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«ҚАЗАҚСТАН РЕСПУБЛИКАСЫ
ҰЛТТЫҚ ҒЫЛЫМ АКАДЕМИЯСЫ» РҚБ

ХАБАРЛАРЫ

ИЗВЕСТИЯ

РОО «НАЦИОНАЛЬНОЙ
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Қазақстан Республикасы Ұлттық ғылым академиясы «ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы» ғылыми журналының Web of Science-тің жаңаланған нұсқасы Emerging Sources Citation Index-те индекстелуге қабылданғанын хабарлайды. Бұл индекстелу барысында Clarivate Analytics компаниясы журналды одан әрі the Science Citation Index Expanded, the Social Sciences Citation Index және the Arts & Humanities Citation Index-ке қабылдау мәселесін қарастыруда. Webof Science зерттеушілер, авторлар, баспашылар мен мекемелерге контент тереңдігі мен сапасын ұсынады. ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы Emerging Sources Citation Index-ке енуі біздің қоғамдастық үшін ең өзекті және беделді геология және техникалық ғылымдар бойынша контентке адалдығымызды білдіреді.

НАН РК сообщает, что научный журнал «Известия НАН РК. Серия геологии и технических наук» был принят для индексирования в Emerging Sources Citation Index, обновленной версии Web of Science. Содержание в этом индексировании находится в стадии рассмотрения компанией Clarivate Analytics для дальнейшего принятия журнала в the Science Citation Index Expanded, the Social Sciences Citation Index и the Arts & Humanities Citation Index. Web of Science предлагает качество и глубину контента для исследователей, авторов, издателей и учреждений. Включение Известия НАН РК. Серия геологии и технических наук в Emerging Sources Citation Index демонстрирует нашу приверженность к наиболее актуальному и влиятельному контенту по геологии и техническим наукам для нашего сообщества.

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OPTIMIZATION OF THE PROCESS OF CARGO DELIVERY OF AGRO-INDUSTRIAL COMPLEX THROUGH THE INTRODUCTION OF NEURAL NETWORKS

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Abstract. Studies have been carried out in the field of improving the quality of cargo movement of mining enterprises. The paper substantiates the introduction of a control system module using digital tools based on neural network algorithms as a tool for optimizing the process of cargo delivery in the mining sector. Goals and objectives. Formation of a model for the functioning of the mining sector, in

terms of real-time regulation of cargo transportation, by developing a logistics architecture for the use of digital tools of neural networks to optimize the process of cargo delivery, including the automation of warehouse operations, demand forecasting, routing and delivery planning. The methods include analytical research, probabilistic estimation method, simulation modeling, modal analysis, modeling of digital architectures, neural network programming techniques, basic theories of solving optimization solutions, theory of transport logistics. Results of the study – the created neural network includes a simulation model, a cloud platform for permanent storage of a bank of solutions. Thanks to functional and cloud resources, when managing the process of product delivery, it is possible to take into account the technical characteristics of the vehicle, the method of cargo placement, optimize the logistics of delivery and distribution for the regional consumer. A cloud database was created, which made it possible to transfer the neural network training process offline. An interface for information processing has been developed. **Conclusions:** the use of the data bank allows you to effectively solve the problem of choosing optimal solutions, accumulate an information resource for adaptation to real transportation conditions, taking into account the variability of influencing factors.

Keywords: mining sector, cargo, logistics, resource management, neural networks, efficiency.

