies can provide a variety of interactions and real-time feedback, such as the deformation of the logo when shaking the phone, sound effects when touching the logo, etc. This method of human-computer interaction will bring the audience a multi-sensory and immersive experience, increasing user engagement and their identification with the brand.

2.2. Benefits of Interactive and Dynamic Logos

The integration of dynamic effects and multimedia elements makes the brand image more vivid and three-dimensional, attracting the attention of users and conveying the core values and unique charm of the brand.

With dynamic effects and interactive design, interactive and dynamic logos can provide users with a richer and more diverse interactive experience, thereby increasing user engagement and satisfaction.

Dynamic logos can be easily adapted to various new media platforms such as social media, mobile apps, etc., allowing brand messages to reach a wider audience.

Designing interactive and dynamic logos requires constant attempts to use new technologies and ideas, which encourages brands to constantly seek innovation and breakthroughs in the design process, thereby stimulating brand creativity and competitiveness.

To sum up, interactive and dynamic logos are becoming an important part of modern brand communication due to their key characteristics such as humanization, recognition and interactivity, as well as the benefits of enhancing brand image, improving user experience, expanding communication channels and promoting brand innovation. The trend is to improve brand image, improve user experience, and expand communication channels.

3. Practical application of interactive signs in advertising and marketing

As an innovative means of brand communication, interactive logos demonstrate their unique charm and great potential in the field of advertising and marketing. Combining advanced technology and creative design concepts, interactive signs not only attract consumers' attention, but also increase brand awareness, promote user engagement, and ultimately boost sales.

The basis of a logo is a recognizable and precise pattern. Therefore, when developing the shape of a logo, the precise expression of creativity is of crucial importance, which requires designers to highlight elements that fully correspond to the concept of the logo. The clarification of the logo graphics is not only related to the accuracy of the visual form and composition, but is also the cornerstone of the transmission of information about the logo. These carefully designed graphic images as information carriers must be clearly visible and have the ability to be widely distributed through various media.

The process of refining logo graphics is essentially an inventive use and combination of basic visual elements such as points, lines, surfaces, bodies, spaces and momentum. These elements not only constitute the basic symbols of logo graphics, but are also the key to achieving the unity of dynamic effectiveness and creativity of the logo. The process of refining is preceded by creative graphic modeling, which gives the logo a unique visual language and form of expression; animation follows, and, thanks to digital media technologies, the logo glows on a static base.

- **Increase brand awareness**

Interactive signage can stand out from the crowd of advertisements and grab the attention of consumers with its unique visuals and interactive experience. For

example, in a shopping mall or exhibition, a dynamic logo that changes based on the audience's movement will surely attract a large number of people to stop and take a look, thereby increasing brand awareness. Additionally, interactive logos can also spread virally through social media and other channels, further expanding the brand's influence.

- **Encourage user participation and interaction**

The main advantage of interactive signage is its interactivity. Through various interaction methods such as touch, voice, gestures, etc., consumers can personally participate in the brand experience, thereby establishing a deeper emotional connection. For example, an interactive billboard that can recognize and respond to consumers' voice commands can not only provide personalized product recommendations, but also make consumers feel cared for and respected by the brand. This interactive experience can not only increase consumer satisfaction and loyalty, but also inspire them to share it with friends and family, creating word-of-mouth communication.

- **Increase advertising efficiency and sales conversion**

Interactive signs can not only increase brand awareness and user engagement, but also optimize advertising content and marketing strategies through data collection and analysis, thereby improving advertising effectiveness and sales conversion. For example, with the help of user behavior data collected through interactive signs, brands can understand the interests, preferences, intentions of buyers and other information, and then adjust advertising strategies to improve advertising accuracy and conversion rates. At the same time, interactive signs can also be used as a traffic redirection tool for offline stores to attract consumers to the store by providing incentives such as coupons and discount information.

4. Digital Transformation of Logos: Prospects and Challenges from Static Symbols to Interactive Media

- **Prospects**

Interactivity and improved service quality. With advances in technology, logos are no longer just static visual symbols, but are evolving into interactive media. This shift allows brands to build deeper connections with consumers and increase brand awareness and loyalty through interactive experiences. For example, dynamic signs can change based on user actions or environmental changes, providing consumers with a personalized visual experience.

Innovation and differentiation. Digital transformation opens up more opportunities for innovation in logo design. By combining new technologies and creative elements, companies can create a unique identity to stand out and differentiate themselves in a highly competitive marketplace.

- **Problem Analysis**

Compatibility of technologies and platforms

As technology continues to evolve and innovate, companies need to ensure that their logos can be displayed and interacted with correctly across a variety of new technologies and platforms. This requires businesses to have strong technical strength and continuous research and development capabilities to cope with the changing technical environment.

User Experience Sequence

When displaying logos across platforms, companies need to ensure a consistent user experience across all devices. This requires companies to fully consider the characteristics of different devices and user needs when designing their logo to ensure a seamless cross-platform experience.

Conclusion

Logo design is undergoing a digital transformation from static symbols to interactive media, which is both a result of technological advances and a reflection of changing consumer needs. Digital transformation opens up innovative opportunities for logos, allowing them to more fully convey brand messages and enhance brand recognition. At the same time, logos in interactive media environments enhance consumer connections and increase brand loyalty through interaction. However, this transition also comes with technical challenges, data security issues, user experience consistency, and cultural transmission. Addressing these challenges requires companies to strengthen technological research and development, optimize data protection measures, improve user experience design, and deeply understand brand connotations. The digital transformation of logos is an inevitable trend in the evolution of brand identity elements. In the future, we expect to see more creative digital logos that will breathe new life into brand building and marketing.

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文化传承与空间设计：传统文化元素在室内设计中的创新运用
CULTURAL HERITAGE AND SPACE DESIGN: INNOVATIVE USE OF TRADITIONAL CULTURAL ELEMENTS IN INTERIOR DESIGN

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Introduction. *Cultural heritage carries national memory and wisdom, and its preservation and innovation are especially important in the context of globalization. Traditional cultural elements in interior design not only reflect national characteristics, but also strengthen national cohesion. The key to innovation lies in combining traditional elements with modern design that not only preserves cultural heritage but also meets modern spatial needs. This study examines how traditional cultural heritage can be reinterpreted in interior design, analyzes design examples and strategies, and shows how traditional elements can be revived in contemporary design.*

Keywords: *cultural heritage, interior design, fusion of tradition and modernity, cultural heritage and innovation, tea rooms, bookstores.*

1. The relationship between cultural heritage and interior design

1.1 Definition and role of cultural heritage

Cultural heritage is a tangible and intangible heritage of historical, cultural and artistic value that carries the historical memory of a particular region and people. In particular, some historic ancient cities are the most valuable thing that should not be destroyed due to impatience and ignorance. [2] Cultural heritage links the past with the future, promotes cultural diversity and social cohesion. It is historical, regional and culturally symbolic. In interior design, cultural heritage is not

only a carrier of national memory, but also a source of aesthetic inspiration and innovation. Designers combine traditional elements with contemporary design to preserve historical flavor and give it new life, contributing to the protection and development of cultural heritage.

1.2 The concept of innovation

"Innovation" of traditional cultural elements means that on the basis of transmitting cultural heritage. Inheriting traditional design concepts and deep cultural heritage, it gives interior design a deeper meaning and contains people's emotions and spiritual quests [3]. Drawing inspiration from them and combining them with contemporary design concepts, we create new forms that preserve the traditional flavor and meet modern requirements. This innovation is not only a formal renewal, but also a re-expression of cultural subtext. In balancing tradition and modernity, design must respect cultural roots while taking into account modern functionality and aesthetics in order to promote the revival and reinterpretation of cultural heritage. Tradition and modernity can be integrated and developed together.

2. Innovative approaches to traditional cultural elements

2.1 Innovative design strategies

Innovation in interior design is achieved through the thoughtful combination of elements such as form, materials, color, light, textures and patterns. By changing these elements, the space acquires new visual effects and emotional subtext, so that it has a sense of modernity, but at the same time conveys the spirit of traditional culture, enhancing creativity and depth of design.

However, in the process of implementing innovations The designer cannot directly apply traditional national decorative elements and must avoid simple formal imitation. Simple copying leads to the emasculation of the spiritual origin of the ancient artistic tradition.[4]. The balance between tradition and modernity is the main challenge for designers. Design must convey the essence of traditional culture and at the same time meet the functional, comfortable and aesthetic requirements of modern spaces. Thanks to this balance, traditional elements are revived in modern spaces, preserving cultural features and adapting to modern needs.

2.2Analysis of similar projects

Modern innovations in traditional architecture continue, such as the digitalization of the Palace Museum in Beijing, which combines traditional culture with modern technology. This innovation enhances the visitor experience and revives traditional culture in the modern world.

Another example: Hi-Tea Wuxi Nanchang Street Store successfully combines tradition and modernity. The designers preserved the original appearance of the building and skillfully reconstructed the space, using modern materials such as stainless steel and terrazzo as opposed to traditional ones, as well as cement and art

paint in the design. The fusion of different materials and smells allows the space to achieve a timeless intersection of tradition and modernity, history and innovation.

In the field of contemporary home design, Japanese architect Kengo Kuma is known for his concept of "negative architecture," which often incorporates natural elements and traditional materials into contemporary architectural design in innovative ways. His masterpiece, "The Commune at the Foot of the Great Wall," uses local stone and wood to blend in with the surrounding environment, respecting traditional culture and meeting modern people's needs for comfortable living.

These examples show that the combination of traditional cultural elements with modern functional and aesthetic needs can create works with unique charm and far-reaching impact, promoting cultural heritage and improving the quality of life. At the same time, Strengthen the excavation and development of outstanding traditional Chinese culture, and strive for creative transformation and innovative development of traditional Chinese virtues [1].

3. Innovative practices of using elements of cultural heritage in interior design

3.1 Practical application of elements of cultural heritage

The integration of cultural heritage elements has become a trend in contemporary design. Renovating traditional buildings is one of the effective ways to demonstrate the charm of cultural heritage. Taking the bookstore design as an example, it can be said that the inclusion of cultural elements can not only create a unique cultural atmosphere, but also greatly enhance the cultural value of the space. Preserving the structural and decorative elements of traditional buildings, such as wooden beams, sculptures and characteristic roof shapes, and simultaneously combining them with materials and design techniques such as stainless steel, glass, art paint, etc., not only improves the functionality and comfort of the space, but also brings new forms of expression to traditional elements. In addition to the thoughtful use of color, pattern and cultural meaning, the new interpretation of traditional elements gives the space a new visual effect, while demonstrating the vitality of time, so that customers can enjoy reading while experiencing cultural cultivation and enlightenment. This combination of old and new design not only brings new vitality to traditional architecture, but also adds unique colors to modern life, making the bookstore an important place for cultural heritage.

An effective design method is not only to reconstruct a traditional building, but also to create a new building while preserving and updating the elements of traditional culture. Taking the design of the "Tea House" as an example, the elements of traditional tea culture can be extracted and combined with modern design techniques and materials to preserve the cultural heritage and at the same time demonstrate a sense of modernity. For example, inspiration can be drawn from the traditional tea ceremony, the shape of tea utensils and the spatial layout, and the

traditional elements can be updated with modern techniques and materials. At the same time, traditional patterns (such as the Tibetan "Eight Treasures" pattern) can be applied to the design of walls, floors and windows with modern technology, which not only conveys cultural flavor but also adds a modern sense of aesthetics. In terms of materials, the combination of traditional materials such as bamboo and wood with modern metal and glass creates a space that is both traditionally cozy and meets modern aesthetics and functional needs. Thanks to this design, the tea room meets modern requirements for aesthetics, comfort and functionality, while conveying traditional culture.

3.2 How to find a balance between tradition and modernity and avoid a clash of cultures in design.

When renovating traditional buildings, designers must respect the historical context and design features, and preserve historical elements for cultural heritage. The choice of materials should combine modern technology and traditional craftsmanship to ensure durability and safety while preserving character. New buildings should integrate modern and traditional elements, combining clean lines with traditional motifs, and create a harmonious interior layout that enhances functionality and comfort. The design should respect local culture and customs, invite residents to participate in decision-making, and ensure the building is in harmony with the surrounding environment, reflecting the harmony between modern style and the historical landscape.

4. Conclusion

Integrating cultural heritage elements into interior design is a tribute to tradition and an effective way to integrate traditional culture into modern life. Such integration requires a deep understanding of the essence of traditional culture, and through innovative design, ancient culture is revived in modern space. Innovative application of traditional culture enriches the language of design, breaks down the boundaries between tradition and modernity, and makes the work both culturally rich and fashionably practical. The future generation of interior designers should explore a new direction of innovation and protection of cultural heritage, and promote the exchange and integration of various cultures, which requires deep study of cultural heritage, keen insight, open-mindedness and innovative thinking. The cultural value of design is manifested not only in aesthetics, but also in deepening the understanding and recognition of traditional culture in society, strengthening people's trust and pride in traditional culture, and promoting cultural diversity and inclusive development.

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坪山树光玉堂社区活动中心重新设计（中国安徽省）
REDESIGN OF PINGSHAN SHU KWONG YUTANG COMMUNITY ACTIVITY CENTER (ANHUI PROVINCE, CHINA)

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摘要。本作品致力于重新设计平山树光裕堂（中国安徽省）祖先的祖屋。这个房间是徽州建筑风格的代表。简要介绍了历史背景，并考虑了重新设计此类房屋的基本要求。还介绍了中国古代家族房屋成功重新设计的例子。

关键词：重新设计，宗祠，徽州建筑风格，重新设计概念发展，历史文化古迹。

Abstract. *The work is devoted to the redesign of the ancestral premises of the ancestors of Pingshan Shu Kwong Yutang (Anhui Province, China). This room is representative of the Huizhou architectural style. A brief historical background is provided and the basic requirements for the redesign of such premises are considered. Examples of successful redesign of ancient family premises in China are also presented.*

Keywords: *redesign, ancestral hall, Huizhou architectural style, redesign concept development, historical and cultural monuments.*

Introduction

Historical buildings are traces of an era in the process of urban evolution, preserve its memory and testify to its changes. When redesigning, it is necessary to look for ways to use historical cultural buildings so that history and modernity coexist harmoniously. This is not only an internal requirement for promoting urban renewal, but also an effective way to protect and transmit historical and cultural heritage. However, the redesign and use of historic buildings face many challenges, including technical difficulties of renovation, legal restrictions, lack of funding, and the need to balance protection and development [1].

It should be noted that redesign is the process of making changes to an existing building in order to adapt to new functional requirements or improve its opera-

tional efficiency, while taking into account aspects of aesthetics, functionality and sustainability [2].

Purpose of the work

This project will examine the redesign of the ancient ancestral premises of Pingshan Shu Kwong Yutang (Anhui Province, China), and will explore how to create a community activity center that meets modern needs through spatial planning and optimization of functional parameters.

This article used a methodological approach involving a systematic review of a large body of literature to summarize the theoretical framework and development of the redesign and use of historic buildings. Through the analysis of typical domestic examples, successful implementations and lessons for the redesign and use of historical buildings in China were identified.

Pingshan Shu Kwong Yutang, geographical location

Huizhou architectural style, found in Huangshan City, Anhui Province, China, is one of the most famous historical and cultural cities of ancient China (Fig. 1, left). Huizhou's architectural culture has a long history and carries rich historical overtones. It is known as one of the treasures of ancient Chinese architectural art. Huizhou architecture not only embodies the essence of traditional Chinese architecture, but also exhibits the unique style and characteristic features of Huipai architecture [1], [3].

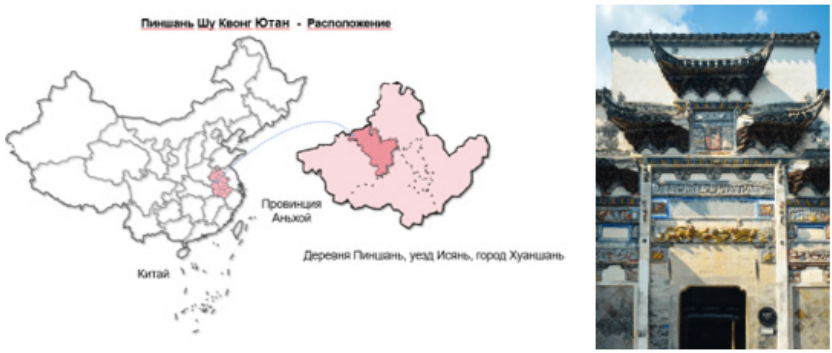

Figure 1. *Geographical location and gate tower of Shu Kwong Yutang*

The multicolored gate tower of Shu Kwong Yutang, an ancestral hall similar to a church in Russia, is a ceremonial structure of Chinese folk architecture, a place for people to worship ancestors, the root of local culture, the symbol and center of the family, and is also a symbol of the level of local economic development (Fig. 1, right). From the point of view of folklorists, ancestral palaces "interpret the civilization of that time in the sense of their own existence" [4].

Historical purpose of Pingshan Shu Kwong Yutang building

Since the ancestral hall is the place where the spirits of the ancestors reside, where the gods and goddesses are kept, the main function of the ancestral hall is to worship the ancestors, and another important function of the ancestral hall is to collect and compile the genealogy of the ancestors. The ancestral hall is also a meeting place for discussing clan affairs, a place for training and education, holding family court, a place for celebration and fun for the entire clan during annual holidays or major celebrations.

Directions for room redesign

Cultural heritage and protection. It is necessary to respect the authentic historical and cultural values of ancient buildings, preserve and restore their unique architectural elements and characteristics. The long-term preservation and sustainable use of ancient buildings must be ensured through appropriate measures to protect cultural relics and technical means. Using display, education and other methods to convey to the public the historical and cultural background of ancient buildings and increase people's understanding and respect for traditional culture.

Community participation and functionality expansion. The needs and interests of the surrounding communities should be integrated to organize various public events, including cultural exhibitions, artistic performances, public meetings, etc. Open space and multi-functional activity areas need to be created to meet the needs of people of different ages, interests and specializations. Community members should be encouraged to participate in the operation and management of the activity center and develop a sense of community and ownership.

Sustainability and innovative design. At the same time, on the basis of preserving the original characteristics of ancient buildings, the combination of modern science and technology with the concept of green buildings should be used to realize the transformation of buildings for the purpose of energy saving and environmental protection. Renewable materials and energy-saving equipment should be used to reduce the consumption of natural resources and environmental pollution. Innovative design concepts and technology are required to enhance the functionality and attractiveness of an activity center, making it an important anchor for sustainable community development. Figure 2 shows examples of successful redesign of ancestral ritual buildings in China [5].