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НЕЙРОНДЫҚ ЖЕЛІЛЕРДІ ЕНГІЗУ АРҚЫЛЫ ТАУ-КЕН ӨНЕРКӘСІБІ КӘСІПОРЫНДАРЫ ҮШІН ЖҮКТЕРДІ ЖЕТКІЗУ ПРОЦЕСІН ОҢТАЙЛАНДЫРУ

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аспиранты, Ресей мемлекеттік аграрлық университеті – Мәскеу К.А.Тимирязев атындағы ауылшаруашылық академиясы, Мәскеу, Ресей, E-mail: sergej.nekrasov@rgau-msha.ru, https://orcid.org/0000-0002-6844-5773;

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Аннотация. Тау-кен өнеркәсібі кәсіпорындарында жүк тасымалдау сапасын арттыру бағыты бойынша зерттеулер жүргізілді. Жұмыста тау-кен секторындағы жүктерді жеткізу процесін оңтайландыру құралы ретінде нейрондық желі алгоритмдеріне негізделген цифрлық құралдарды пайдалана отырып, басқару жүйесінің модулін енгізу негіздемесі келтірілген. *Мақсат-міндеті.* Жүктерді жеткізу процесін оңтайландыру үшін цифрлық нейрондық желі құралдарын пайдалану үшін логистикалық архитектураны әзірлеу арқылы нақты уақыт режимінде жүк тасымалдауды реттеу бөлігінде тау-кен өндіру секторының жұмыс істеу моделін қалыптастыру, оның ішінде қойма операцияларын автоматтандыру, сұранысты болжау, бағыттау және жеткізуді жоспарлау. *Әдістері* – аналитикалық зерттеу, ықтималдық бағалау әдісі, имитациялық модельдеу, модальды талдау, цифрлық архитектураны модельдеу, нейрондық желіні бағдарламалау әдістемесі, оңтайландыру шешімдерін шешудің негізгі теориялары, көліктік логистика теориясы. *Зерттеу нәтижелері:* құрылған нейрондық желі имитациялық модельді және шешімдер банкін тұрақты сақтауға арналған бұлтты платформаны қамтиды. Функционалды және бұлтты ресурстардың арқасында өнімді жеткізу процесін басқару кезінде көліктің техникалық сипаттамаларын, жүкті орналастыру әдісін ескеріп, аймақтық тұтынушы үшін жеткізу және тарату логистикасын оңтайландыруға болады. Бұлтты деректер базасы құрылды, ол нейрондық желіні оқыту процесін автономды режимге көшіруге мүмкіндік берді. Ақпаратты өңдеуге арналған интерфейс әзірленді. Қорытынды: деректер банкін пайдалану оңтайлы шешімдерді таңдау мәселесін тиімді шешуге, әсер етуші факторлардың өзгермелілігін ескере отырып, нақты тасымалдау жағдайларына бейімделу үшін ақпараттық ресурстарды жинақтауға мүмкіндік береді.

Түйін сөздер: тау-кен секторы, жүк, логистика, ресурстарды басқару, нейрондық желілер, тиімділік.

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ОПТИМИЗАЦИЯ ПРОЦЕССА ДОСТАВКИ ГРУЗОВ ПРЕДПРИЯТИЙ ГОРНОЙ ИНДУСТРИИ ПУТЕМ ВНЕДРЕНИЯ НЕЙРОННЫХ СЕТЕЙ

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Аннотация. Исследования проведены в области повышения качества перемещения грузов предприятий горной индустрии. В работе дается обоснование введение модуля системы управления с применением цифровых инструментов основанных на базе алгоритмов нейронной сети, как инструмент оптимизации процесса доставки грузов в горнодобывающем секторе. *Цели и задачи.* Формирование модели функционирования горнодобывающего сектора, в части регулирования грузоперевозок в режиме реального времени, путем разработки логистической архитектуры применения цифровых инструментов нейронных сетей для оптимизации, процесса доставки грузов, включая автоматизацию складских операций, прогнозирование спроса, маршрутизацию и планирование доставки. *Методы* – аналитические исследования, метод вероятностной оценки, имитационное моделирование, модальный анализ, моделирование цифровых архитектур,

методика программирования нейронных сетей, базовые теории решения оптимизационных решений, теория транспортной логистики. *Результаты исследования* – созданная нейронная сеть включает в себя имитационную модель, облачную платформу для постоянного хранения банка решений. Благодаря функциональным и облачным ресурсам при управлении процесса доставки продукции имеется возможность учитывать технические характеристики транспортного средства, способ размещения груза, оптимизировать логистику доставки и распределения для регионального потребителя. Создана облачная база данных, которая позволила перевести процесс обучения нейронной сети в автономный режим. Разработан интерфейс для обработки информации. Выводы – использование банка данных позволяет эффективно решать задачу выбора оптимальных решений, накапливать информационный ресурс для адаптации к реальным условиям перевозок с учетом вариативности факторов влияния.

Ключевые слова: горнодобывающий сектор, грузы, логистика, управление ресурсами, нейронные сети, эффективность.

Introduction. The task of distributing material flows in mining technologies contains in its structure functions with substantiation of efficiency indicators according to various criteria of the vehicle route. Mining products can have significant transport costs during the lag of goods movement from the primary raw material source to the final consumer of finished products (Tumanov, et al., 2022; Gendler, et al., 2021).

According to statistics, logistics costs for material flows in the mining industry are about 70%. The intensity and diversity of cargo transportation are solved by various logistics schemes, but for mining enterprises (MEs), additional requirements are imposed on delivery times, quality of cargo preservation and its territorial redistribution, which is difficult to optimize in a variable environment of factor influence (Martirosyan, et al., 2025; Kukharova, et al., 2024; Polekhina, et al., 2022). Obviously, the problems considered can be solved by adapting existing or developing new digital tools, up to the use of neural networks for the formation of a database of technological processes of production, processing and sale of products "from mining to consumer". The aim of the study is to develop a logistics architecture for the use of digital neural network tools to optimize, in real time, the functioning of the mining sector, the process of cargo delivery, including automation of warehouse operations, demand forecasting, routing and delivery planning.

Materials and methods. The development of a neural network for optimizing the process of cargo delivery in MEs is based on the use of simulation modeling. At the first stage, a theoretical and methodological analysis of the production process was carried out. To take into account various factors, a probabilistic assessment method was used, which allowed a more detailed description of the transportation business process. Using mathematical analysis, the obtained characteristics of cargo transportation, selection of equipment, loading methods, and delivery methods

were processed. Based on the developed model, recommendations for making optimization decisions designed to improve the cargo transportation process and reduce logistics costs are proposed. Moreover, the model can be used to analyze and predict the cargo transportation system in the production sector of the mining industry as a whole, which the neural network can be used for training.

Results and discussions. Solving logistics transportation problems as complex optimized ones by several variables does not now allow to obtain their exact value. In this regard, a rather interesting approach is an algorithm for searching for a solution close to optimal for an acceptable period of work. In this case, when developing the architectural structure of a neural network, the most effective is the formation of an algorithm based on a swarm, which is an alternative to direct search algorithms, since it uses a set of solutions for each iteration, and not a single solution (Pham, et al., 2006).

Considering optimization problems of cargo transportation for mining infrastructure from a strategic point of view, it is necessary to take into account the variability in the form of searching for the implemented solution. At the same time, it is obvious that some methods may contain incorrect optimization criteria, which in the variability of solutions will not allow generating the most acceptable result. The optimization criterion should have the property of increasing the value of the efficiency indicator, in particular, compiling an algorithm on the principles of applying nature-like effects to solve optimization problems (Pham, et al., 2006; Dorigo, et al., 2004; Goldberg, 1989).

The formation of a neural network for optimization of the transportation process routing, similar to an "intelligent swarm", is based on the ability to select the shortest path between specified points, in the considered option of receiving cargo to the place of its delivery (Mathur, et al., 2000; Bonabeau, et al., 1999). In mining, the process of obtaining products is one of the stages of the technological chain of production, processing and sale of products: "from extraction to consumer". The algorithm for solving problems based on neural networks is based on the formation of individual solutions for each structural "agent", which evolve or change their position over time. In the decision-making field, each "agent" changes its position in the search space in accordance with the experience gained, coordinating the result with the neighboring structural element, choosing the best position, combining local and global search methods depending on the specified criteria of the problems being solved (Camazine, et al., 2003; Duyun, et al., 2022; Pastukhov, et al., 2023).