Figure 2. *Examples of redesign of ancient premises*

Conclusion

To summarize, it should be noted that, as a representative of Huizhou architecture, Pingshan Shu Kwong Yutang has irreplaceable historical value and cultural significance. The Chinese government attaches great importance to the preservation and use of historical and cultural heritage and has a policy of supporting and encouraging the redesign of historical buildings. Modern construction technologies are very advanced and make it possible to effectively restore, preserve and restore historical buildings. The redesign of Pingshan Shu Kwong Yutang is technically feasible as a community activity center and can meet the cultural and recreational needs of the community and will enjoy great demand and response.

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苗族文化符号在品牌设计中的运用及形成
UTILIZATION AND FORMATION OF MIAO CULTURE SYMBOLS IN BRAND DESIGN

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诠释。分析苗族文化符号的类型与内涵，探讨其在品牌设计中的理论基础与实际应用，以及如何通过标志、包装、广告等形式将苗族文化符号融入现代品牌设计，提升品牌的文化价值与市场竞争力。

关键词。苗族，品牌设计，传统文化，民族。

Annotation. *Analyze the types and connotations of Miao cultural symbols, explore their theoretical basis and practical application in brand design, and how to integrate Miao cultural symbols into modern brand design through logos, packaging and advertising so as to enhance the cultural value and market competitiveness of the brand.*

Keywords: *Miao, brand design, traditional culture, nation.*

Introduction

This research analyzes the types and connotations of Miao cultural symbols, explores their theoretical basis and practical application in brand design, and studies how to integrate Miao cultural symbols into modern brand design through logos, packaging and advertising so as to enhance the cultural value and market competitiveness of brands.

Miao brand design integrates elements of Miao culture into the brand image and product design to enhance the brand's uniqueness and cultural value. This not only enhances the brand's competitiveness in the market, but also conveys the rich cultural history and promotes the inheritance and innovation of national culture. Using traditional arts such as Miao embroidery, silver jewelry, Miao songs and

dances, we apply modern design techniques to show their characteristics, forming a unique visual style and deep cultural connotations.

In fact, the brand does not have such a long history, because the traditional culture of the ethnic group has been rather conservative for a long time. The traditional culture of the Miao people is a rich and colorful cultural heritage of China. Elements such as traditional Miao costumes, folk music and dance, and traditional festive customs embody the unique cultural atmosphere of the Miao, which has distinctive ethnic characteristics and artistic value. The study of how to integrate the traditional culture of the Miao people into the creation of the brand aims to enrich and promote traditional Chinese culture, strengthen the sense of national identity, and improve the cultural connotation of the brand.

With the development of the Miao brand, the unique value of the Miao culture is increasingly valued and recognized. The Miao brand is not only the introduction of commercial products, but also the heritage and embodiment of the Miao culture. At present, this principle has become an integral part of the design concept of the Miao brand, and the development of the Miao brand not only has important economic significance, but also plays an active role in cultural heritage, social responsibility and international influence. Through continuous innovation and promotion, the Miao brand can not only achieve commercial success, but also contribute to the protection and inheritance of the Miao culture. [4]

However, few studies have addressed the issue of race in brand design. Problem: Strengthening research on ethnic brand design can not only enrich the theoretical system of brand design but also provide reliable guidance for practice.

1 Using miao cultural symbols in brand design

Miao culture symbols, with their unique artistic charm and deep cultural connotations, serve as a rich source of inspiration for brand design. Miao culture is an important part of Chinese traditional culture, and its unique symbols and elements have deep historical and cultural heritage and artistic value. In brand design, reasonable use of Miao culture symbols can give the brand a unique charm and cultural connotations.[5]

The symbols of Miao culture are rich and diverse: traditional Miao costumes, silver jewelry, embroidery, totems, etc. These symbols not only have a beautiful visual effect, but also carry the history, beliefs and lifestyle of the Miao people. The combination of Miao culture and brand concept creates a brand image with regional characteristics and cultural charm. Brand logo is one of the core elements of brand image, which directly affects consumers' first impression of the brand. Integrating Miao cultural symbols into brand logo design can enhance the uniqueness and cultural identity of the brand.[3]

Miao culture is used to create symbols with national characteristics. Through abstraction and simplicity, these symbols retain their cultural connotations, but at the same time adapt to modern aesthetic needs. For example, in the design of

the Mama Butterfly brand logo (Appendix 1, Fig. 1), the drum and the ox horn " 苗" The Chinese character "苗" is used as the "艹" of the head, which is also the antenna of the butterfly, and the initial letters of the Miao word "Mother Butterfly" are broken and rearranged into "田" (field), which is the character of the Miao language. The initials "MBML", which means "Mother Butterfly" in the Hmong language, are rearranged into the character "田", which can also be used as the wings and body of the butterfly, and the whole composition is in the shape of a butterfly with the character "苗". The composition is taken from the symmetrical pattern of the Miao costume, which represents the mystery and long history of the mythological culture of the Miao. "Mother Butterfly" is a brand image design that takes the mythological story culture of the Miao as the main research object, which represents the study and improvement of the traditional mythological story culture of the Miao, ethnic patterns, etc. The logo is based on drums and the horns of the Miao ox, combining Chinese characters and the Pinyin alphabet, and expressing the overall meaning of the logo in a concise form. The derivatives are the logo stickers and paper tape (Appendix 1, Fig. 2). [1]

Poster is an important means of brand communication, and visual marketing directly influences consumers' purchasing decisions. Using Miao cultural symbols in poster design can create a brand image that is rich in ethnic characteristics. For example, when creating posters, including elements of Miao dance or traditional costumes can attract the audience's attention and enhance the memorization of the advertisement. Using traditional Miao clothing in a poster can attract consumers' attention and arouse people's interest and curiosity about traditional culture. The gorgeous colors and exquisite craftsmanship of Miao costumes can give the advertisement a sense of art and uniqueness. Miao costumes can convey the idea of cultural diversity and tolerance, and highlight the brand's cultural heritage and sense of social responsibility.

When developing a brand, the selection and refinement of Miao cultural symbols should be carried out in the following steps:

Classification and selection of symbols: From the rich cultural elements of the Miao, symbols with representativeness and uniqueness are selected, such as embroidery patterns, silver ornament shapes and traditional clothing patterns.

Cultural Subtext Analysis: A deep understanding of the historical background, cultural significance, and symbolic value of these symbols to ensure that the symbols chosen convey the correct cultural message.

Contemporary Design: Combining traditional symbols with modern design concepts to preserve their original characteristics and adapt to the needs of modern brand design.

Abstraction and simplification of symbols: Based on the preservation of core cultural connotations, symbols are abstracted and simplified to make them more design-oriented and practical, applicable to various brand usage scenarios.

With unique artistic charm and deep cultural connotations, Miao cultural symbols have broad application prospects in brand design. Through the selection, improvement and innovative application of Miao cultural symbols, the uniqueness and cultural value of a brand can be enhanced, and its competitiveness in the market can be improved. In the context of globalization, the integration of Miao cultural symbols into brand design can not only promote the inheritance and development of traditional culture, but also bring new vitality and connotations to modern brands.

2 Formation of Miao cultural symbols in brand design

Forming the symbols of Miao culture in brand design is a difficult but promising task. Miao culture has a centuries-old history and contains the richest traditions, beliefs and values, so skillfully incorporating these symbols into brand design not only gives it a unique cultural heritage, but also attracts the attention of consumers and establishes an emotional connection between the brand and the consumer.

First, it is very important to incorporate Miao cultural symbols into the brand logo design. This can be achieved by subtly incorporating traditional Miao patterns, motifs, or decorative elements into the logo. These patterns are often characterized by geometric beauty and a sense of hierarchy, which can give the brand a visual impact while conveying the emotions and values associated with Miao culture.

Secondly, the brand color scheme can use the common colors of Miao culture, such as bright red, blue, green, etc. These colors not only have sharp contrast and richness, but can also symbolize the auspiciousness, festivity, and vitality of Miao culture, thus filling the brand with positive energy. Miao culture symbols can also be used in packaging and advertising. For example, adding traditional Miao patterns or decorations to the product packaging can give it a unique style and charm.[2]

Finally, when using Miao cultural symbols, brands should respect the traditions and values of Miao culture and avoid distorted or exaggerated interpretations. It is very important to cooperate with relevant groups and organizations in the Miao region to gain deep knowledge and advice on Miao culture. Only on the basis of full respect and understanding can brand design truly reflect respect and support for Miao culture and win the recognition and trust of consumers.

Conclusion

The traditional Miao culture contains rich national spirit and values such as reverence for nature, respect for tradition, and pursuit of unity and harmony. These values are compatible with modern society's concerns about environmental protection, cultural heritage, social harmony, etc., which is conducive to building a brand image with Chinese characteristics and strengthening the brand's sense of

social responsibility and public image. There is a long history of exchanges and integration between the Miao and Han people and other ethnic minorities, and this multicultural symbiosis and coexistence reflects the characteristics of China as a multi-ethnic country, which helps to strengthen the sense of identity and cohesion of Chinese brands in the domestic market.

The use of Miao cultural symbols in brand design is of great significance. It is not only the heritage of traditional culture, but also an innovative way of self-expression. It can not only give the brand a unique cultural value, but also evoke an emotional response from consumers. By combining Miao cultural symbols with brand image, a brand with regional characteristics and cultural charm can be created.

This culture has a distinctive personality and uniqueness, and its integration into brand design can give the brand a unique cultural connotation and value, make the brand stand out in the market competition, and enhance the brand's differentiation and competitiveness.

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Application

Figure 1. *Mama brand logo Butterfly*

Figure 2. *Derivatives of the Mama Butterfly brand*

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苗族创造力是一种独特的艺术形式
MIAO CREATIVITY AS A UNIQUE ART FORM

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注：苗族艺术作为一种独特的设计形式，有着丰富的传统和深厚的文化内涵。每个地区都有自己独特的艺术表现方式，其中苗族艺术以其独特性吸引了众多研究者的关注。苗族艺术不仅包括绘画、雕刻和刺绣等传统形式，还包括建筑、服饰和家居装饰中的设计元素。这些作品浸透着苗族人民的情感、信仰和生活方式，成为他们身份认同的重要组成部分。

关键词：苗族，苗族图案，民族。

Annotation. *As a unique form of design, Hmong art has rich traditions and deep cultural connotations. Each region has its own unique way of artistic expression, among which Miao art has attracted the attention of many researchers for its uniqueness. Miao art includes not only traditional forms such as painting, carving and embroidery, but also design elements in architecture, clothing and home furnishings. These works are imbued with the emotions, beliefs and lifestyle of the Miao people and have become an important part of their identity.*

Keywords: *Miao, Miao pattern, nation.*

Introduction

The Miao are an ethnic minority in China with a rich cultural heritage. Among them, the Miao patterns, as a unique art form, have strong ethnic characteristics and cultural connotations. The traditional Miao patterns are mainly characterized by geometric patterns and images of plants and animals, with distinctive national characteristics and decorative effects. Common patterns include brocade flower patterns, cloud patterns, butterfly patterns, etc. These patterns are generally composed of fine lines and flowers. These patterns not only reflect the aesthetic ideas and lifestyle of the Miao people, but also record the history and traditions of the

Miao people. Therefore, the study of Miao patterns has important academic significance and practical significance. Miao patterns have unique artistic charm and cultural connotations, and their application in modern design can provide rich material and inspiration for design innovation.

1 Creativity of the miaos as a unique art form

The Miao are an ethnic group with a unique culture, and they have created colorful patterns in their daily life. These patterns not only reflect the aesthetic ideas and cultural traditions of the Miao people, but also have high artistic value and cultural connotations. The Miao lived near the water, and therefore doubted whether there were gods and immortals in the water, so the patterns of water, fish and frogs appeared. After a series of large-scale migrations, the Miao's life gradually became more stable, and they gradually began to try to express their thoughts and feelings through plants and animals. When the Miao were no longer threatened by wars and natural disasters, their lives became more colorful and they began to engage in more active activities. The Miao women found that the beautiful nature of the cottages where they lived was filled with singers, flowers, insects, birds and butterflies that sang and danced, so they used this as inspiration to create various animal and plant motifs that they sewed onto their dresses and skirts. Since then, Miao patterns have not only become the basis for expressing the thoughts and feelings of the Miao people, but also contain a strong sense of Miao history [1].

Miao pattern is a traditional folk pattern in China, which is mainly abstract graphics with good meaning, such as fish, birds, dragon and phoenix, birds, flowers, plants, sun, moon, stars and people. Miao patterns and ice cracks can be used in modern graphic design, through the combination of dots, lines and surfaces to deconstruct and reconstruct graphics to generate new graphics, introducing traditional Chinese culture and art forms into graphic design, enriching the concept of graphic design, building a graphic design system with Chinese characteristics and applying traditional

Geometric patterns are one of the most common types of patterns. Geometric patterns mainly include linear, triangular, rhombic, circular and square patterns. Linear patterns play a decorative role by dividing and connecting different patterns, while triangular, rhombic, circular and square patterns can be formed independently. Miao patterns are exquisite, often using symmetry, repetition and gradation, smooth lines and high artistic value. (Appendix 1, Fig. 1). Animal patterns clearly reflect the totemic culture of the Miao, with birds, dragons, butterflies and fish as the main totemic elements. Plant motifs are mainly borrowed from common plants such as peaches and pumpkins. Plant motifs are mainly borrowed from common plants such as peaches and pumpkins. [2] (Appendix 1, Fig. 2, Fig. 3)

Miao art as a unique form of design has a wide range of applications in the field of contemporary design. Miao patterns are full of personality and unique style,

often based on natural elements such as landscape, flowers and plants, animals and plants, etc., and also incorporate various abstract geometric shapes and symbols. These patterns are widely used in contemporary design, not only giving the work a unique artistic atmosphere, but also conveying the Miao people's unique understanding of nature, life and beauty.

The application of Miao patterns in modern design is not limited to traditional arts and crafts, but has gradually spread to many fields such as architecture, home, clothing, accessories, advertising design and so on. Hmong pattern is a kind of fabric whose texture is combined with wood structure. Both materials are taken from nature, giving people a sense of simplicity and romance. Through the overall visual and tactile sensation of interior decoration, people can evoke different emotional reactions and aesthetic interests physiologically and psychologically, giving people different forms of beauty.3] In home decor, Miao patterns can be applied to all kinds of furniture, curtains, carpets, etc., adding a strong atmosphere of Miao art to the space.

In modern design, the designer should respect the objective form, give full freedom to subjective initiative, dare to break the routine, break through the inertia of thinking, use innovative thinking, use creative design thinking, use deformation, destruction, reconstruction and other design methods to clarify and rework the characteristics of national patterns. Symbolic processing of design in line with modern design aesthetics, enhancing its symbolic communication function, improving the artistic aesthetics and design meaning of cultural creative products, and enhancing the visual effect.[4] The design of the "Miao Mother Butterfly" refrigerator sticker released by Guizhou Provincial Museum is very unique. The design of this refrigerator sticker is based on the Miao butterfly pattern, rearranging the mother butterfly pattern and flower pattern, and the centripetal round shape gives people a simple and vivid visual aesthetic. (Appendix 1, Fig.4)

Conclusion

As a unique form of design, Hmong art demonstrates the deep cultural undertones and artistic talent of the Miao people. In Miao art, we can see their unique observation and understanding of nature and life, as well as their worship of the universe, religion, and mysterious power. As a unique form of design, Miao art reflects not only the aesthetic ideas and life attitudes of the Hmong people, but also their thoughts on the meaning of life and the structure of the universe.

Miao art is unique in its form. The unique aesthetic concepts and artistic talents of the Miao people have given it a unique way of artistic expression. In the design of Miao art, we can see a rich variety of patterns, motifs and carvings, and these design elements have been inherited and updated by the Miao people to form a unique artistic style. At the same time, Miao art pays attention to the unity of material and spirit, creates a harmonious and balanced visual effect through the combination of form and meaning, giving people the enjoyment of beauty.

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Application

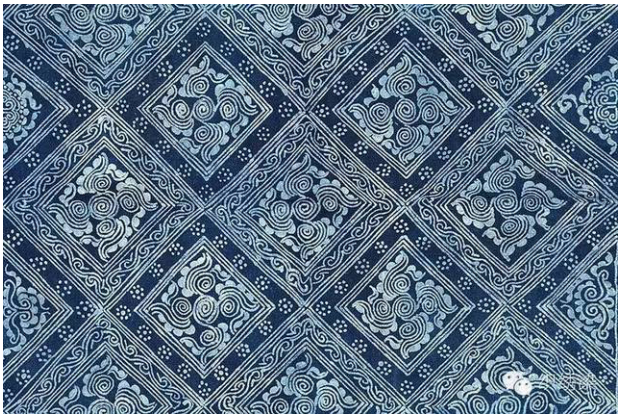

Figure 1. *Geometric pattern*

Figure 2. *Animal print*

Figure 3. *Botanical pattern*

Figure 4. *Miao Pattern Fridge Stickers*

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基于中国非物质文化遗产泥塑元素的品牌设计传播有效性探究
INVESTIGATING THE COMMUNICATION EFFECTIVENESS OF BRAND DESIGN BASED ON ELEMENTS OF CLAY SCULPTURES OF CHINESE INTANGIBLE CULTURAL HERITAGE

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引言。泥塑是我国非物质文化遗产的重要组成部分，历史悠久、形式多样，蕴含着丰富的地域文化和传统审美价值。然而，现代工业化、城镇化的快速发展，导致泥塑等传统工艺缺乏创新，市场需求下降。将泥塑艺术与现代品牌传播相结合，不仅是保护文化的新方式，也是传播传统文化价值观的重要途径。随着消费市场的现代化和对文化的信任度不断提高，品牌传播已经超越了商业，成为传递文化价值观、塑造民族认同的一种手段。将泥塑元素融入品牌设计中，不仅可以提升品牌的个性和吸引力，还可以赋予品牌深厚的文化内涵，实现非传统文化的创新传承与传播。

关键词：非物质文化遗产、泥塑、品牌传播、文化复兴、视觉传播、品牌价值、设计创新。

Introduction. *Clay sculpture is an important part of China's intangible cultural heritage, with a long history and diverse forms, containing rich regional culture and traditional aesthetic value. However, the rapid development of modern industrialization and urbanization has led to the lack of innovation and declining market demand for traditional crafts such as clay sculpture. Combining the art of clay sculpture with modern brand communication is not only a new way to protect culture, but also an important way to disseminate traditional cultural values. With the modernization of the consumer market and the growing trust in culture, brand communication has gone beyond business and has become a means of conveying cultural values and shaping national identity. By integrating clay sculpture elements into brand design, it can not only enhance its individuality and attractiveness, but also give it a deep cultural connotation, and realize the innovative inheritance and dissemination of non-traditional culture.*

Keywords: *Intangible cultural heritage, clay sculpture, brand communication, cultural renaissance, visual communication, brand value, design innovation.*

1. Theoretical foundations and state of research

1.1 Theoretical intersection of intangible heritage preservation and brand communication

The interdisciplinary study of the protection of intangible cultural heritage (ICH) and brand communications is based on the concept of "living inheritance" of ICH. The protection of intangible cultural heritage involves not only preserving its form, but also giving it new vitality in modern society through innovative development and creative transformation. [1]. Brand communication is an effective means of cultural transmission, which allows, through systematic visual communication and market management, to transform intangible cultural heritage from "museum culture" to "everyday culture". Theories of cultural semiotics and communication provide the basic foundation for branding intangible cultural heritage: symbolization, visualization and scene creation based on ICH elements make it more relevant to the perception and aesthetic preferences of modern consumers.