To maintain product quality, robotic systems can be used in the mechanization of mining operations, in particular, a robotic manipulator with PID control, which provides the ability to follow a given trajectory, adjusting movements based on the difference between the actual and desired positions (Muhammad, et al., 2024)

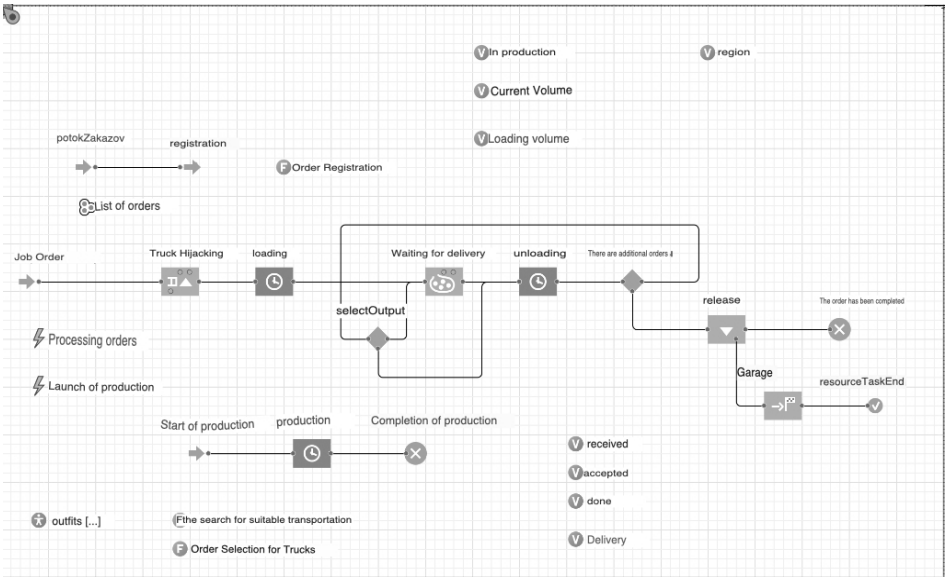
The solution to the criterial problem also requires not only a formal repetition of the movement scheme in the algorithm, but also an additional assessment of the quality characteristics, in particular, for the transportation of products, the choice of the type of vehicle, the method of placing the cargo in the back of the vehicle, and

guaranteed preservation of quality for the entire period of delivery to the destination (Sevryugina, et al., 2015).

In the process of modification, the logistics system management model is adapted to the format of the architectural structure of the neural network with the source code of the database algorithmization and the variability of the factor specificity of the operating conditions of mining enterprises.

To optimize the construction of the business process, a typical organizational infrastructure of three mining enterprises and seven quarries was adopted, which receive a certain number of applications every day. Mining enterprises have a list of vehicles of various carrying capacities that deliver cargo from the deposits. If there is not enough cargo in the quarry, the order waits until the enterprise receives the required number of requests to completely fill the vehicle. Transportation logistics combines several methods and uses GIS maps to position vehicles according to the conditions of cargo delivery. In the problem statement, the type of cargo transported is not detailed by the type of MEs product, but is identified as "bulk cargo" (Fig. 1).

In the simulation model, the coordinates of enterprises and quarries are set using the database, and the transportation route by vehicles is formed according to real routing requests. The modification of the model is represented by the logistic architecture of the system, which simulates the process of cargo transportation between regions.



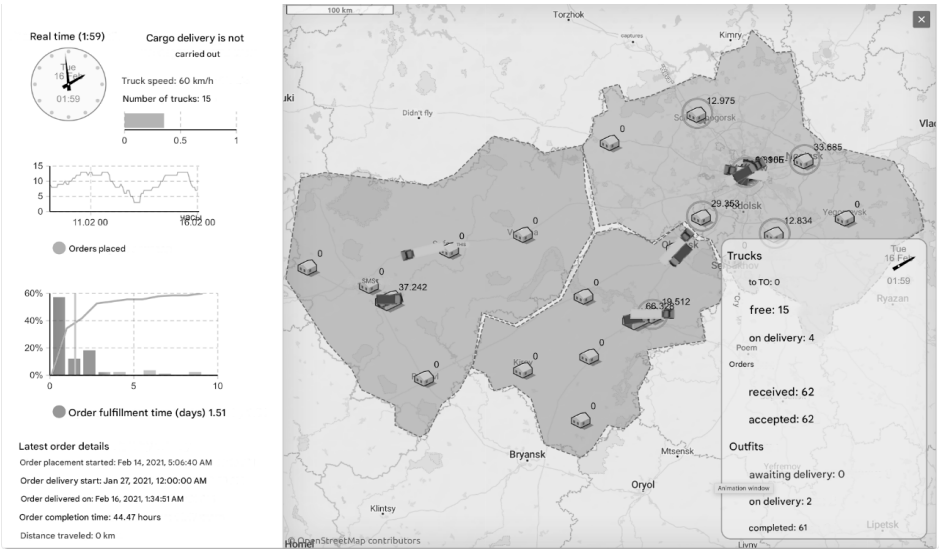


Fig. 1. Simulation model (AnyLogic) of management of the logistics system of mining enterprises

The optimization task is to implement the algorithm of the current model of the vehicle loading configurator. With this tool, it is possible to more accurately determine the volume, weight and quantity of cargo for optimal filling, while ensuring that the vehicle's carrying capacity is not exceeded. The most suitable transportation method is selected and loading advice is provided, avoiding overloading and promptly providing accurate information about the cargo and its current location (Fig. 2).

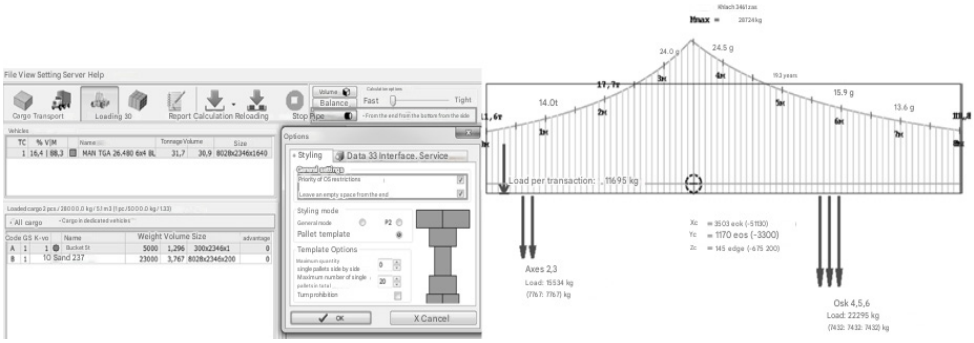


Fig. 2. Vehicle loading configuration

Training a neural network involves creating an information structure. The information includes environmental variables that the "agent" examines to determine what action needs to be taken. The main goal of training is to ensure the ability to work in real conditions, so it is important to create a simulation model that

most accurately reflects the real environment. In the algorithm under consideration, three elements are distinguished: a simulation environment; a business process; a function for correcting the correctness of the system (Fig. 3).