1.2 Review of research on the integration of cultural elements into brands

Chinese scholars have mainly focused on studies that integrate cultural and creative industries with heritage protection. For example, they have studied the application of traditional artistic elements such as Dunhuang murals and blue and white porcelain to contemporary brands, and have also explored cultural innovations in terms of aesthetic symbols and market value. Internationally, there is a strong focus on combining minority cultures, crafts and brand design, such as the use of Indian textile crafts in fashion brands and the expression of Scandinavian folk culture in product design. Although the researchers' points of view differ, they all agree that the combination of symbolic extraction of non-heritage culture and contemporary design language is an important way to disseminate non-heritage [2].

2. Methods of using non-heritage clay sculptures in brand communication

2.1 Visual symbolization of the visual language of clay sculpture

Clay sculpture has distinctive figurative characteristics, and its simple and intuitive modeling language is easy to identify and has a strong ability to convey emotions. In brand design, typical clay sculpture modeling elements such as exaggerated character proportions, unique lines and textures, anthropomorphic animal images, etc. can be used to create visual symbolic design. These symbols contain deep cultural connotations and historical significance and can be skillfully used in logos, packaging, icons and other brand elements that evoke an emotional response in consumers and make the brand image more memorable from a cultural perspective. [3].

2.2Matching color, shape and brand identification system.

Color is the most important element of visual identification of any object, as it has a strong emotional impact on the addressee. [4]. The colors of the clay

sculptures usually have a strong folkloric atmosphere, and the use of paints is straightforward and enthusiastic: rich colors such as red, yellow, blue and green are often found. The brand design can integrate the visual characteristics of clay sculpture colors using modern color mixing technology, on the basis of preserving the original color, to give the brand a more modern visual identity system. For example, integrating the traditional colors of clay sculpture with the main colors of the brand creates a design solution that not only inherits the culture, but also meets modern aesthetics.

2.3Interactive design and new media communications.

The development of digital technologies has provided more opportunities for innovative use of clay sculpture elements in brand communication. For example, with the help of 3D modeling and virtual reality (VR) technology, clay sculpture elements can be digitized, allowing users to create interactive scenes or characters online. In addition, new forms of media communication such as short videos and live broadcasts also make it possible to create clay sculptures. Brands can combine clay sculpture images to create dynamic advertising content and even develop digital IP images for cross-border co-branding and social media communication to attract the attention of younger consumer groups.

3. Analysis of similar projects

3.1 Examples of successful branding using non-heritage elements

Taking Dunhuang culture as an example, it can be seen that the patterns, colors and shapes of Dunhuang murals have been widely used in cultural and creative products, clothing design and brand marketing. For example, the "Dunhuang Flying Sky" has been used as the main visual element in co-branded cosmetic packaging and fashion clothing, quickly attracting the attention of young consumers. Such examples show that non-heritage cultural symbols have great market potential in brand communication, and the key to success lies in exploring traditional cultural connotations and modernizing design expressions.

3.2 Analysis of the advantages and disadvantages of clay elements in modern design communication.

Advantage:

Deep cultural memory: Clay figurines have vivid shapes and simple outlines that are easily remembered by consumers.

Emotional connection: Clay sculptures carry strong folkloric emotions that can evoke a sense of cultural identity in users.

Plasticity: clay modelling elements can be integrated with different design languages and applied to different communication media.

Flaws:

Limited recognition: Compared with non-story forms such as Dunhuang murals and ceramics, the cultural recognition and market acceptance of clay sculpture is limited.

Design Complexity: Clay sculpture has a strong sense of three-dimensionality and the characteristic of handcrafted work, so it is a challenge to realize it in a flat form according to the brand design requirements.

4. Conclusion

As a representative of non-heritage culture, clay sculpture has great brand communication potential. Through the symbolic extraction of the molding language, the modernization of color translation, and the application of digital technology, clay sculpture can be deeply integrated into brand design, giving the brand a distinctive cultural connotation and unique artistic expression. At the same time, clay figurines can not only be used as cultural materials for brand design, but also become an important medium to promote the dissemination of non-heritage culture through the exploitation of IP.

In the future, with the promotion of cultural revival and scientific and technological development, the integration of non-heritage and design will represent the following trends: first, the digital drive will make the application of non-heritage more extensive, from virtual reality to artificial intelligence to create content, and traditional arts such as clay sculpture will be revived in the digital realm; second, cross-border co-branding will promote the cooperation between non-heritage elements and more commercial brands and fields, from fashion to entertainment, to further expand the scope of non-heritage. Finally, user co-creation will attract consumers to deeply participate in the development and dissemination of non-heritage products through interactive design and DIY products, enhancing the sense of cultural participation and involvement. As a link between traditional culture and modern design, non-heritage clay sculpture not only brings new inspiration to brand communication, but also opens up new paths for the inheritance and development of non-heritage. The combination of cultural elements of clay sculpture with design innovation will become an important direction for promoting cultural revival and brand development.

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中国非遗泥塑数字设计转化与品牌视觉形象创新
DIGITAL DESIGN TRANSLATION AND VISUAL BRAND IDENTITY INNOVATION FOR CHINESE NON-HERITAGE CLAY SCULPTURES

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引言：泥塑作为传统工艺，具有丰富的文化价值与历史意义，面对传承与保存的问题，数字技术成为关键因素，通过3D扫描建模将泥塑转化为虚拟数据，实现时空传播。此外，数字技术为泥塑艺术的设计创新带来机遇，特别是在将非物质文化遗产与品牌设计相结合，促进泥塑艺术与现代市场需求互动，创造出融合传统文化魅力与现代审美的品牌产品。因此，数字化不仅是泥塑保存的有效手段，也是推动其文化传承与品牌化发展的重要工具，让泥塑在全球文化产业中获得新的活力和市场价值。

关键词：泥塑数字化、企业形象、视觉符号学、数字文化价值观、3D建模。

Introduction. *As a traditional craft, clay sculpture has rich cultural value and historical significance. In the face of problems related to inheritance and preservation, digital technology has become a key factor, turning clay figurines into virtual data through 3D scanning and modeling to achieve dissemination in time and space. In addition, digital technology brings opportunities for design innovation in the art of clay sculpture, especially in combining intangible cultural heritage and brand design, facilitating the interaction between clay sculpture art and modern market demand, and creating brand products that integrate the charm of traditional culture and modern aesthetics. Therefore, digitalization is not only an effective means of preserving clay figurines, but also an important tool for promoting their cultural heritage and branding development, allowing clay figurines to gain new vitality and market value in the global cultural industry.*

Keywords: *Digitization of clay sculptures, corporate identity, visual semiotics, digital cultural values, 3D modeling.*

1. Techniques and methods of digital transformation

1.1 3D modelling and material extraction techniques from non-heritage clay sculptures

With the development of digital technologies, more and more areas are becoming closely related to 3D modeling [2]. With high-precision 3D scanning equipment, the shape, texture, and color of clay works can be fully captured. Common 3D scanning equipment includes laser scanners, structured light scanners, and photogrammetric systems. After scanning is completed, the scan data can be processed and optimized using professional 3D modeling software (such as ZBrush, Blender, etc.) to create high-quality 3D models.

Material extraction technology, on the other hand, is designed to restore the real texture of clay sculptures. Using high-resolution photography and spectral analysis technology, it is possible to extract information about the materials on the surface of the clay sculpture, such as color, gloss, and texture. This information can be used in the material mapping of 3D models to make the digitized works more realistic.

1.2 Using AR/VR for Communication in Non-Heritage Design

With the development of science and technology, augmented reality (AR) and virtual reality (VR) technologies have been gradually applied to various fields such as healthcare, education, equipment manufacturing research and development, and smart city urban planning [4]. With the help of AR technology, clay sculpture works can be presented in a virtual form in a real environment, and consumers can interact with these virtual works using mobile phones or AR glasses to enhance the enjoyment and sense of participation in the process. For example, an AR application can be developed in which users can scan a certain QR code or image using a mobile phone to see 3D models of clay works in a real environment and interact with them.

Virtual reality (VR) technology, on the other hand, creates a completely virtual environment where users can immerse themselves in the production process and cultural background of clay products using VR headsets. This immersive experience not only increases consumer awareness but also stimulates their interest and passion for non-heritage culture.

2. Visual translation and branding of non-heritage clay sculpture symbols

2.1 Disassembling and reconstructing visual symbols in clay sculpture

People receive information in the form of symbols and at the same time express their understanding of things in the form of symbols [2]. Clay sculptures contain many visual symbols that not only have aesthetic value but also carry deep cultural meaning. By deconstructing and analyzing the visual symbols of clay works, it is possible to extract their basic visual elements, such as shapes, lines, colors, and textures. These elements can be used as inspiration for design and applied to the brand's visual identity system.

Based on the dismantling, designers can combine these visual elements through reconstruction to form a new design language. The reconstruction process must be combined with the core values of the brand and the needs of the target market so that the design is innovative and practical. For example, the visual symbols of a clay sculpture can be transformed into a clear and concise brand logo or graphic element through abstraction, simplification or exaggeration.

2.2 Digital design and brand logo development

Assuming that the market is divided, intelligent self-positioning and a distinctive logo can create an intuitive inclination in buyers [3]. The development of digital technologies provides new opportunities for pattern creation. Using algorithmic generation technology, it is possible to quickly create a large number of clay-style tattoos. These patterns can be used in brand logo designs to give them a unique visual identity. For example, a set of generation algorithms based on clay patterns can be developed to automatically generate patterns that meet the requirements of the core concept and visual style of the brand.

The brand logo is the core element of the brand's visual identity system, and by combining the visual symbols of clay sculpture with the core concept of the brand, a brand logo with cultural connotations and modernity can be created. For example, traditional clay sculpture elements can be combined with modern design techniques to create a brand logo that simultaneously has traditional cultural heritage and meets modern aesthetic needs.

3. Case studies

3.1 Examples of brands using digital technologies

Example 1: Cultural Creativity in the Forbidden City

The Forbidden City's cultural creations are one of the successful examples of combining non-elite culture with modern design. With the help of digital technology, the Forbidden City carries out 3D modeling and material extraction of the works in the collection to create high-precision digital models. These digital models are not only used for online exhibitions, but also applied to the design of cultural and creative products. For example, the Forbidden City has launched a series of cultural and creative products "Forbidden City" that combines the visual symbols of cultural relics with modern design, and has also developed a series of stationery and accessories with cultural connotations, which are very popular with consumers.

Example 2: The clay sculpture brand "Zhang Mud Man" is not a heritage item.

"Mudman Zhang", a famous Chinese clay sculpture brand, has launched a series of innovative cultural products by merging traditional clay craftsmanship and modern design through digital technology. The brand uses 3D scanning and modeling technology to digitalize traditional clay sculptures and combines these digital

models with modern product designs to create a series of clay art derivatives for the modern market, such as decorative items, home furniture, and toys.

In addition, Mudman Zhang enhances consumer immersion with AR technology. Consumers can scan the clay products with their smartphones to see the 3D effect and get to know the production process and cultural background of the clay sculptures, which enhances the brand's appeal and improves cultural communication. This combination of digitalization and innovative design not only gives the brand a unique competitiveness in the market, but also helps revive the traditional craft of clay sculpture in the modern world.

3.2 A comparative study of digital applications in different brands

A comparative study of the cases of "Forbidden City Cultural Creations" and "Mud Man Zhang" can draw conclusions about the different strategies and effects of digital technology application. Forbidden City Cultural Creations focuses on the combination of traditional art and modern design, paying more attention to the transmission of cultural value and artistic display, and its digital application mainly reflects in high-precision 3D modeling and virtual exhibition, emphasizing the protection and dissemination of cultural heritage. On the other hand, Mud Man Zhang focuses more on the commercialization of mud sculpture products, and applies digital technology more to product design and user experience, such as 3D printing and AR interaction, and aims to enhance consumers' purchase motivation and brand identity.

The difference between them reflects the different requirements of different brands for the digital application of clay figurines: one emphasizes academic value and the dissemination of cultural heritage, while the other emphasizes the combination of market demand and innovative design. This serves as a reference for other brands in the process of digital design translation and branding of clay figurines.

4. Conclusion

Digital design translation and innovative visual brand identity for non-heritage clay sculptures open up new opportunities for the inheritance and development of clay sculpture art. Through digital means such as 3D modeling and AR/VR technology, clay sculptures can be effectively preserved and disseminated, and innovative opportunities for brand design can be created. The visual symbols of clay sculptures can be transformed into brand elements with cultural value and commercial appeal after disassembly and reconstruction, which not only promotes the dissemination of non-heritage culture, but also enhances the market competitiveness of the brand. Digital design and translation of clay figurines is not only an important initiative for the protection of non-heritage, but also an important path to the integration of Chinese traditional culture and modern brand design. Through the combination of innovative design and digital technology, the art of clay sculpture will gain new life and contribute to the development of the global cultural industry.

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传统皮影戏基础上的现代装置
MODERN INSTALLATIONS ON THE BASIS OF TRADITIONAL SHADOW THEATRE

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摘要：皮影戏，一项源自中国的非物质文化遗产，历经千年，承载着深厚的民族情感和历史文化底蕴。21世纪，伴随着全球化和技术创新的浪潮，装置艺术作为先锋艺术流派应运而生，其独特的视觉表现力和互动性为皮影戏的创新提供了广阔的天地。装置艺术的“场所”、“材质”、“情感”三要素构建出了一个全新的体验场景，使皮影戏在现代语境中焕发新生，成为连接过去与未来的桥梁。

关键词：皮影戏，文化遗产，装置艺术，创新。

Abstract. *Shadow puppetry, an intangible cultural heritage originated from China, has endured for thousands of years and carries deep national emotions and historical and cultural deposits. In the 21st century, along with the wave of globalisation and technological innovation, installation art has emerged as a pioneering art genre, whose unique visual expressiveness and interactive nature have provided a wide world for the innovation of shadow art. The three elements of installation art, namely 'place', 'material' and 'emotion', construct a brand new experience scene, which enables shadow art to be revitalised in the modern context, and become a bridge between the past and the future. It is a bridge between the past and the future.*

Keywords: *Shadow puppetry, cultural heritage, installation art, innovation.*

Shadow puppetry, as an important part of China's long-lasting cultural heritage, has carried a rich historical memory and national cultural identity for thousands of years. Its unique artistic charm is not only embodied in those exquisite shadow puppets, but also lies in the profound social and humanistic feelings behind them and the celebration of traditional values. Entering the 21st century, along with the pace of globalisation and the rapid development of science and technology, installation art, as a new art genre, is showing up in front of the world in an unprecedented manner. With its unique visual expressiveness and interactivity, installation art has provided fertile soil for the modernisation and transforma-

tion of shadow theatre, giving it a new lease of life in the field of contemporary art, and making it a bridge between the past and the future.

Installation art is a perfect fusion of 'place', 'material' and 'emotion', giving people an immersive emotional experience of modern technology and traditional art. The combination of installation art and shadow art greatly enhances the expressive effect of shadow art. From the point of view of the development of the two arts and culture, their combination is a cross-fertilisation of the two major art fields, and this artificial combination of art will enrich the content and form of art, enhance the emotional experience of the audience, and bring people a pleasant spiritual enjoyment. In the process of combining installation art and shadow art, it brings the audience into shadow art and accelerates the dissemination of shadow art, on the contrary, for installation art, it can also absorb the cultural connotation and national style of shadow art in the process of combining and realise the development of installation art itself. This paper mainly discusses the inheritance and development of installation art to shadow art, and discusses that the use of shadow installation will strengthen the scientific nature of shadow art.

The infinite extensibility of installation art makes shadow theatre to glow under the new carrier. Artists use modern materials and techniques, such as digital media, mechanical movement, sound and light effects, to make bold innovations in the traditional narrative of shadow. The art of light and shadow has been pushed to an unprecedented level. For example, by replacing the animal skin with laser-engraved transparent material, not only the original shadow effect of the shadow is preserved, but also the transparency and colour gradient characteristics are added, which greatly increases the sense of hierarchy and dynamics of the image. At the same time, the application of multimedia interactive technology makes the audience no longer passive viewers, but a part of the creative process, they can change the state of the installation through touch, sound and even body movement, and establish an emotional link with it, so as to realise the deep-level cultural communication.

In installation art, shadow theatre elements are widely and diversely applied, involving visual expression, interactive experience, cultural integration and other levels. The following methods can be used:

- Laser engraving and transparent materials: using laser cutting technology to engrave shadow patterns on transparent or semi-transparent materials (e.g. acrylic, glass), which not only maintains the fine texture of the shadow, but also integrates the design concepts of modern art to create works with strong contrast and three-dimensional sense.
- Dynamic Light and Shadow: Drawing on the light and shadow effects of shadow puppetry and combining it with modern lighting technology to create multi-level light and shadow projection, such as the use of LED

lights, projectors, etc., to simulate the changes of natural light and increase the artistic expression and dynamic beauty of the installation.

- Touch Response: Setting up sensors to allow the audience to directly affect the state of the installation through touch, gesture or even voice operation, such as changing the light intensity and image position, so that the audience becomes part of the work and enhances the sense of participation.
- Virtual Reality/Augmented Reality (VR/AR): Using VR/AR technology, the shadow art is placed into a virtual environment, and the audience can wear special glasses to interact with the shadow in three-dimensional space and experience a new immersive viewing.
- Modular design: The shadow is disassembled into multiple small units that can be freely assembled, allowing the audience to reorganise the shadow patterns according to their personal preferences, creating an infinite variety of shapes and reflecting personalised aesthetics.
- Public Space Installation: Large-scale shadow art installations are set up in parks, squares and other high-traffic areas, encouraging spontaneous participation by the public and promoting community cohesion and social interaction through joint creation and sharing.
- Environmentally friendly materials: Recyclable or biodegradable materials will be used to create the shadow installations, reflecting the concept of green design and advocating environmental awareness.