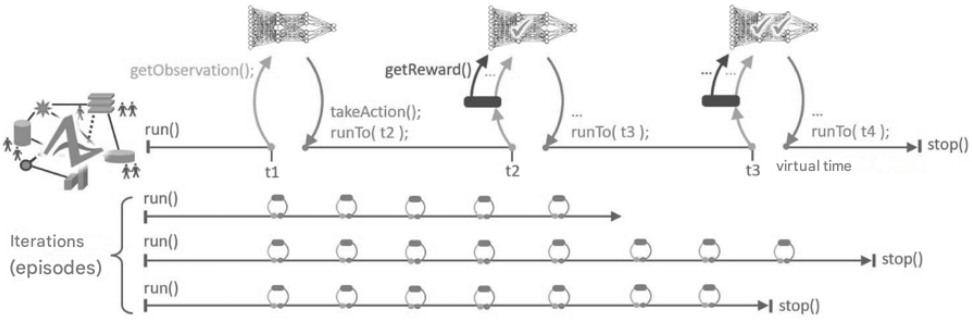


Fig. 3. The structure of neural network learning

To create an information system for decision-making, artificial intelligence should be able to appeal to the following data:

- the current volume of production at a particular MEs quarry;
- the number of vehicles that can be used in the logistics chain for cargo transportation;
- the number of available vehicles by positioning points based on fast delivery to the loading point;
- the number of recipients of finished products or product components based on the stated need.

An information database using a neural network creates “agents” that are trained by analyzing data and evaluating the effectiveness of selecting options for factor influence to make an optimization decision for the given conditions for transporting quarry cargo.

An “agent” has a set of possible actions that it can perform.

Under the given conditions, the action space is defined by a 7x3 vector. This means that seven warehouses generate orders, and the “agent” decides which of the three enterprises should fulfill each order.

The condition of no order is taken as the basic guideline, i.e. the number of requests is zero. In the case of the absence of an order from any quarry, the corresponding action is not performed.

Using the correction function, the environment reports whether the correct actions are performed. During training, the “agent” chooses the best solution, thereby learning and optimizing the transportation process.

The following function was used in the simulation model:

$$reward = before.avgWaitingTime - after.AvgWaitingTime$$

Training of filling the vehicle with products occurs according to the principle of minimizing the waiting time: if the waiting time increases, the value of the function decreases, and the "agent" realizes that its work is ineffective. The average waiting time (1) and the average transportation distance (2) during training are shown in Figure 4.

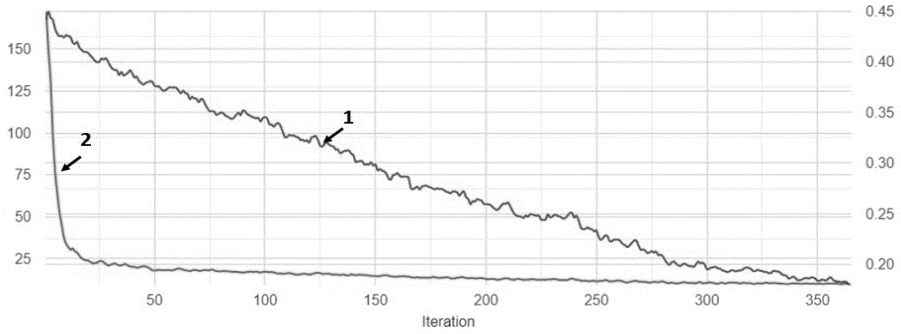


Fig. 4. The dependence of the waiting time on the distance of transportation

When the warehouse closest to the enterprise reaches its maximum capacity, the agent automatically sends some of the requests to other enterprises. Thus, there is an optimal match between capacity utilization and demand, which reduces production costs and increases the efficiency of resource use.

The simulation results showed a significant improvement when using the learning approach with the adjustment function.

Further work consists of reformatting the simulation system as a digital twin that collects data on the state of the system in real time, and the neural network module is constantly trained using the model located in the cloud. A database and recommendations for eliminating non-standard situations are formed (Sevryugina, et al., 2017).

As a result of the created algorithm, the solution to the problem of optimizing the transportation of quarry cargo made it possible to reduce the time for collecting, loading and delivering cargo by four times, compared to the traditional heuristic algorithm.

The concept of integrating neural networks into the process of optimizing cargo delivery for MEs involves analyzing data on the movement of vehicles, fuel consumption, transport loading and comparing the simulation results with the operator's actions in non-standard situations (Rybin, et al., 2020; Yarushkina, et al., 2022). This allows us to identify patterns and improve the efficiency of not only a single sector, but also the mining industry as a whole. The development of research in this area, taking into account cloud data, transferring them to the category of multi-criteria accounting of parameters, opens up the possibility of solving higher-level problems, reducing the cost of using publicly available simulation environments for small organizations (Tikunova, et al., 2023; Nekrasov, et al., 2022).

Conclusion and recommendation.

The choice of a neural network as a tool for optimizing the process of cargo delivery in the mining sector is substantiated. Due to functional and cloud resources, when managing the processes of delivery of quarry cargo, it is possible to take into account the technical characteristics of the vehicle, the method of placing the cargo, optimize the logistics of delivery and distribution for the regional consumer. It is proven that the learning algorithm with a correction function based on artificial intelligence can be effectively used as a tool for increasing the digital maturity of an enterprise when optimizing transportation processes in the mining industry. The creation of a data bank located in a cloud environment allows you to effectively solve the problem of choosing optimal solutions, accumulate an information resource for adaptation to real transportation conditions, taking into account the variability of influencing factors.

References

Bonabeau E., Dorigo M., and Theraulaz G. (1999) Swarm Intelligence: from Natural to Artificial Systems. New York: Oxford University Press. (in Eng.)

Camazine S., Deneubourg J., Franks N.R., Sneyd J., Theraula G. and Bonabeau E. (2003) Self-Organization in Biological Systems. Princeton: Princeton University Press. (in Eng.)

Dorigo M. and Stützle T. (2004) Ant Colony Optimization. Cambridge: MIT Press. (in Eng.)

Duyun I.A., Gorlov A.S., Duyun T.A. (2022) Sovmestnoe modelirovanie dvizheniya parallelnogo manipulyatora s ispolzovaniem Adams-Matlab [Co-simulation parallel manipulator movements using Adams-Matlab]. Bulletin of BSTU named after V.G. Shukhov. – 2022. – №11. – P. 108–119. DOI 10.34031/2071-7318-2022-7-11-108-119. (In Russian)

Gendler S.G., Fazylov I.R. (2021) Ocenka effektivnosti ispol'zovaniya zakrytoj sistemy sbora nefti dlya normalizacii mikroklimata v ekspluatacionnyh galereyah neftyanyh shaht [Application efficiency of closed gathering system toward microclimate normalization in operating galleries in oil mines]. Mining Informational and Analytical Bulletin. – 2021. – 2021(9). – P. 65–78. https://doi.org/10.25018/0236_1493_2021_9_0_65. (In Russian)

Goldberg D.E. (1989) Genetic Algorithms in Search, Optimization and Machine Learning. Longman: Addison-Wesley. (in Eng.)

Kassenov A.Zh., Abishev K.K., Yanyushkin A.S., Absadykov B.N., Iskakova D.A. (2023) Research of the Stress-Strain State of the Bucket Elevator Node Chain. News of The National Academy of Sciences of The Republic of Kazakhstan. Series of Geology and Technical Sciences. – Vol. 5, No 461 – 167 – 178. https://doi.org/10.32014/2023.2518-170X.340 (in Eng.)

Kukharova T., Martirosyan A., Asadulagi M.-A., Ilyushin Y. (2024) Development of the Separation Column's Temperature Field Monitoring System. Energies. – 17. – 5175. https://doi.org/10.3390/en17205175. (in Eng.)

Martirosyan A., Ilyushin Y., Afanaseva O., Kukharova T., Asadulagi M., Khloponina V. Development of an Oil Field's Conceptual Model. International Journal of Engineering. – 2025. – 38(2). – P. 381-388. https://doi.org/10.5829/ije.2025.38.02b.12. (in Eng.)