The shadow elements in the installation art do not only stay in superficial reproduction, but more importantly, they evoke a deep sense of traditional culture. Through the creative transformation of traditional scripts, music and costumes, the artist visualises abstract concepts so that the audience can intuitively feel the rhythm and emotions of shadow puppetry. At the same time, the traditional symbolic meaning of shadow puppetry is expanded and deepened through dialogue with modern urban life. For example, combining shadow puppets with the cityscape to tell stories about change, memory and belonging shows the humanistic concern that remains unchanged in the passage of time.

The integration of shadow puppetry elements in installation art has promoted the dialogue between Eastern and Western art. Many international artists have begun to experiment with combining shadow puppets with cultural symbols from outside China, creating new works with both local characteristics and global perspectives. These cross-border works not only show the beauty of cultural diversity, but also break down geographical boundaries and enhance understanding and respect among different cultures. For example, the fusion of shadow puppets with Japanese ukiyo-e and Indian mandala art has given birth to a series of amazing visual wonders that have broadened the boundaries of artistic expression.

Installation art, as a modern art form, sublimates traditional art forms with its artistic ideas, expression forms and performance effects. The combination of

shadow culture and modern installation art aims to give full play to the positive influence of the modern and scientific forms of expression of installation art on traditional shadow culture, so that the audience can experience the spiritual significance of shadow art from different perspectives and positions of cultural values, and feel the cultural impact of the combination of modern scientific and technological elements and traditional shadow.

The rebirth of shadow theatre in the field of installation art is not accidental, but the result of the joint action of cultural confidence and artistic pursuit. It not only allows the ancient shadow art to find a new stage, but also promotes the deep integration of traditional culture and modern expression, showing the vitality of the Chinese national culture with the times. In the future, more artists are expected to explore and innovate, so that shadow art and installation art can move forward hand in hand and shine more brilliantly on the global art stage.

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现代服装中的中国青铜文化
CHINESE BRONZE CULTURE IN MODERN GARMENTS

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摘要：随着人们对传统文化的日益关注和审美诉求的不断提升，青铜元素在现代服饰中的运用前景越来越广阔，不仅推动了服装产业的创新发展，也为传统文化的传承与弘扬提供了新的平台和契机。青铜元素作为中华传统文化的重要组成部分，在现代服饰中的运用有助于传承和弘扬传统文化。同时，通过与现代时尚元素和创新设计的结合，现代服饰中的青铜元素获得了新的活力和魅力。青铜在现代服饰中的运用是设计的创意和文化潜台词，通过深入渗透青铜文化的意义和价值，将其与现代审美理念相结合，创造出具有独特魅力的服饰作品，促进文化展览与特色产业的跨界融合。

关键词：服装创新、文化传承、传统文化。

Abstract. *With people's increasing attention to traditional culture and the ever-increasing aesthetic demands, the application of bronze elements in modern clothing is becoming more and more promising. It not only promotes the innovation and development of the clothing industry, but also provides a new platform and opportunity for the inheritance and promotion of traditional culture. As an important part of Chinese traditional culture, the application of bronze elements in modern clothing helps to inherit and promote traditional culture. At the same time, through the combination of modern fashion elements and innovative design, bronze elements in modern clothing gain new vitality and charm. The application of bronze in modern clothing is the creative and cultural subtext of design. By deeply penetrating the meaning and value of bronze culture and combining it with modern aesthetic concepts, we can create clothing works with unique charm and promote the cross-border integration of cultural exhibitions and special industries.*

Keywords: *clothing innovations, cultural heritage, traditional culture.*

Bronze, as an art form born in the early human civilization, exudes its unique charm in the current of modern art. Bronze art flourishes with the vitality of art in the fusion of ancient and modern, the clash of old and new. The fusion of bronze and clothing design is different from the traditional bronze archeology, showing

its unique beauty in the style of modern clothing design, paying more attention to its realistic application value and reference. Early bronze still retains the shadow of ceramics, the overall style is simple and dignified, simple and naive, rich in the charm of original art, giving a feeling that it is bright and generous, simple and sincere. Bronze products in the heyday of the period, artistic achievements have reached their peak, this period, strong political color, religious meaning is most clearly manifested, the overall shape is sacred, dignified.

Later bronze products gradually disappear mysterious colors, simple life forms become the main direction, the shape is constantly changing, the lines are smoother, showing a soft and economical beauty.

The application of bronze art in clothing design includes historical application in traditional clothing and modern application in clothing design. Traditional clothing uses bronze ornamentation as the main application method, and it is mainly concentrated in the pre-Qin period. The reference and application of bronze art in modern clothing design exists in both completely retro films and television works and bold creative clothing designs of designers, many clothing designs also have the shadow of bronze art. These applications are rich in both the rich atmosphere of bronze art and the strong sense of fashion that combines ancient and modern with East and West, bronze art and clothing art.

The application of bronze patterns in modern clothing-the use of bronze elements in traditional Chinese clothing is mainly the application of its geometric patterns, which are most concentrated and widely used in clothing in the Shang and Zhou Dynasties. The clothing form in the Shangzhou period is mainly linear, with a small number of provincial roads, the structure is relatively simple, the geometric pattern decoration has become its main decorative element, mainly decorated with the edge of clothing. The images are mainly double-sided continuous patterns, consisting of cloud lightning or echo, pursuing orderly beauty, like the composition of bronze patterns, some decorative patterns use geometric patterns combined with the composition of exotic birds and animals, also mainly decorated on the edge of clothing.

The Application of Bronze Elements in Modern Clothing--Along with the revival of traditional Chinese culture, Chinese elements appear in various forms in modern clothing design, showing a new style of colorful Chinese clothing. Bronze element, as a typical Chinese element, is supported by many designers and creates a large number of clothing design works with bronze charm. These works include various forms of high fashion, popular clothing, performing clothing, etc. Because of the differences in their uses and design methods, their references to bronze art show their own characteristics and laws. 1. The Application of Bronze Elements in Creative Clothing--The creative clothing mentioned here mainly refers to the design attempts of professional clothing designers to explore innovative clothing

styles. This attempt can be purely academic experimental innovation or creative design combined with the promotion of commercial brands. Creative clothing design has distinctive personality traits and clear thematic intentions. Rich design language, unique form of expression, rich use of materials, special production process, emphasis on structural design, symbolic language is obvious, in the design concept influenced by post-modern design trends and other characteristics. 2. The use of bronze elements in clothing - and the most characteristic feature of ready-made clothing is its adaptation to mass production and compliance with consumer requirements common to a certain category of mass consumption groups. reading

The above characteristics, the design of such costumes has special commercial and technological requirements, the use of bronze elements in clothing is relatively implicit. 3. The application of bronze elements in actor's clothing - The rich style of the era and the artistic characteristics of bronze art meet the requirements of artistic techniques such as historical reproduction and exaggeration pursued by performance clothing, which is a general term for all costumes intended for artistic performance, including both stage clothing and film and television clothing. In addition, according to the creative ideas and expressive means of performance, the style of performance clothing is generally generalized: realistic clothing, informal clothing, visualized clothing with programmatic premises.

Artistic theatrical clothing is clothing designed using a realistic creative method and often used in realistic

Dramas and film and television costumes. For example, in the film "Confucius" the repertoire is mainly in which the style of clothing.

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小剂量辐射暴露对公众健康的风险评估
ASSESSMENT OF THE RISK TO PUBLIC HEALTH OF RADIATION EXPOSURE IN SMALL DOSES

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注释。本文简要概述了地球上主要的人造放射性污染源，这些污染源由于生物圈的放射性污染而造成了紧张的环境局势。目前，放射性污染的规模是全球性的。特别重要的是研究核爆炸因放射性核素污染领土以及小剂量辐射对人口的慢性影响而造成的长期后果。有必要进行研究，以研究食物链中放射性物质含量的模式以及在人体长期暴露于低剂量辐射的情况下人群健康状况的变化。

关键词：辐射、核爆炸、军事试验、事故、长期暴露于辐射、低剂量辐射、健康风险。

Annotation. *The article provides a brief overview of the main man-made sources of radioactive contamination on Earth, creating a tense environmental situation as a result of radioactive contamination of the biosphere. Currently, the scale of radioactive contamination is global. Of particular relevance is the study of the long-term consequences of nuclear explosions caused by contamination of the territory with radionuclides and as a result of the chronic effects of radiation*

in small doses on the population. There is a need to conduct research to study the patterns of the content of radioactive substances in the food chain and changes in the health status of the population in conditions of chronic exposure to low doses of radiation on the human body.

Keywords: *radiation, nuclear explosion, military tests, accidents, chronic exposure to radiation, low doses of radiation, health risk.*

Currently, the environmental situation in the world is tense due to radioactive contamination of the Earth's biosphere, excess of natural levels of radioactive substances in the environment, formed as a result of nuclear tests, man-made accidents, disasters, as well as underground nuclear explosions for economic purposes.

The world's first nuclear bomb was detonated by the Americans on July 16, 1945, in the Alamogordo Desert in New Mexico.

The United States dropped two atomic bombs on Japan towards the end of World War II: one called "Little Boy" on Hiroshima on August 6, 1945; the other called "Fat Man" on Nagasaki on August 9. Together, the two bombs killed about 220,000 Japanese citizens immediately, and more than 200,000 subsequently died from a fatal radiation overdose. On August 29, 1949, the USSR acquired nuclear weapons - a 22-kiloton bomb exploded at the Semipalatinsk test site. The atomic bomb exploded 700 meters above the ground. The radioactive cloud was carried by the wind to the Novosibirsk region, where the products of nuclear fission fell with precipitation and exceeded the natural radiation background by 4 thousand times.

In 1952, the British tested their atomic weapons, in 1960 - the French, in 1964 - the Chinese, followed by India and Pakistan.

The explosions continued for more than fifty years, until September 24, 1996, when the Comprehensive Nuclear-Test-Ban Treaty was signed, a total of more than 2,000 nuclear tests were conducted worldwide. During this time, countries possessing nuclear weapons detonated 2,059 charges: on the ground and underground, in water (at a depth of up to 600 m) and in the air. About 500 explosions occurred in the atmosphere. The largest number of tests was carried out by the USA (1,032), slightly fewer explosions were carried out by the military of the USSR and Russia (715), and France (210), Great Britain, China (45), and one more test was carried out in 1974 by India.

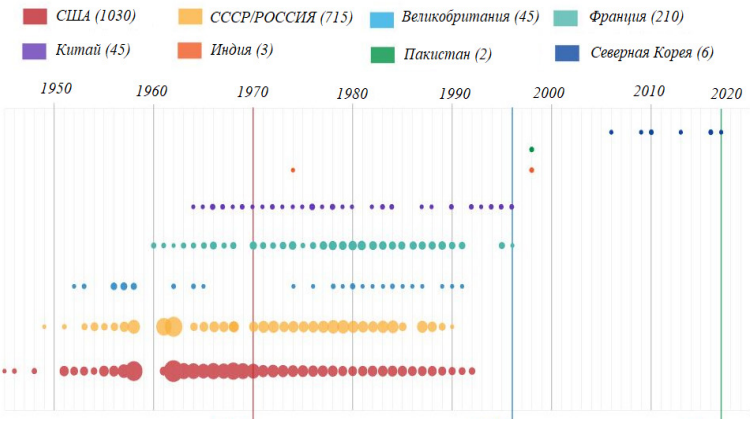

Figure 1. *Chronology and geography of nuclear weapons use in the world*

Nuclear accidents at nuclear power plants and other nuclear fuel cycle facilities began to occur from the moment nuclear energy was put into practice, that is, since 1945. In total, in 14 countries of the world, from 1945 to 1987, more than 150 incidents occurred at facilities that used nuclear energy or processed radioactive waste, of which 27 are classified as serious accidents.

The four cases in the USSR, Great Britain and the USA are considered the most dangerous for the environment, as a result of which large areas around the facilities where the accidents occurred were contaminated with a huge amount of radionuclides, which caused significant damage to the environment and public health.

On September 29, 1957, a liquid radioactive waste storage facility exploded at a weapons-grade plutonium plant near the city of Kyshtym in the Southern Urals. According to the International Nuclear Event Scale, this accident is classified as level 6 out of seven possible. The accident occurred at the Mayak chemical plant in the closed city of Chelyabinsk-40. The radioactive contamination zone included 217 settlements in three regions - Chelyabinsk, Sverdlovsk and Tyumen with a population of 270,000 people.

In the history of the most dangerous nuclear accidents, the Chelyabinsk accident is second only to the Chernobyl disaster in terms of its scale and consequences.

In addition, peaceful underground nuclear explosions were carried out in many countries for the purpose of “developing the national economy”, as a result of which a colossal amount of radionuclides were released into the environment.

In Russia, from 1949 to 1990, 715 nuclear explosions of various types were carried out, which led to radioactive contamination of the environment in many regions of Russia.

After accidents at a number of nuclear industry facilities, tests of atomic bombs, fairly large groups of the population are forced to live in regions where the radiation background is elevated as a result of radioactive contamination of the area.

In this regard, Russia ranks among the first among all regions on five continents [11].

The Chernobyl Nuclear Power Plant (CNPP) accident that occurred on April 26, 1986, undoubtedly caused long-term environmental problems over vast territories. As a result of the accident, territories of nineteen administrative regions of Russia were contaminated with radionuclides. Soil contamination caused by the accident, with a density of 1 Ci/sq. km and higher, covers more than 57.5 thousand sq. km, which is 1.6% of the area of the European part of Russia [11].

In September 1954, a ground-level nuclear explosion occurred in the Totsky District of the Orenburg Region during military tests. As a result of the fallout of nuclear explosion products on the earth's surface, the territory of the Totsky District was radioactively contaminated. Also, 13 underground nuclear explosions were carried out in the interests of the national economy on the territory of the region and in the immediate vicinity of its borders. Radionuclides entering natural ecosystems as a result of man-made accidents with global fallout or emergency emissions and discharges are distributed unevenly within them, which results in a wide range of dose loads within contaminated areas, and therefore a variety of biological effects.

Figure 2. *Totsk nuclear explosion on September 14, 1954*

Dose loads on the population are formed due to small, but practically constant amounts of radionuclides entering the human body with water and food. Over time, the scale of radioactive contamination becomes global in nature as a result of soil weathering and dispersion of nuclear fission products on the earth's surface. Therefore, there is a need to conduct research on the study of radioactive substances in soil, water, and plant products.

Currently, the study of the remote effects of nuclear explosions caused by contamination of the territory with radionuclides and, as a consequence, chronic exposure to radiation in small doses on the population is becoming especially relevant.

The problem of biological effects of small doses of ionizing radiation is currently one of the central and very important for medical and environmental monitoring and risk assessment of radiation exposure.

According to the non-threshold concept of the radiation effect, recognizing the probability (risk) of disease in a person irradiated in any small dose. The concept of the non-threshold effect of ionizing radiation has been adopted by the world radiobiological community on the recommendation of the International Commission on Radiological Protection and the UN Scientific Committee on the Effects of Atomic Radiation.

Diseases caused by ionizing radiation may manifest themselves many years after exposure, in subsequent generations, including in small doses. Low-dose irradiation can contribute to the development of leukemia, cancer of all types, decreased fertility, chromosomal aberrations, physical and mental developmental defects, weakened resistance to infections, increased cardiovascular diseases, and premature aging.

Currently, a group of scientists led by Natalia Nikolaevna Rakhimova, PhD in Engineering, Associate Professor, and Corresponding Member of International Academy of Sciences of Ecology, Human Safety and Nature (MANEB), is conducting a study to assess the risk of low-dose radiation exposure to the population of the Orenburg Region. The assessment includes a study of the environmental situation in the area of nuclear explosions in the region, as well as a change in the background radiation level. To assess the degree of radioactive contamination, soil, plants of natural and agrosystems are used [4,5,6]. The migration of radionuclides in soil-plant complexes of the steppe zone is studied. The content of radionuclides in the food chains of the local population of the Totsky district of the Orenburg region is studied.

It is worth noting that 70 years have passed since the nuclear tests at the Totsky test site and the radiation load on the human body should be reduced due to physical processes, the level of oncological and endocrine diseases in local residents who have lived in areas exposed to low doses of radiation for a long period of time continues to grow. To study the patterns of accumulation of radionuclides and

morbidity of the population, a correlation analysis of the content of radionuclides in the hair of the population and an analysis of the health status of the population is carried out, based on the accounting and analysis of morbidity, mortality, life expectancy, and the functional state of the contingent belonging to the risk group [7,8]. The study of the remote consequences of nuclear explosions, as a result of chronic exposure to radiation in small doses on the population, will allow us to identify the characteristics and patterns of changes in the health status of the population under conditions of chronic exposure to small doses of radiation on the human body.

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植物源场化感作用的时空动态

TEMPORAL AND SPATIAL DYNAMICS OF ALLELOPATHIC EFFECTS OF PHYTOGENIC FIELDS

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摘要。确定了模拟休闲负荷在 1.39–8.33 人/公顷范围内对化感作用的影响程度，负荷时间为 0 至 60 分钟。研究发现，在树冠下空间的植物源场中，化感作用潜力恢复到控制值的速率与休闲负荷的大小成反比关系。

关键词：湿润亚热带，植物源场，休闲负荷。

Abstract. *The degree of influence on the allelopathic regime of simulated recreational loads in the range of 1.39–8.33 people/ha with a load time from 0 to 60 minutes was determined. It was found that in the phytogenic field of the undercrown space, the rate of restoration of the allelopathic potential to control values has an inverse relationship with the magnitude of the recreational load.*

Keywords: *humid subtropics, phytogenic field, recreational load.*

In forest ecosystems, the main allelopathic interaction is closely related to the phytogenic field [1]. The influence of the altered biochemical environment [2], in particular, the change in allelopathic activity [3] in transformed under the influence of uncontrolled recreational activity is beyond doubt, however, studies of phytogenic fields in time dynamics confirming these changes have not been conducted.

Recreational forests in the humid subtropics of Russia are characterized by a richness of relict and endemic species [4] and, therefore, require detailed and comprehensive study. One of the possible approaches in this direction is the assessment of the regulation of recreational loads.

The aim of this study was to assess the temporal and spatial dynamics of allelopathic effects of phytogenic fields under standardized recreational loads.

Materials and methods of research

The studies were conducted at stationary sites of southwestern exposure in the basins of 11 rivers (Shepsi, Shakhe, Kiet, Uch-Dere, Psakhe, Eastern and Western Dagomys, Sochi, Khosta, Bolshaya Khosta, Mzymta), in the formations:

Fagus orientalis Lipsky, Castanea sativa Mill., Carpinus betulus L., Quercus petraea (Matt.) Liebl, Quercus pubescens Willd., Buxus colchica Pojark. Phytogenic fields of model trees were assessed in biogeocenotic single-species parcels of tree edificators, with a canopy density of 0.8–0.9.

Imitation of recreational loads (trampling) was carried out according to the recommendations developed by the All-Russian Research Institute of Forestry and Forestry Mechanization, using the "step load modeling" method [5], with a time step of 5 days (table). In each variant, 3 transects were laid out in a fan shape from the tree base in the southern direction to the border of the crown projection, divided into 7 conditional equal sections – accounting plots (AP) No. 1–7, – with the addition of 1 conditional section behind the crown projection (AP No. 8). Soil samples were taken ($\bar{x}$, days): 3, 120, 180.

Table.

Parameters of imitation of recreational loads

Option	Load time (min)	Recreational load		
		man*min/m ^{2}	man*hour/ha	man*hour/ha – season (man/ha)
Control	0	–	–	–
1	10	10	1 666,7	1,39
2	20	20	3 333,3	2,78
3	30	30	5 000,0	4,17
4	45	45	7 500,0	6,25
5	60	60	10 000,0	8,33

Soil samples (cores) were taken with a cylindrical cut-in drill in the upper soil horizon (0-10 cm) on the sampling sites (3-fold replication) using the envelope method (5-fold replication), followed by an assessment of the bulk density of the soil using standard methods and allelopathic activity.

The assessment of the allelopathic activity of the soil, according to the recommendations of A.M. Grodzinsky [6], was carried out on the seeds of common radish (*Raphanus sativus var. radicula Pers.*), at an analytical concentration of 1:50. The index of relative allelopathic effect (IRAE) was determined based on the germination rate [7]: $I_{RAE} = (Io - Ic)/Ic$, where I_O – are the germinated seeds in the experiment; I_C – the germinated seeds in the control.

The results obtained. The values shown in Fig. 1–3 profiles of phytogenic fields of tree species on the third day after the simulated recreational load reflect the general tendency of control conditions in the decrease of allelopathic activity with distance from the butt to the outer zone of the phytogenic field, recording an increase in activity at the butt and in the crown projection zone, i.e. in the zone of enhanced root formation.

Large values of inhibition caused by recreational impact in individual zones of the field and UP correspond to conditions of high soil trophism [8], the power of the enzymatic horizon, humidity, water permeability and thermal regime of the soil.

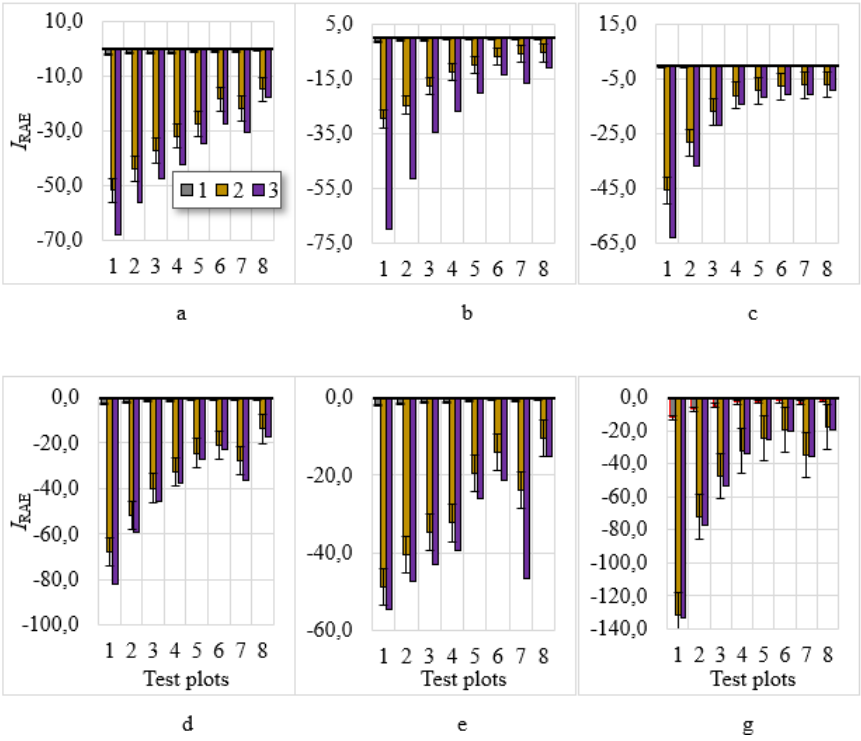

Figure 1. *Allelopathic regime of the rhizosphere on the 3rd day after recreational load in communities: A – Castanea sativa, B – Quercus pubescens, C – Quercus petraea, G – Buxus colchica, D – Fagus orientalis, E – Carpinus caucasica,*

Most ecosystems within the phytogenic field are characterized by a close feedback with the transformed bulk soil mass ($r = -0.926 – -0.994$, at $p \geq 0.95$). Exceptions are represented by ecosystems with the participation of F. orientalis and C. caucasica ($r = -0.868 – -0.894$, at $p \geq 0.95$; UP No. 1, 2, 4–7). In the latter case, satisfactory indicator characteristics are explained by the rapid physical destruction of dry foliage due to the species-specific ability of fallen leaves to curl when drying, forming a loose litter layer. Significant correlation values for F. orientalis ($r = -0.996 – -0.999$, at $p \geq 0.99$; UP No. 1–4, 6) are explained by the weak development of the ground cover and litter.

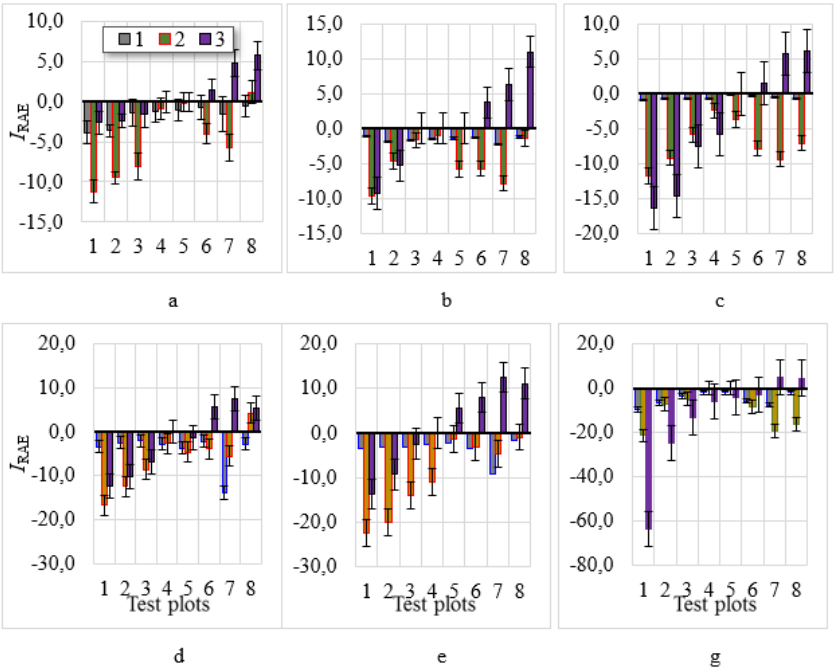

Figure 2. *Allelopathic regime of the rhizosphere on the 120th day after recreational load in communities: A - Castanea sativa, B - Quercus pubescens, C - Quercus petraea, G - Buxus colchica, D - Fagus orientalis, E - Carpinus caucasica,*

The influence of recreational compaction of the rhizosphere zone on the differentiation of the phytogenic field profile, with a simulated load of 1.39 people / ha, varying in the range of 23.3-26.9% ($\bar{x}$= 23.8%), is statistically rejected in C. sativa communities (Ffact = 2.36; Ftable 0.05 = 2.60, Ftable 0.01 = 3.78) and remains completely unproven for Q. petraea (Ffact = 2.41; Ftable 0.05 = 1.94, Ftable 0.01 = 2.51), F. orientalis (Fact = 2.27), Q. pubescens (Fact = 2.06), i.e. the effect on F. orientalis and Q. pubescens is reliable only with a probability of p = 0.95, which is generally consistent with the previously obtained results for chronic recreational impact [8].

With a simulated recreational load of 2.78 people/ha, the impact of the recreational factor becomes statistically significant for phytogenic fields of all ecosystems with monodominant forest stand in the influence range of 21.0–24.6% (p = 0.99), maintaining the average value ($\bar{x}$= 22.8%).

Recreational load of 4.17 people/ha is accompanied by a reliable increase in the influence of the allelopathic factor in all woody edificators (27.4–38.0%) with a high level of significance (p = 0.99).

On the 120th day after load modeling (see Fig. 2), at 1.39 people/ha, the inhibitory properties are preserved in all ecosystems and in the entire range of phytogenic fields (UP No. 1–8).

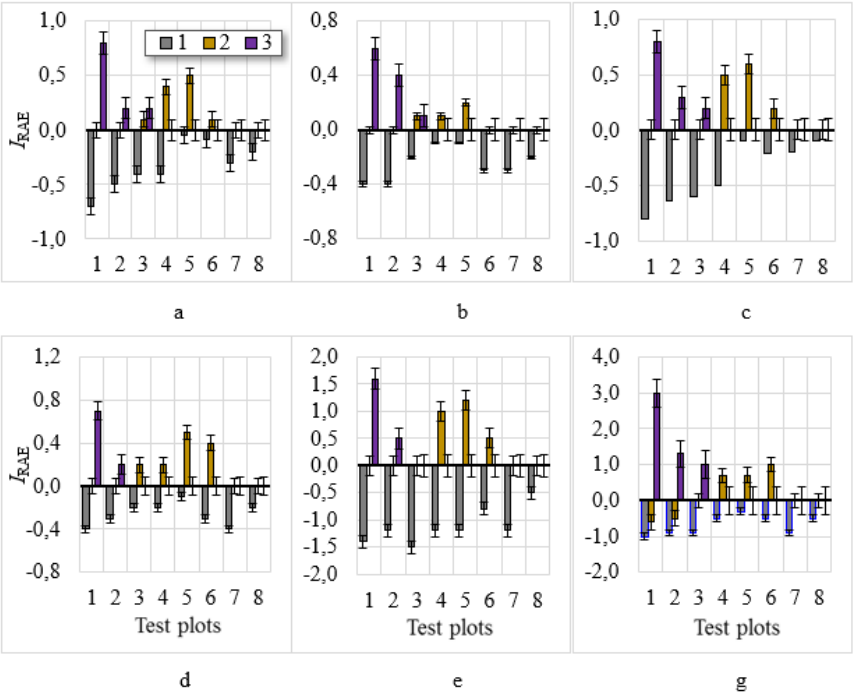

Figure 3. *Allelopathic regime of the rhizosphere on the 180th day after recreational load in communities: A – Castanea sativa, B – Quercus pubescens, C – Quercus petraea, G – Buxus colchica, D – Fagus orientalis, E – Carpinus caucasica*

With a load of 2.78 people/ha, greater inhibitory properties are recorded in the butt zone and crown projection (UP No. 1–3, 6, 7) – the differences are reliable at t = 2.88; p = 0.99. The stimulating properties of colins were noted only in the crown projection zone (UP No. 7; the difference is reliable at t = 3.73; p = 0.999) and in the outer zone (UP No. 8; reliable at t = 2.46; p = 0.98) in C. sativa and B. colchica. At a recreational load of 4.17 people/ha, the stimulating properties on UP No.

6–8 increase with high reliability as they approach the crown projection (reliable at t = 1.94–2.11; p = 0.95–0.97) and the outer zone (reliable at t = 2.81; p = 0.99), and the allelopathic regime is restored to control values on UP No. 4, 5 (reliable at t = 2.77; p = 0.01), i.e. only UP No. 1–4 are stable. On the 180th day (see Fig. 3) after a simulated load of 1.39 people/ha, weak inhibition is maintained over the entire range of the phytogenic field. After a load of 2.78 people/ha, stimulating properties appear on UP No. 3–6 (reliable at t = 2.85; p = 0.99). With a greater recreational impact (4.17 people/ha), stimulating effects are preserved only on UP No. 1–3 (reliable at t = 2.54; p = 0.98).

Thus, in the phytogenic field of the undercrown space, the rate of restoration of the allelopathic potential to control values has an inverse relationship with the magnitude of the recreational load, which is possibly explained by increased enzyme activation with increasing hypoxia in compacted soil.

A load of 1.39 people/ha increases protective properties up to and including the 180th day, ensuring the stability of phytogenic fields to recreational digression.

A load of 2.78 people/ha protects the space in the phytogenic field from a possible change in the composition, structure and functioning of the cenosis only for 120 days.

After a load of 4.17 people/ha, only the zone from the butt to the middle of the crown remains protected in the undercrown space on the 120th day.

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神经网络算法在牙科实践中的应用
APPLICATION OF A NEURAL NETWORK ALGORITHM IN DENTAL PRACTICE

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注释。本文探讨了人工智能（AI）技术在牙科实践中的现状和发展。该综述致力于分析现有的研究和出版物，确定AI在牙科疾病诊断、治疗和预后中的关键应用。主要关注神经网络及其在图像分析中的应用，包括X射线图像、计算机断层扫描和颌骨的3D模型。强调了使用AI诊断龋齿、识别牙齿、可视化病理过程、评估牙齿和骨骼结构的形态以及预测治疗的重要性。本文介绍了作者自己的研究结果，以及对卷积神经网络（CNN）、人工神经网络（ANN）等各种技术的有效性的分析，并讨论了深度学习领域的成就。研究结果证实，使用AI可以显着提高诊断准确性，促进治疗计划和改善临床决策，以及优化牙科实践中的工作流程。

该研究是作为开发神经网络分析方法和预测发生咬合关系违规风险的科学工作的一部分进行的，该方法是在 2024 年 4 月 12 日俄罗斯科学基金会第 24-25-20098 号拨款和 2024 年 5 月 31 日第 10 号区域预算（伏尔加格勒地区）补贴协议的实施框架内进行的。

关键词：神经网络算法、牙科、人工智能、风险预测、专家系统。

Annotation. *The article examines the current state and development of artificial intelligence (AI) technologies in practical dentistry. The review is devoted to the analysis of existing research and publications, identifying key applications of AI in the diagnosis, treatment and prognosis of dental diseases. The main focus is on neural networks and their use for image analysis, including X-ray images, computed tomography and 3D models of jaws. The importance of using AI for the diagnosis of caries, identification of teeth, visualization of pathological processes, assessment of the morphology of teeth and bone structures, as well as predicting*

treatment is emphasized. The article presents the results of the authors' own research, as well as an analysis of the effectiveness of various technologies such as convolutional neural networks (CNN), artificial neural networks (ANN), and discusses achievements in the field of deep learning. The findings confirm that the use of AI can significantly improve diagnostic accuracy, facilitate treatment planning and improve clinical decisions, as well as optimize workflows in dental practice.

The study was conducted as part of the scientific work on the development of a methodology for neural network analysis and forecasting the risk of developing violations of occlusive relationships within the framework of the implementation of the Russian Science Foundation grant dated 12.04.2024 No. 24-25-20098 and the Agreement on the provision from the regional budget (Volgograd region) subsidies dated 31.05.2024 No. 10.

Keywords: *neural network algorithm, dentistry, artificial intelligence, risk forecasting, expert system.*

Relevance: Throughout the development of mankind, an integral part of the overall development of civilization is the model of learning based on past experience. Today, this principle of knowledge organization is one of the most effective methods of preserving, transferring, learning and generating new knowledge from generation to generation. This allows you not only to preserve the experience and knowledge of the past, but also to acquire new knowledge.

Not a single living being on planet earth from the entire species diversity of the planet has come close to human capabilities in analyzing, structuring and multitasking the performance of various actions by a single representative of the species.

Since ancient times, people have been trying to learn the secret of the human brain and recreate its unique data storage and analysis capabilities. The first attempts began to bring positive results with the advent of computer technology. Already in 1956, John McCarthy [1] introduced the term artificial intelligence (AI) or "artificial intelligence" (AI) to the world for the first time [1-2]. He became the goal of many scientific minds, over the embodiment of which scientists around the world began to steadily modernize scientific knowledge and put it into practice. Already in 1978, Richard Bellman defined AI as the activity of computer programs similar to human thinking abilities [3].

A revolutionary change with the advent of AI was the change in the way computers work. As you know, a computer processes data strictly in sequential order. Thus, the system can simultaneously solve only one problem of minimal dimension. It's like simply reading the text in a sentence one character at a time. A simple computer program is a set of instructions written in a programming language

that perform certain operations. The program works with data according to the logic set by the programmer. In this format, it is extremely difficult for data processing to analyze or compare data of a heterogeneous structure.

The advent of AI has fundamentally changed the approach to data analysis, it allowed us to simulate the behavior of the program as a biological structure of the human brain, in which information is simultaneously read from the entire field of perception. AI is a mathematical model consisting of many artificial neurons combined into layers. A neural network processes data by passing it through layers, where each neuron performs operations with input data simultaneously. Weights and connections between neurons are adjusted during the learning process. Such data processing is very similar to human vision, when the perception of an entire object occurs. This allows you to analyze the structures in the entire picture at one time (lines, objects, structures, colors, shapes, etc.) and structure them (Figure 1).

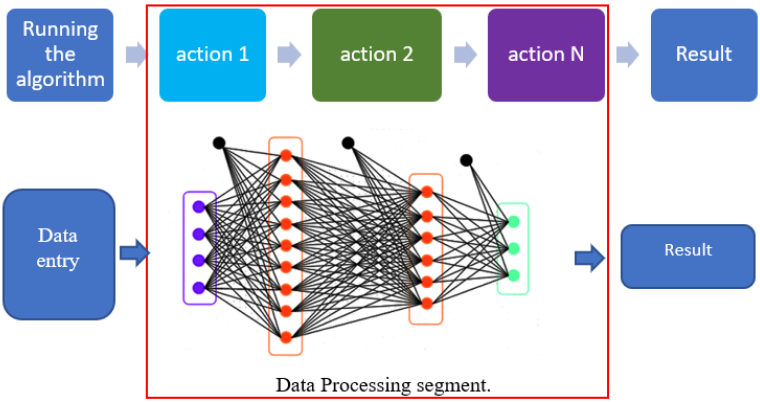

Figure 1. *Schematic diagram of the operation of sequential program code and neural network algorithm.*

Currently, artificial intelligence refers to any computer program or technology capable of simulating the cognitive skills of the human brain.