Mathur M., Karale S.B., Priye S., Jayaraman V.K. and Kulkarni B.D. (2000) Ant Colony Approach to Continuous Function Optimization. Ind. Eng. Chem. Res. – 39(10). – P. 3814–3822. (in Eng.)

Muhammad I. Azeez, Khaled R. (2024) Atia, Modeling of PID controlled 3DOF robotic manipulator using Lyapunov function for enhancing trajectory tracking and robustness exploiting Golden Jackal algorithm. ISA Transactions. – 145. P. 190–204. https://doi.org/10.1016/j.isatra.2023.11.033. (in Eng.)

Nekrasov S.I., Gornostaev V.I. (2022) Use of simulation modeling techniques in solving optimization problems of transport support. Digital Technologies in Agriculture of the Russian

Federation and the World Community, Stavropol: AIP PUBLISHING 27–30.09.2021. – 2661. – 040007. (in Eng.)

Pastukhov A., Timashov E., Stanojević D. (2023) Temperature Conditions and Diagnostics of Bearings. Applied Engineering Letters. – 8(2). – P. 45–51. https://doi.org/10.18485/aeletters.2023.8.2.1. (in Eng.)

Pham D.T., Ghanbarzadeh A., Koç E., Otri S., Rahim S., Zaidi M. (2006) The Bees Algorithm – A Novel Tool for Complex Optimisation Problemsт. Intelligent Production Machines and Systems. – P. 454-459. https://doi.org/10.1016/B978-008045157-2/50081-X. (in Eng.)

Polekhina V.S., Shestopalov M.Y., Ilyushin Y.Y. (2022) Identification of Magnetic Field Strength Realisation as a Necessary Solution for High-Quality Metal Synthesis. Proceedings of the 2022 Conference of Russian Young Researchers in Electrical and Electronic Engineering, ElConRus.. – P. 831-833. https://doi.org/10.1109/ElConRus54750.2022.9755649. (in Eng.)

Rybin V.V., Konstantinov K.N., Kagan M.M., Panasenko I.G. (2020) Principles of Organization of a Comprehensive System for Monitoring the Stability of Mining Enterprise Facilities. Gornyi Zhurnal. –1. – P. 53–57. DOI: 10.17580/gzh.2020.01.10. (in Eng.)

Sevryugina N.S., Melikhova S.B., Volkov E.A. (2015) The Solution of Applied Problems of Optimization of Stability of System "Environment-Man-Technics. Mathematical Models and Methods in Applied Sciences.. – 9. – 200. DOI: 10.5539/mas.v9n3p200. (in Eng.)

Sevryugina N.S., Stepanov M.A. (2017) Vertikal'nyj transport: korrektirovka resursa po kriteriyu bezopasnosti [Vertical transport: resource by the criterion of safety]. Inzh.-Stroit. Zh. – 7. – Pp. 23–36. doi: 10.18720/MCE.75.3 (In Russian)

Tikunova S.V., Kalinina G.N., Bolshakov A.G. (2023) Principles of urban planning organization of the park in Irkutsk. Bulletin of BSTU named after V.G. Shukhov. – 7. – P. 27–36. DOI: 10.34031/2071-7318-2023-8-7-27-36. (In Russian)

Tumanov M.V., Gendler S.G., Kabanov E.I., Rodionov V.A., Prokhorova E.A. (2022) The results of experimental studies of the thermal regime of oil mines in the thermal method of oil production. Mining Informational and Analytical Bulletin.– (6-1). – P. 230–247. https://doi.org/10.25018/0236_1493_2022_61_0_248. (In Eng.)

Yarushkina N.A., Matyugina E.G., Kerb O.M. (2022) Vybor postavshchika resursov dlya kompanii ugol'noj promyshlennosti [Selecting assets supplier for coal mining company]. Gornyi zhurnal. – 2022. – 3. – P. 13–18. DOI: 10.17580/gzh.2022.03.03. (In Russian)

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