AI itself has no value without a trained behavior model based on big data, which makes it identical to the human brain – working on the basis of learned experience from past iterations of work or training [4]. As mentioned above, weights and connections between neurons are adjusted in the process of deep learning. The retrospective method is most often used, it is based on the principle of learning with a teacher. First, the data of a single instance of data is loaded into an existing neural network of any degree of training and the solution of the task is performed in the way that the algorithm is able to do at the moment, and after that the result

of AI care is analyzed with the training data of the sample (correct initial values) using the teacher algorithm. If the result of the AI operation differs from the data of the training sample, the degree of error in the data of the weighting coefficients of the neural network is calculated, their correction is based on new experience and the modified structure is preserved (Figure 2).

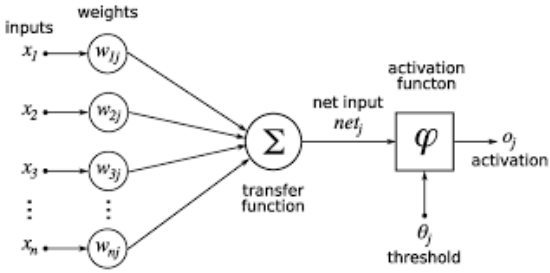

Figure 2. *The structure of a neuron in AI and the principle of its organization in the system.*

This is all: parallel work with data, nonlinear analysis, work based on experience gained and self-learning in the process makes AI as similar as possible to the human brain, which brings it closer to the possibilities of diagnosing and typing atypical structures and algorithms. Such models have important diagnostic value in solving medical problems of diagnosis, systematization and structuring of medical knowledge and clinical data of patients [5].

For quite a long time, many authors have argued that dentistry is gaining an increasing number of digital solutions and is increasingly dependent on mathematical and computer solutions [6-8]. Due to the breakthrough development of artificial intelligence technology in the last few years, we were interested in the issue of its development in the dental industry.

The aim of the study — to assess the current state and development of artificial intelligence technology in practical dentistry to improve the quality of diagnosis, patient treatment and clinical decision-making, forecasting.

Materials and methods: The scientific review article presents an analysis of current literature data. The review was conducted in modern search databases: Pubmed, Medline, Cochrane, Google Academic, Scopus, Web of Science, e-library, etc. In search queries, in conjunction with the term “dentistry”, terms such as: deep learning, artificial intelligence, machine learning, neural networks, computer diagnostics were used.

The selection of scientific papers was carried out sequentially and in stages, taking into account the results of each study. For inclusion in our research, publications of any design, unique in structure, were accepted, which presented the results of AI’s own research in any field of dentistry (Figure 3).

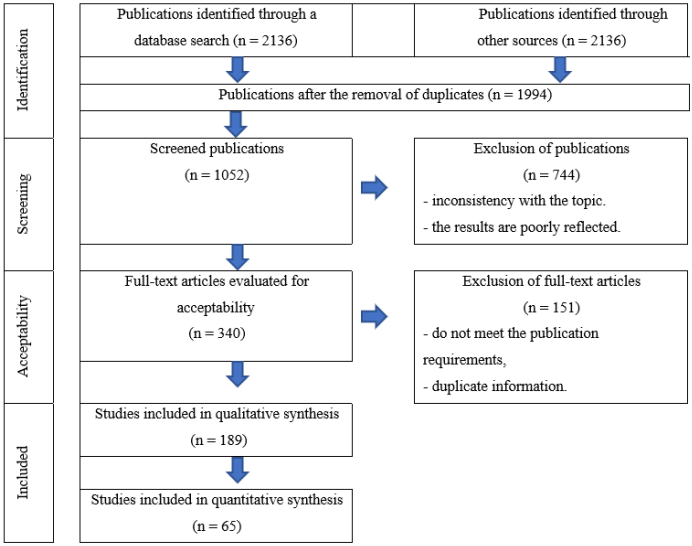

Figure 3. *Study design.*

Results. The study analyzed 2,036 literature sources. Of these, 65 full-text studies on the topic of interest were selected. Most of the data showed that research in this area has been conducted for about 15 years. An analysis of the number of publications by year shows the increasing interest of researchers in this field in both foreign and domestic literature (Figure 4).

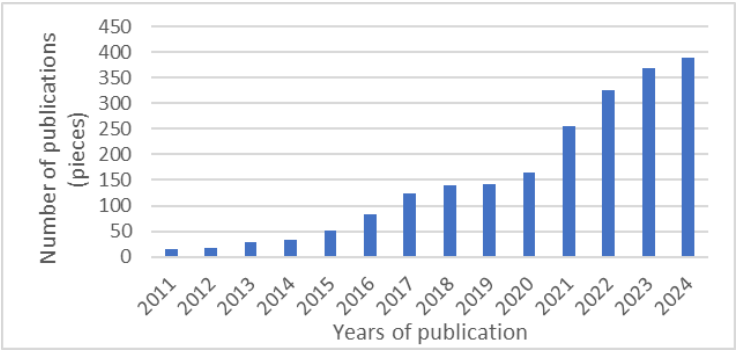

Figure 4. *The number of publications related to the research topic.*

An analysis of the literature data showed that artificial intelligence is most often used in the following cases:

• diagnosis and detection of dental caries in 32% of cases,

• identification of teeth on various medical data in 21% of cases (computed tomography (CT), orthopantomography (OPTG), 3D models of jaws),

• visualization or detection of periapical foci in 12% of cases,

• detection of a violation of the tooth structure in 10% of cases (longitudinal, vertical fracture),

• assessment of the morphology of the tooth structure in 9% of cases,

• diagnosis of bone structures in normal and pathological 9% of cases,

• prognosis of treatment in 4% of cases

• and other types of pathologies 3%.

According to the literature, it has been revealed that the following technologies are most often used in neural networks: artificial neural networks (ANNs), convolutional neural networks (CNNs), bayesian network (BN), probabilistic neural networks (PNNS). Each of them has shown its effectiveness in certain areas and research. Most often, this is an analysis of 2D or 3D images.

The analysis of the studies in this review showed that at the moment, research related to neural networks in dentistry in the direction of comparative analysis and object detection prevails. Most often, they try to visualize dental caries, bone structures on OPTG or CT, as well as to detect foci of pathological formations.

Discussions: Zhang K and co-authors [9] published a study that reports on the successful experience of using a convolutional neural network using a label tree to analyze the structure of tissues on an X-ray image and localization of teeth. The authors' research has shown high accuracy of work, reaching 95%. In a similar study, Tuzoff DV and co-authors [10] identified teeth and numbered them using a Faster R-CNN neural network. In the study, the neural network demonstrated high accuracy, reaching values of 0.9997, with an accuracy of 0.9998 from experts.

The above tells us that modern computer algorithms based on neural networks can identify teeth on X-ray images at the expert level.

The increasing complexity of the image search and analysis process has allowed a number of authors to analyze more complex structures and formations. Casalegno F [11] with co-authors, as well as Schwendicke F with co-authors [12] demonstrated the possibility of artificial intelligence to analyze and identify the carious process of various groups of teeth using near-infrared transillumination imaging (TI). Similar results were achieved in the Lee JH study [13], in which X-ray data was fed to the input of the neural network.

In the course of our own research, our team of authors was able to develop an expert system based on a trained neural network algorithm. Of particular practical interest is the prediction of patients belonging to the risk group for the de-

velopment of occlusive imbalance in connection with the implementation of a preventive approach and improving the quality of rehabilitation potential [14]. The results of the study confirm the possibility of using neural network models for the diagnosis of dental diseases and the risk of their occurrence, as well as in the formation of recommendations for additional examination methods in dentistry for diagnosis and preparation of a patient's treatment plan [15].

Conclusion. The study highlights the significant potential of artificial intelligence (AI) technologies in modern dentistry to improve the accuracy of diagnosis, treatment planning, clinical decision-making and prognosis. The growing interest in artificial intelligence applications, as evidenced by the growing number of relevant publications over the past 15 years, underscores its importance in the dental field.

The analysis of the selected studies showed that artificial intelligence is most often used for: Diagnosis and detection of dental caries, identification of teeth using various medical imaging methods such as computed tomography, ophthalmoscopy and 3D models of jaws, visualization or detection of periapical lesions, identification of structural anomalies of teeth, assessment of tooth morphology, diagnosis of bone structures in normal and in pathology, predicting treatment.

The results of this study highlight the transformative role that artificial intelligence can play in dentistry. Further development and integration of artificial intelligence technologies are likely to lead to improved clinical outcomes, optimized workflows and improved quality of patient care in dental practice.

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具有预测咬合关系违规风险的专家系统的开发和应用经验

EXPERIENCE IN THE DEVELOPMENT AND APPLICATION OF AN EXPERT SYSTEM FOR PREDICTING THE RISK OF VIOLATIONS OF OCCLUSIVE RELATIONSHIPS

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注释。本文介绍了开发和应用基于人工神经网络的专家系统来预测咬合关系违规风险的经验。这项研究的意义在于咬合障碍的患病率很高，需要个性化的方法来诊断和治疗。

该系统基于机器学习方法，分析患者数据并为牙医提供准确的预测和建议。一项涉及 150 名患者的随机对照试验证实了该模型的有效性，证明了风险分类的准确性，每项研究的准确率均超过 93%。

结果证实了将此类技术引入临床实践以提高诊断准确性、优化治疗过程和预防并发症的可行性。

该研究是作为开发神经网络分析方法和预测发生咬合关系违规风险的科学工作的一部分进行的，该方法是在 2024 年 4 月 12 日俄罗斯科学基金会第 24-25-20098 号拨款和 2024 年 5 月 31 日第 10 号区域预算（伏尔加格勒地区）补贴协议的实施框架内进行的。

关键词：牙科、风险预测、专家系统、神经网络算法、机器学习、咬合障碍。

Annotation. *The article presents the experience of developing and applying an expert system based on artificial neural networks to predict the risk of violations of occlusive relationships. The relevance of the study is due to the high prevalence*

of occlusive disorders and the need for an individual approach in their diagnosis and treatment.

The system, based on machine learning methods, analyzes patient data and provides dentists with accurate forecasts and recommendations. A randomized controlled trial involving 150 patients confirmed the effectiveness of the model, demonstrating the accuracy of risk classification with an accuracy of more than 93% for each study.

The results confirm the expediency of introducing such technologies into clinical practice to improve the accuracy of diagnosis, optimize treatment processes and prevent complications.

The study was conducted as part of the scientific work on the development of a methodology for neural network analysis and forecasting the risk of developing violations of occlusive relationships within the framework of the implementation of the Russian Science Foundation grant dated 12.04.2024 No. 24-25-20098 and the Agreement on the provision from the regional budget (Volgograd region) subsidies dated 31.05.2024 No. 10.

Keywords: *dentistry, risk forecasting, expert system, neural network algorithm, machine learning, occlusive disorders.*

Relevance: Diagnosis and treatment of occlusive disharmony remains an important task of modern dentistry [1,2]. According to research, 80% of people over the age of 18 have occlusive disorders, which can be caused by both anatomical and functional features of the body [3-5]. These disorders include pathological conditions of the maxillofacial region, functional disorders of the chewing system and associated pain syndrome [6]. For effective treatment, it is necessary to predict the development of the disease and assess the risks of complications, which requires the use of modern technologies [7,8].

In this regard, a solution based on artificial intelligence was developed: an expert system for predicting the risk of violations of occlusive relationships [9,10]. This system relies on data on the patient's condition, analyzes them using artificial neural networks and provides doctors with forecasts and recommendations for further examination. The main advantage of the approach is the integration of machine learning technologies, which allows taking into account the individual characteristics of the patient and classifying complex relationships [11,12].

The aim of the study to demonstrate the capabilities of the developed expert system for the diagnosis of conflict of laws violations.

Materials and methods: As part of the study, a randomized controlled trial was conducted, which included 150 patients. The work was carried out on the basis of the Department of Dentistry of the Institute of Continuing Medical and Pharmaceutical Education of the Volgograd State Medical University and the Volgograd Regional Clinical Dental Clinic.

To analyze the data, machine learning methods were used, implemented in the Python 3.11 software environment using NVIDIA CUDA to speed up calculations. The neural network algorithm was based on the multilayer perceptron (MLP) architecture.

The patients were divided into two groups:

• The control group (30 people) was used to test the system.

• Training group (120 people) — divided into a training sample (90 patients) and a validation sample (30 patients) in a ratio of 80/20.

The inclusion and exclusion criteria ensured the standardization of the sample, and the dental examination included both traditional diagnostic methods and modern imaging technologies such as cone beam computed tomography and 3D scanning. Additional methods were applied, including electromyography and anthropometry of the maxillofacial region, which allowed us to collect an extensive set of data for training the neural network. The analysis included: predicting the condition, making recommendations for further examination.

Results: The developed expert system successfully classified the risks of violations of occlusal relationships in individuals from the control group in comparison with the data of the clinical examination of patients according to the criteria: determining the accuracy of predicting the risk of developing violations of occlusal relationships, assessing the need for further examination of the patient.

The proportion of correct classification of patients in the training validation and control samples in determining the risk of occlusive imbalance reached 0.933±0.25 and 0.967±0.18 units, respectively, whereas the same indicator for verifying the need for additional examination was 0.967±0.18 in each sample, respectively.

Discussions: The introduction of an expert system into clinical practice can open up new prospects for the diagnosis and treatment of occlusive disorders. The developed system provides individualized forecasts, which can help dentists make informed decisions and adjust treatment plans.

The results obtained confirm the expediency of using such technologies in dentistry.

The use of machine learning methods makes it possible to improve the quality of diagnosis by analyzing complex data, reduces the time for diagnosis and treatment selection, and makes it possible to prevent the development of complications.

Conclusion: The developed expert system based on artificial neural networks has demonstrated high efficiency in predicting the risk of violations of occlusive relationships. Its application in dental practice makes it possible to improve diagnostics, increase the accuracy of forecasts and optimize treatment processes.

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结节病患者外周血细胞毒性T淋巴细胞亚群组成
SUBPOPULATION COMPOSITION OF CYTOTOXIC T LYMPHOCYTES IN PERIPHERAL BLOOD OF SARCOIDOSIS PATIENTS

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摘要。结节病是一种病因不明的多系统疾病。其特点是肉芽肿的形成和 T 细胞连接的激活。结节病发病机制中的主要作用被归因于 Th1 和 Th17 淋巴细胞，但 CD8+ T 淋巴细胞的作用尚未得到充分研究。本研究旨在与 40 名健康供体的对照组相比，对 34 名首次诊断为肺结节病的患者中的细胞毒性 CD8+ T 淋巴细胞亚群进行表征。分析显示，结节病患者血液中的 CD3+ 和 CD4+ T 淋巴细胞水平降低。在 CD8+ T 细胞亚群中，观察到“幼稚”细胞和中央记忆细胞减少，TEMRA 效应细胞增加。研究表明，细胞毒性T淋巴细胞与Th1和Th17辅助细胞一起在结节病的发病机制中发挥了积极作用。关键词：结节病，CD8+T淋巴细胞，T淋巴细胞分化。

Abstract. *Sarcoidosis is a multisystem disease of unknown etiology. Its peculiarity is the formation of granulomas and activation of the T-cell link. The leading role in the pathogenesis of sarcoidosis is assigned to Th1 and Th17 lymphocytes, but the role of CD8+ T-lymphocytes has not been studied enough.*

The aim of the study was to characterize the subpopulations of cytotoxic CD8+ T-lymphocytes in 34 patients with the first diagnosed pulmonary sarcoidosis compared with the control group of 40 healthy donors. The analysis revealed a decrease in the level of CD3+ and CD4+ T-lymphocytes in the blood of patients with sarcoidosis. In the subpopulations of CD8+ T-cells, a decrease in "naive" and central memory cells and an increase in TEMRA effector cells were observed. The study showed that cytotoxic T-lymphocytes, along with Th1 and Th17 helpers, take an active part in the pathogenesis of sarcoidosis. Key words: sarcoidosis, CD8+ T-lymphocytes, T-lymphocyte differentiation.

Introduction.

Sarcoidosis is a systemic disease with an unknown etiology, characterized by the formation of granulomas [1]. The causes of the disease can be infectious agents [2], autoimmune processes [3], external physical and chemical factors [4] affecting the functioning of immune system cells. The main role in the pathogenesis of sarcoidosis is assigned to proinflammatory cytokines Th1 and Th17 [5], while the role of CD8+ T-lymphocytes remains poorly understood.

Purpose of the study.

Characteristics of subpopulations of cytotoxic T-lymphocytes in the blood of patients with sarcoidosis.

Materials and methods.

A total of 34 patients aged 20-65 years with newly diagnosed chronic pulmonary sarcoidosis were examined. All patients were observed at the Research Institute of Interstitial and Orphan Lung Diseases, First Saint Petersburg State Medical University named after Academician I.P. Pavlov, Ministry of Healthcare of the Russian Federation. The control group consisted of 40 healthy donors, comparable in gender and age with the group of patients with sarcoidosis.

To identify the key stages of maturation of CD8+ T cells in peripheral blood, the following set of antibodies manufactured by Beckman Coulter, USA, was used: CD57-FITC, CD56-PE, CD62L-ECD, CD28-PC5.5, CD27-PC7, CD4-APC, CD8-APC-AF700, CD3-APC-AF750, CD45RA-PacBlue and CD45-KromeOrange. To identify "polarized" populations of CD8+ T cells, the "gating tactics" agglomeration was used [6]. The samples were analyzed using a Navios™ flow cytometer (Beckman Coulter, USA), and flow cytometry data were processed using Kaluza™ v.2.0 (Beckman Coulter, USA).

The normality of the distribution was checked using the Pearson chi-square test. The results were expressed as a % of positive cells from the target population and were presented as a median and interquartile range (Med (Q25%; Q75%)). The Mann-Whitney U test was used to compare groups, and the Spearman rank correlation method was used to perform correlation analysis. Statistical processing

was performed using Statistica 8.0 (StatSoft, USA) and GraphPad Prism 4.00 for Windows (GraphPadPrism Software Inc., USA) software.

Results.

When analyzing the main lymphocyte populations, a significant decrease in the level of relative and absolute CD3+ cell counts was noted in patients with chronic sarcoidosis relative to the values of the control group (69.88% (61.83; 75.15) versus 78.29% (73.35; 81.20) and 936 cells/1μL (724; 1185) versus 1273 cells/1μL (11.36; 1570) with $p<0.001$ in both cases). A decrease in the level of T cells is associated with a decrease in the peripheral blood of patients with sarcoidosis of CD4+ T lymphocytes (40.54% (32.47; 47.80) versus 47.63% (44.92; 52.20) and 519 cells/1μL (441; 767) versus 775 cells/1μL (679; 1041) at $p=0.001$ and $p<0.001$, respectively). When studying the main subpopulations of CD8+ lymphocytes, it was found that within the total pool of circulating CD8+ T cells, the relative content of "naive" cells and central memory cells decreases (18.42% (5.44; 28.28) versus 27.94% (16.60; 35.54) and 6.64% (4.00; 9.68) versus 11.04% (7.13; 13.32) at $p=0.011$ and $p=0.001$, respectively), whereas the level of effector cells of the TEMRA population is significantly increased (40.88% (22.34; 46.32) versus 25.89% (15.10; 35.79) at $p=0.009$).

Conclusions.

Analysis of subpopulations of circulating CD8+ T cells at different stages of maturation in patients with pulmonary sarcoidosis showed that the bloodstream contains a decreased level of cells capable of proliferating in lymphoid tissue ("naive", CM, EM1 and pE1), while the level of cells with pronounced effector properties (EM3, TEMRA, Eff) - cytokine production, degranulation and destruction of target cells - is increased, despite the general lymphopenia characteristic of sarcoidosis. Thus, cytotoxic T lymphocytes, along with helpers types 1 and 17, take an active part in the pathogenesis of sarcoidosis.

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使用 Flutter 开发用于 RC 管理的跨平台应用程序的方法
METHODOLOGY FOR DEVELOPING A CROSS-PLATFORM APPLICATION FOR RC MANAGEMENT USING FLUTTER

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摘要。本文介绍了用于开发机器人综合体（RC）控制系统的跨平台 Flutter 技术，包括其架构、Dart 编程语言的特点以及在实现与确保软件在不同操作系统上的可操作性相关的程序功能时出现的困难。以连接到基于 Arduino Mega 板和各种控制工具的控制器的 RC 为例，介绍了开发应用程序的方法。描述了 RC 的结构和开发的程序。以使用串行端口工作的示例分别考虑了用户权限管理问题和实现跨平台功能的特点。

关键词：跨平台应用程序、Flutter、机器人、控制系统。

Abstract. *The article describes the cross-platform Flutter technology used in the development of control systems for robotic complexes (RC), including its architecture, features of the Dart programming language and the difficulties that arise when implementing program functions related to ensuring the operability of software on various operating systems. The methodology for developing an application is presented using the example of a RC connected to a controller based on the Arduino Mega board and various control tools. The structure of the RC and the developed program is described. The issues of user rights management and the features of implementing cross-platform functions are considered separately using the example of working with a serial port.*

Keywords: *Cross-platform application, Flutter, robot, control system.*

Introduction

Currently, many platforms are used in automatic control systems: server, desktop, mobile. As well as a large number of operating systems, such as Windows, Linux, MacOS, Android, IOS with their versions and variations. Recently, the issue of switching to Russian platforms, such as Aurora, Astra Linux, RedOS, etc., has

become increasingly relevant. Some organizations can simultaneously use a whole range of operating systems in their activities, therefore, the control program must work on each of them. Many large developers come to this conclusion, for example, MPS Soft - the creator of MasterSCADA, AdAstra - Trace mode and others. This raises the question of choosing the means of designing a control system.

There are 3 main approaches to development: Creating native applications for each OS; Creating a web application; Creating a cross-platform application.

The main disadvantage of the first approach is the need to develop and support separate programs for each platform, which entails large costs, both financial and time, as well as possible differences in the user interface5e and the implementation of some functions. From this we can conclude that it is preferable to use a cross-platform or web application.

The project decided to use the Flutter framework, since it allows you to simultaneously build not only a cross-platform application, but also a web one. It is worth noting that the issue of cross-platform development is poorly covered in the scientific community. Basically, only mobile or web solutions are described, and the area of control systems is practically not covered.

Analyzing articles [1-3], one can notice that most authors focus on mobile platforms and pay little attention to desktop systems. However, many enterprises are switching to Russian Linux-based OS or have such systems on Windows that require modernization.

Description of the Flutter framework

Flutter is an open cross-platform technology from Google designed to create applications for iOS, Android, Web and desktop operating systems from a single code base. It uses the Dart programming language and provides its own set of widgets for creating an interface. Flutter currently supports: iOS, Android, Web, Windows, Linux, macOS, and recently WebAssembly and “embedded devices”. [4]

1. Architecture: Flutter’s architecture consists of three layers: Framework, Engine and Embedder - their structure and components are shown in Figure 1.

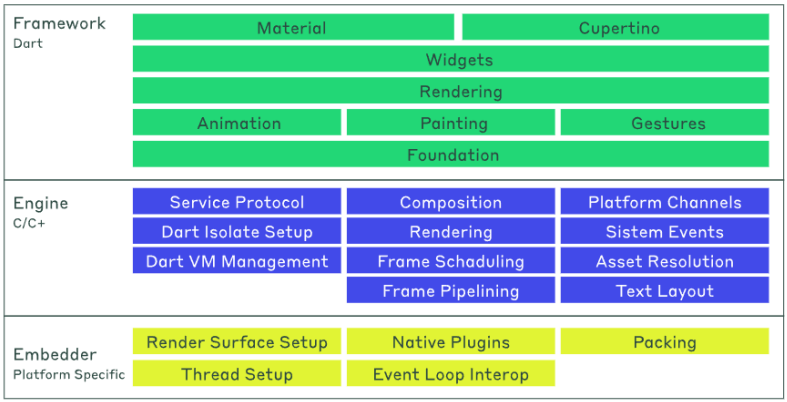


Figure 1. *Flutter Architecture*

In general, the Framework layer, consisting of Dart code, is responsible for the user interface and its interaction with the application, Engine is responsible for the rendering logic and provides a low-level implementation of the main Flutter APIs, and Embedder integrates the Flutter engine into various platforms. [5]

2. Rendering process: Unlike Android and iOS, which use elements specific to each platform, Flutter has its own rendering engine, the Skia Graphics Engine. With its help, the framework draws each UI element (widget) on the canvas provided to any platform.

3. Compilation: Flutter uses the Dart language, which is compiled to native code. This allows you to interact with the platform without a JavaScript bridge (as in some other cross-platform solutions), which provides performance close to native. [4]

CS structure

The application described in this article is part of the control system of a robotic complex, which includes two manipulators MP 11 and a conveyor. The equipment is controlled by a controller specially developed for this RC based on the Arduino Mega 2560 Pro Mini board

Control commands can be given using the radio control panel and the infrared remote control. However, the main means of interaction between the operator and the RC is supposed to be a program that should provide access from any type of device, such as mobile phones and tablets connected via Bluetooth, computers - via USB or via a web browser. To display the state of the manipulators, video from the camera can be transmitted to the program. The structural diagram is shown in Figure 2.

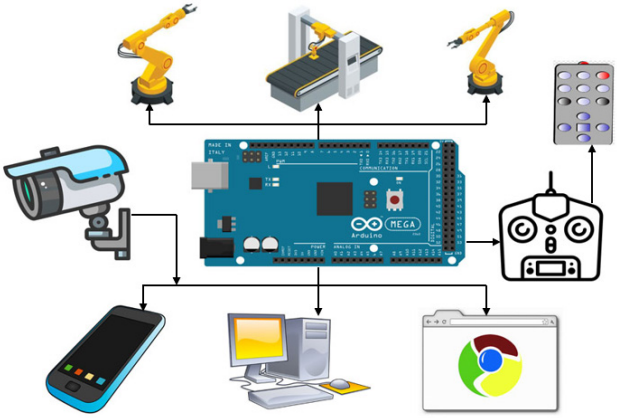


Figure 2. *Structural diagram of the robotic complex*

A specially developed low-level program is written into the controller, which performs: control of the functions of receiving, processing and sending commands, control of connected components (relays, expansion boards, etc.). More details about the creation of the controller and its software component are described in the article [6]

The main features of the program include: automatic and manual control of the RC, local and remote control of the RC, simulation mode and control directly of the RC, control using buttons, text and voice commands, creation of control programs in training mode

User authentication is a mandatory function of any control system. Currently, a whole set of control tools is used to control the RC: IR and radio remote control, programs for PC and Android, web application. Therefore, it is necessary to ensure verification of user rights, while the operator enters a single login and password for any of them. It is also important to exclude the possibility of multiple connections to the RC at the same time in order to avoid joint control attempts that can lead to abnormal situations. Based on this, it was decided to perform authentication directly on the controller, as the final control device for all systems.

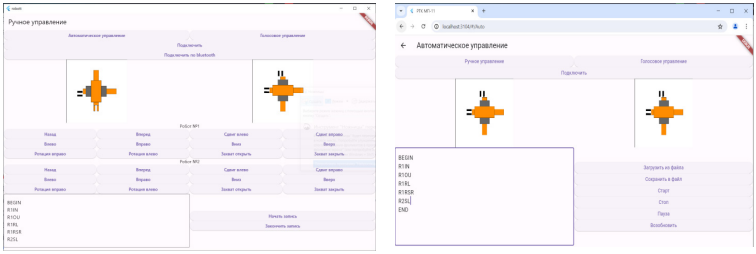
Application Description

As stated above, the developed application works on most modern operating systems and supports three main operating modes: manual control, automatic control, voice control. Each mode has its own screen, which is selected using the buttons at the top of the form.

The application allows you to control both the RC itself and its model in the simulation mode, which is set as the default mode.

All modes support the function of recording the executed commands, used to create control programs. As a result of the recording, a text file is generated and saved in the selected directory.

In manual mode, control (Fig. 5a) of the robots' movement is carried out using the buttons located on the screen. The position of the robots can be tracked both in images and by text commands displayed in the corresponding windows.



a ***b***

Figure 5. *(a) "Manual control" screen on a PC, (b) "Automatic control" screen in a web browser*

Automatic control mode (Fig. 5b) is used to generate and execute control programs. For this purpose, a window is located on the screen, which displays commands, control buttons (Start, Stop, Pause, Resume), loading from a file and saving to a file.

The voice control mode generally corresponds to the manual one, only instead of pressing buttons, you need to pronounce the corresponding command into the microphone, so the buttons on the screen are replaced with text commands.

Features of implementing functions when interacting with the platform

One of the main reasons for choosing Flutter is the ability to create applications that run on multiple platforms with a single code base. In most cases, all the required functionality is implemented using basic user interface elements. However, difficulties arise when it is necessary to ensure interaction with the platform, for example, working with ports, as in the control system under consideration.

There are several main problems with implementing features on different platforms:

1) One device has use cases for features that another does not, which is related to specific hardware, such as the presence or absence of a camera.

2) Another reason is the platform itself. Flutter Mobile and Desktop are installed directly on the device, which means that it has the ability to perform I/O operations, read, write and create local files. On the other hand, Flutter Web will be tied to the HTML document and will have direct access to JavaScript, allowing

you to perform certain operations, such as: navigating to other websites, setting cookies and changing the DOM.

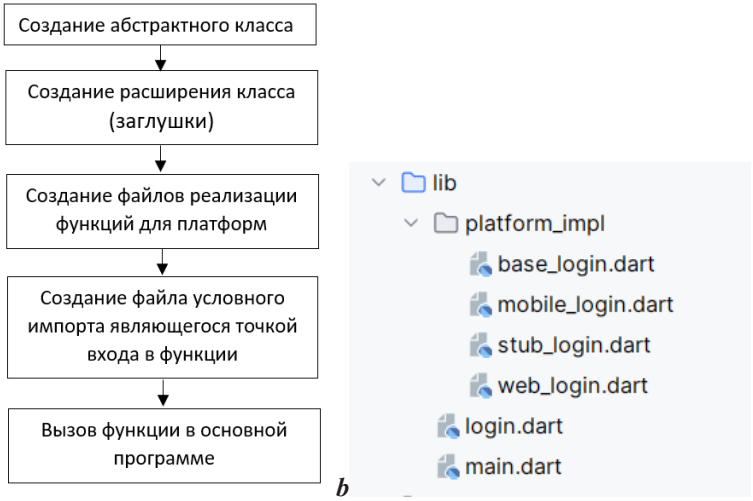
The first problem is solved by checking the hardware and prohibiting the use of features or handling runtime errors. The second requires a more complex solution.

The essence of this problem is that the application relies on different underlying libraries: Flutter for mobile and desktop uses dart:io, and Flutter Web - dart:html. This leads to the fact that when using dart:io and dart:html simultaneously, an error message will be displayed, or an error will occur during compilation.

There are three main methods for solving this problem: Building separate projects for the mobile/desktop platform and for the web.; Conditional import of packages; Creating an intermediate module (stub)

The main disadvantage of the first method is that it partly defeats the purpose of cross-platform development, since the process of fixing errors and maintaining the code becomes more complicated. The disadvantage of the second method is that it only works if the package is used in isolated functions. Therefore, the third approach described below [7] is used in the program. Figure 9a shows the algorithm for using packages.

Let's consider an example of implementing an intermediate module that performs the functions of connecting via USB, polling the port status and sending commands. Two packages are used to implement these functions: serial.dart for the web and flutter_libserialport.dart for other platforms. When creating an intermediate module, we get the following structure of program files (Fig. 9b).



a *b*

Figure 9. *(a) Function call algorithm when using the "Create an intermediate module" method, (b) - Structure of program files (modules)*

The first file that needs to be created is base_login.dart. It contains the code for declaring an abstract class. An abstract class describes the general structure and defines methods that must be implemented by any subclass.[8]

To implement the created class, it is necessary to form an extension (subclass) and associate it with the main class. The implementation is contained in the stub_ login.dart file. It describes all the functions that can be executed when calling the class. Then two files are created: mobile_login.dart and web_login.dart. It is worth noting that the names of the functions in them must be the same and correspond to stub_login.dart. These files also contain a link to an abstract class and packages for working with the port on different platforms flutter_libserialport.dart in mobile_ login.dart and serial.dart in web_login.dart respectively. Further implementation of the functions is written for each platform, taking into account the features of the equipment (a special procedure for connecting and configuring the port, converting data for transmission, etc.).

Now you need to create a file that will perform a conditional import of the created implementations of the functions and provide a single entry point login. dart. In the main file of the program main.dart, the login.dart package is imported, providing an entry point (import 'package:robott/login.dart).

Comparison of programs created during the study

As part of the study, a number of programs were developed for this RC: for Windows using the Visual Basic language, for Android using MIT App Inventor, Web application - ASP.Net, cross-platform MAUI / Xamarin and described in this article - using the Flutter framework. All these software tools represent different approaches to creating a control system, have different functionality and capabilities.

Analyzing the process of creating programs, the following conclusions were made (Table 2)

Table 2

Analysis of development tools

Development environment	Disadvantages	Advantages
Visual Basic	Windows OS oriented	A large number of ready-made solutions for a wide range of tasks, reference literature, libraries; User-friendly interface and high development speed
MIT App Inventor	Android OS only; Inconvenience of generating and reading program code; Little reference information and examples; Limited functionality.	Ease of interface design and program debugging; Placement in the store, from the development environment; Convenience of joint work on the project or access from various devices

ASP.Net	Complexity of implementing some functions since processing is performed on the server, not on the local device; A web server is required for operation	The web application is cross-platform with access through a browser over the network or through a local server
MAUI/ Xamarin	A small number of OS are supported; Difficulties in implementing many functions; Little reference literature and examples	Cross-platform solution
Flutter	Not all functions work on different OS, or require the use of special algorithms; The interface and processing are described in a single file, which makes it difficult to read the code and work with it.	Cross-platform solution; A fairly convenient process for creating an interface; A large number of available libraries and solutions with detailed descriptions and examples

Conclusion

Flutter is currently rarely used in the development of control systems, especially for desktop and server devices, but with such a variety of platforms used, it could be an excellent solution in the field of software development. One of the main advantages of this framework is its very high speed, almost indistinguishable from native ones.

The methods described in the article are an example of the implementation of the approach to creating programs for RC, but they can also be used for other robots and control systems.

The recently introduced ability to run Flutter applications on embedded systems allows you to create equipment control panels with a familiar user interface.

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矿棉节能产品性能与结构研究
STUDY OF PROPERTIES AND STRUCTURE OF MINERAL WOOL ENERGY EFFICIENT PRODUCTS

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摘要。在现代世界中，提高能源效率和降低能源强度对于建筑行业尤其重要，这在很大程度上决定了整个生产的发展。可以通过使用高效的隔热材料和基于它们的产品，特别是矿物纤维产品（基于玻璃或岩棉）来降低能源强度。这些产品的性能受粘合剂的类型和引入方法的显着影响，降低其生产能源强度的方法之一是降低这些产品的热处理温度。

本科学论文中提出的研究目的是分析现有的粘合剂类型和引入方法，旨在降低基于岩棉的产品制造的能源强度。

结果，获得了将固化接触强度与各种因素联系起来的数字模型，并开发了用于解决数字建模正向和逆问题的列线图，并确定了最重要因素的最佳值区间：粘合剂消耗量3.75%;热处理温度为 120-140 oC 时，潜在组分含量在粘结剂质量的 3.6% 至 4.0% 范围内。

关键词：岩棉、合成粘结剂、潜在组分、数值模型、分析优化、

Abstract. *In the modern world, increased energy efficiency and reduction of energy intensity are especially important in the construction industry, which largely determines the development of production as a whole. Reduction of energy intensity can be achieved through the use of efficient thermal insulation materials and products based on them and, in particular, mineral fiber products: based on glass or rock wool. The properties of these products are significantly influenced by the type and method of introduction of binder, and one of the ways to reduce the energy intensity of their production is to reduce the temperature of heat treatment of these products.*

The purpose of the research presented in this scientific paper is to analyze the existing types and methods of introduction of binders, aimed at reducing the energy intensity of the manufacture of products based on stone wool.

As a result, a digital model linking the strength of cured contact with varying factors is obtained and a nomogram for solving the forward and inverse problem of digital modeling is developed, as well as optimal intervals of values of the most significant factors are determined: binder consumption 3.75%; content of latent component in the range from 3.6 to 4.0% of the binder mass at the temperature of heat treatment 120-140 °C.

Keywords: *stone wool, synthetic binder, latent component, numerical model, analytical optimization,*

Introduction

As technological development progresses, environmental and sustainable development issues are becoming increasingly important, and energy efficiency and energy intensity play a key role in various sectors of the economy. In the Russian Federation, measures aimed at increasing energy efficiency and reducing energy intensity in various sectors of the economy are being actively developed and implemented. The application of these measures in construction and the production of building materials is especially important. This is due to the fact that the construction industry is one of the most energy-intensive and at the same time is the locomotive of economic development [1-3].

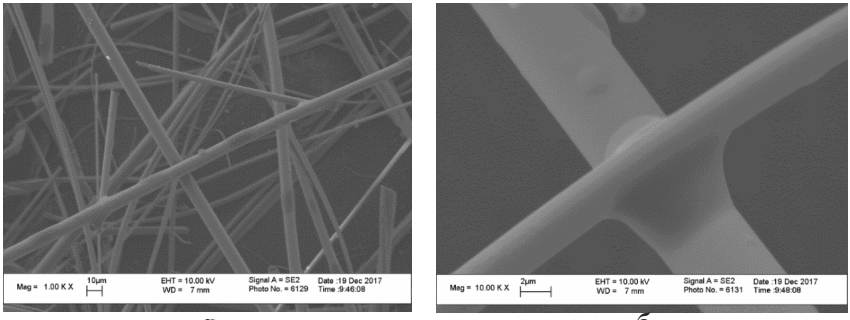
The multi-stage process of producing fibrous thermal insulation materials, including high-temperature melting of mineral components to obtain a mobile melt and its spraying using centrifuges, is completed by mechanical molding of mineral wool products with the introduction of a binder and heat treatment of the mineral wool carpet in a polymerization chamber. These processes are characterized by significant energy costs.

Despite the availability of scientific research in this area, the topic of mineral wool products with reduced technological energy intensity remains insufficiently developed. Existing research and development do not always take into account all aspects related to the production, operation and disposal of such products. In this regard, there is a need for additional research aimed at optimizing technological processes and improving the performance characteristics of mineral wool products [4, 5].

In the context of building insulation technologies, it is important to reduce operating costs and develop new efficient thermal insulation materials with lower energy consumption.

Experiment and results

The properties of mineral wool products and their operational durability depend on three main factors: the properties of mineral fibers, the interweaving of these fibers in the product and the type of synthetic binder. The operational characteristics of fiber from rocks (stone wool) are quite high, during technological processing a volumetric interwoven structure is formed in the product, therefore the most important component in the overall strength structure is the type and properties of the synthetic binder. Mineral wool carpet is a typical example of a chaotic structure stabilized both in time and relative to characteristic parameters. The structure of the fibrous base of the mineral wool carpet is characterized by a significant length of fibers and their intensive interweaving (Fig. 1). The main properties (strength, average density and thermal conductivity) of a mineral wool product depend on the strength of the fiber in the product, on the properties of the fibers (diameter and length), on the number of contacts and the distance between the points of contact of the fibers, the strength of the monolithic contacts (the strength of the carpet). The smaller the fiber diameter, the more fibers are contained per unit volume, and the more points of contact between fibers and the higher the strength of the interwoven structure.



а ***б***

Figure 1. *Structure of the mineral wool layer: a – general plan; b – close-up of the contact of the expected case*

The research was based on the hypothesis that an increase in the strength and operational durability of mineral wool products can be achieved through the use of a low-toxic heat-curing epoxy binder containing latent components (enhancing the adhesion of the binder to the fiber, regulating the curing temperature) under the conditions of forming a cohesive multilayer structure of the mineral wool product.

In the process of implementing the general research plan, an experiment was conducted to determine the dependence of the shear strength of the adhesive joint (U) on the formulation and process parameters. The following were adopted as

variable factors: the consumption of the binder X1 (2–4%), the content of the latent component in the composite binder X2 (0.5–5.5%) and the curing temperature of the composite binder X3 (80–140 °C).

Conducting an active experiment, statistical processing of its results and testing statistical hypotheses made it possible to obtain a regression equation (algebraic polynomial) of the following type:

$$У = 7{,}2 + 0{,}6X_1 + 3{,}2X_2 + 1{,}2X_3 + 1{,}0X_2X_3 - 0{,}4X_1^2 - 0{,}5X_3^2 \quad (1)$$

An analysis of the coefficients of the algebraic polynomial allows us to draw a number of conclusions. Firstly, the greatest influence on the strength of the adhesive joint is exerted by the content of the latent component and the temperature of heat treatment. Secondly, the consumption of the binder in the range established by the experimental conditions has the least influence on the strength. Thirdly, there is an optimum for factor X1, which can be determined by the analytical optimization method.

We carry out analytical optimization in several stages:

1). Considering the algebraic polynomial (1) as an algebraic function of three variables, we can find the partial derivative of this function with respect to factor X1:

$$\partial Y / \partial X_1 = 0.6 - 0.8X_1 = 0 \rightarrow X_1 = \frac{0.6}{0.8} = 0.75 \quad (2)$$

2). We substitute the optimal value X1 = 0.75 into the algebraic polynomial (1) and obtain the optimized strength function:

$$У = 7{,}4 + 3{,}2X_2 + 1{,}2X_3 + 1{,}0X_2X_3 - 0{,}5X_3^2 \quad (3)$$

3). We determine the natural value of the binder consumption: Bc = 3 + 0,75 = 3,75%

4). We carry out a graphical interpretation of function (3) with an optimal binder consumption of 3.75% (Fig. 2)

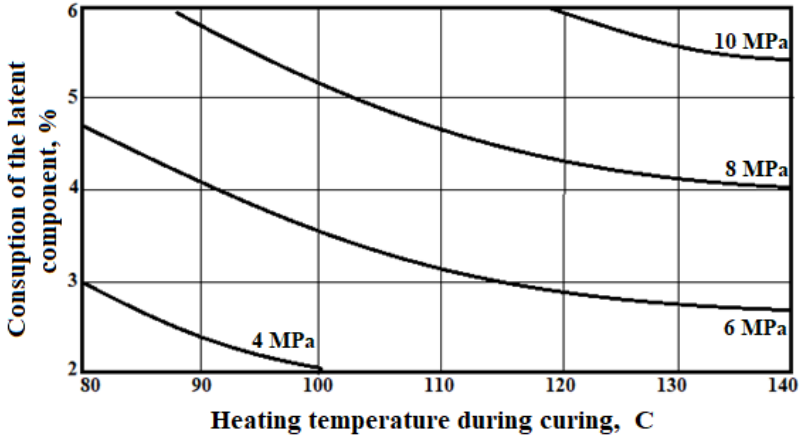


Figure 2. *Dependence of the shear strength of the adhesive joint (at the optimal binder consumption of 3.75%) on the consumption of the latent component in the composite binder and the heating temperature during curing*

The nomogram of the dependence of the adhesive joint shear strength on the latent component consumption in the composite binder and the heating temperature during curing (Fig. 1) allows solving the direct and inverse problems of mathematical modeling. As applied to the experimental conditions, the direct problem consists in determining the strength values based on the values of the variable factors, and the inverse problem consists in determining the values of the variable factors corresponding to the specified strength. As a result of the experiment, it was found that with a low content of the latent component (in the considered biss-phenol technology) in the composite binder, that is, with compositions close to pure epoxy, the shear strength of the adhesive joint is significantly reduced. The combined effect of the latent component consumption and the heating temperature on the contact strength is significant and has a synergistic effect, i.e. it is enhanced with a simultaneous increase in the latent component consumption and an increase in temperature in the intervals established by the experimental conditions. The optimal content of the latent component is in the range from 3.6 to 4.0%, at a heat treatment temperature of 120-140 °C.

Conclusion

The properties of mineral wool products and their operational durability depend on three main factors: the properties of mineral fibers, the interweaving of these fibers in the product, and the type of synthetic binder. The operational characteristics of fiber from rocks (stone wool) are quite high; during technological processing, a volumetric interwoven structure is formed in the product, therefore,

the most important component in the overall strength structure is the type and properties of the synthetic binder.

Reducing the energy intensity of manufacturing products based on mineral (including stone wool) is possible both by optimizing the processes of obtaining the mineral fiber itself, and by introducing innovative types of binders that monolithize these fibers during the curing process as a result of polycondensation of these binders. In this regard, the use of synthetic resins that harden at temperatures up to 160 ° C is promising, including with the use of latent components as a catalyst and plasticizer. The studies used a latex binder with a curing temperature of 120 °C.

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移动结构的工程支持（来自海运集装箱）：供水、排污、电力、隔热
ENGINEERING SUPPORT FOR MOBILE STRUCTURES (FROM SEA CONTAINERS): WATER SUPPLY, SEWERAGE, ELECTRICITY, THERMAL INSULATION

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摘要。本文致力于分析确保基于海运集装箱建造的移动结构正常运行的工程解决方案。考虑了在有限空间和物体移动性条件下供水、排污、供电和隔热系统的设计和安装特点。本文详细描述了各种技术解决方案、其优缺点，以及影响针对不同气候条件和结构功能目的选择最佳方案的因素。本文将对设计工程师、建筑商以及任何对使用海运集装箱建造和运营移动建筑感兴趣的人有用。

关键词：海运集装箱、移动结构、工程支持、供水、排污、供电、隔热、设计、安装、自主系统、能源效率、可持续建筑、模块化建筑。

Abstract. *The article is devoted to the analysis of engineering solutions that ensure the functioning of mobile structures created on the basis of sea containers. The features of design and installation of water supply, sewerage, power supply and thermal insulation systems in conditions of limited space and mobility of the object are considered. The work describes in detail various technical solutions, their advantages and disadvantages, as well as factors influencing the choice of optimal options for different climatic conditions and functional purpose of the structures. The article will be useful for design engineers, builders and anyone interested in the issues of creating and operating mobile buildings from sea containers.*

Keywords: *sea containers, mobile structures, engineering support, water supply, sewerage, power supply, thermal insulation, design, installation, autonomous systems, energy efficiency, sustainable construction, modular construction.*

Introduction

Nowadays, when environmental issues, resource conservation and non-standard architectural solutions are in the focus of attention, the use of sea containers in construction is becoming increasingly relevant. This concept, known as container architecture, offers fast, economical and sustainable solutions for a variety of construction projects, from residential buildings to office buildings. Originally created to transport goods around the world, shipping containers often end up forgotten in warehouses after being decommissioned. Their transformation into functional building blocks is a great example of a creative approach to reuse and recycling, supporting the ideals of sustainable development. The use of containers in construction not only gives a second life to these metal boxes, but also opens up new horizons for architectural design, allowing for the creation of unique, functional and at the same time affordable spaces.

In addition, the widespread use of shipping containers and their availability make this material attractive from an economic point of view. The possibility of reusing containers is in line with modern trends in sustainable construction and reduces the ecological footprint of the construction industry. Flexibility in layout and the possibility of creating individual projects based on standard modules expand architectural possibilities and allow the creation of functional and aesthetic structures for various purposes, from residential buildings to commercial real estate. In the conditions of modern dynamic life, where fast and flexible solutions are required, mobile structures made of sea containers are finding increasing application. However, providing such structures with the necessary engineering systems – water supply, sewerage, electricity, thermal insulation – is a task that requires special solutions and certain technical knowledge [5].

This article is devoted to the analysis of engineering solutions used to ensure the functioning of mobile structures made of sea containers. The issues of design and installation of water supply, sewerage, electricity and thermal insulation systems, as well as the features of their operation in various climatic conditions are considered.

1. Water supply

1.1. Water supply sources

The choice of water supply source for mobile structures depends on their location, the availability of a centralized water supply and the nature of the use of the structures. Possible options include:

• Centralized water supply is the simplest and safest option for water supply, but is not always available. In this case, it is necessary to connect to the central network using water pipes, which must be laid taking into account the possibility of moving the module.

• Using a well requires drilling and equipment, but can provide an autonomous water supply to the facility. This is especially true for mobile structures located in remote areas or in places where there is no centralized water supply. It is necessary to select the appropriate well depth, install a pump and a water filtration system.

• Water intake from open sources such as a river, lake, spring requires water purification, which complicates the water supply system. This option is recommended only in the absence of other water supply sources. It is necessary to install a water purification system that should eliminate all possible contaminants and bacteria.

• Rainwater is collected from the roof, requires filtration and storage in tanks. This is a relatively inexpensive and environmentally friendly method of water supply, but requires additional investment in a system for collecting, filtering and storing water.

1.2. Plumbing system

The plumbing system for mobile structures can be designed using various materials:

• Plastic pipes - lightweight, corrosion-resistant, inexpensive. Widely used in modern water supply systems.

• Metal pipes - durable, but susceptible to corrosion. Rarely used in mobile structures, mainly for connection to centralized water supply networks.

• Cross-linked polyethylene - pipes are resistant to high temperatures, durable, inexpensive. Well suited for hot water supply systems.

The choice of pipe type depends on the operating conditions of the module, water temperature, load and financial capabilities.

1.3. Pumps

Various types of pumps are used to supply water to the system:

• Surface pumps - simple, inexpensive, but less powerful. Used to lift water from shallow wells or reservoirs.

• Submersible pumps - more powerful, suitable for deep wells. Used in autonomous water supply systems of mobile structures.

The choice of pump type depends on the depth of the water source, the required capacity and the load on the system.

1.4. Water heaters

Different types of water heaters are used to supply hot water to a facility:

• Instantaneous water heaters are compact and inexpensive, but cannot provide a large amount of hot water. They are used in cases of low hot water consumption.

• Storage water heaters provide a large amount of hot water, but require a large space. They are used in modular facilities that require a large amount of hot water, such as hotel complexes or hospitals.

• Solar collectors are an environmentally friendly option, but require sufficient sunlight. They are well suited for mobile structures located in sunny regions.

2. Sewage

2.1. Drainage systems

The choice of drainage system depends on the location of the facility, the availability of a centralized sewerage system and the nature of the waste:

• Centralized sewerage is the simplest and safest option for use in a modular facility, but is not always available. In this case, it is necessary to connect to the central sewer network using sewer pipes.

• A septic tank requires periodic cleaning, but can provide autonomous water drainage. A septic tank is a reservoir in which wastewater is separated into solid and liquid fractions. Solid waste settles to the bottom, and liquid waste is discharged into a filter well.

• A cesspool is the most inexpensive drainage system, but requires frequent cleaning and can be dangerous from an environmental point of view. A cesspool is a leaky reservoir into which wastewater is discharged. It is necessary to regularly clean the pit from solid waste, which can be inconvenient and dangerous for the environment.

2.2. Sewer pipes

Plastic or metal sewer pipes are used to discharge wastewater:

• Plastic pipes are lightweight, corrosion-resistant, inexpensive. They are widely used in modern drainage systems.

• Cast iron pipes are durable, but heavy and susceptible to corrosion. Rarely used in mobile structures.

The choice of pipe type depends on the operating conditions of the module, the temperature of the wastewater, the load and financial capabilities [2].

3. Electricity

3.1. Power sources

The choice of power source depends on the location of the facility, the availability of a centralized network and the need for power:

• A centralized network is the simplest and safest option for supplying power to the facility, but is not always available. In this case, it is necessary to connect to the central network using an electric cable, which must be laid taking into account the possibility of moving the module.

• A diesel generator can provide an autonomous power supply, but requires a constant supply of fuel. A diesel generator is an internal combustion engine that drives a generator that produces electricity.

• Solar panels are an environmentally friendly option for supplying a facility with electricity, but require sufficient sunlight. Solar panels convert solar energy into electrical energy.

• Wind turbines are also an environmentally friendly option, but require windy conditions. Wind turbines convert the kinetic energy of the wind into electrical energy.

3.2. Electricity Distribution

Electricity distribution in a mobile structure is carried out using power wiring, including cables and wires.

• Cable is a conductor with insulation, placed in a protective sheath. Cables are used for laying electrical wiring in the ground or in the air.

• Wires are a conductor with insulation. Wires are used for laying internal electrical wiring.

3.3. Electrical panel room

The electrical panel room contains the input distribution device (IDD) and other electrical devices for the safe and efficient distribution of electrical energy. IDD serves to receive electrical energy from the source and distribute it to different consumers [3].

4. Thermal insulation

4.1. Thermal insulation materials

The choice of thermal insulation material depends on the climatic conditions in which the mobile structure will be used, as well as on fire safety requirements:

• Mineral wool is a non-combustible material, it insulates heat well, but can absorb moisture. The input distribution device IDD serves to receive electrical energy from the source and distribute it to different consumers.

• Expanded polystyrene is an inexpensive material, it insulates heat well, but is flammable. Expanded polystyrene is made from polystyrene, which is a lightweight and inexpensive material.

• Polyurethane foam is a good heat insulator, does not absorb moisture, but is flammable. Polyurethane foam is made from polyurethane, which has high thermal insulation properties.

• Ecowool is an environmentally friendly material, it insulates heat well, but requires experienced performers. Ecowool is made from cellulose fibers, which are an environmentally friendly material [4].

4.2. Thermal insulation methods

• External insulation is laid on the outside of the walls and roof. External thermal insulation protects the structure from direct exposure to cold air and precipitation [1].

• Internal insulation is laid on the inside of the walls and roof. Internal thermal insulation prevents heat loss from the structure and creates more comfortable conditions inside.

• Combined insulation combines the most effective thermal insulation methods. Combined thermal insulation allows you to achieve maximum efficiency and minimize heat loss.

5. Features of design and installation of engineering systems

Design and installation of engineering systems in mobile structures from sea containers differ from the design of traditional buildings. In this case, it is necessary to take into account some features of the designed mobile objects from sea containers. • The limited space of the facility serves the need to place all the necessary systems in a small space. This requires the use of compact and efficient solutions.

• The mobility of the facility determines such required characteristics of engineering systems as lightness and resistance to movement. It is necessary to use lightweight materials and strong connections that can withstand the movement of the module.

• The cost-effectiveness of using a modular facility determines the need to use inexpensive and efficient materials and technologies. It is necessary to use materials and technologies that ensure the reliability and durability of systems at minimal cost.

• The requirement for the safety of engineering systems during operation is one of the fundamental ones. It is necessary to comply with all the necessary safety standards and rules when designing and installing engineering systems.

Conclusion

Engineering support for mobile structures from sea containers is a complex task that requires taking into account many factors: location, nature of use of the modular facility, climatic conditions, safety, cost-effectiveness. The choice of technologies and materials for water supply, sewerage, power supply, thermal insulation should be carried out taking into account the specifics of a specific project. Further development of technologies promises the emergence of new solutions that will make mobile structures from sea containers even more functional, comfortable and environmentally friendly.

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