AP19680292 “Development of an expert system of decision-making on the issues of fastening and maintenance of mine workings” - p.m. Tomilov A.N.

Relevance

The main difference of the developed software product is the use of both heuristic and algorithmic methods, which allows giving the most optimal query result.

The knowledge base of the expert system contains rules (or the other knowledge representations), using them as the basis for decision-making. The output mechanism contains general knowledge about the problem-solving management scheme. This mechanism contains two components: an interpreter and a dispatcher. The first of them determines how to apply the rules for the output of new knowledge, and the second one establishes the order of application of these rules. The knowledge base editor is designed to modify the rules of the expert system, as well as to enter new knowledge into the expert system.

Project objective

The objective of the project is to develop a domestic expert system aimed at presenting solutions on the issues of supporting mine workings using both heuristic and algorithmic methods, which allows giving the most optimal query result. The knowledge base and the main software of the expert system are supposed to be hosted using cloud technologies.

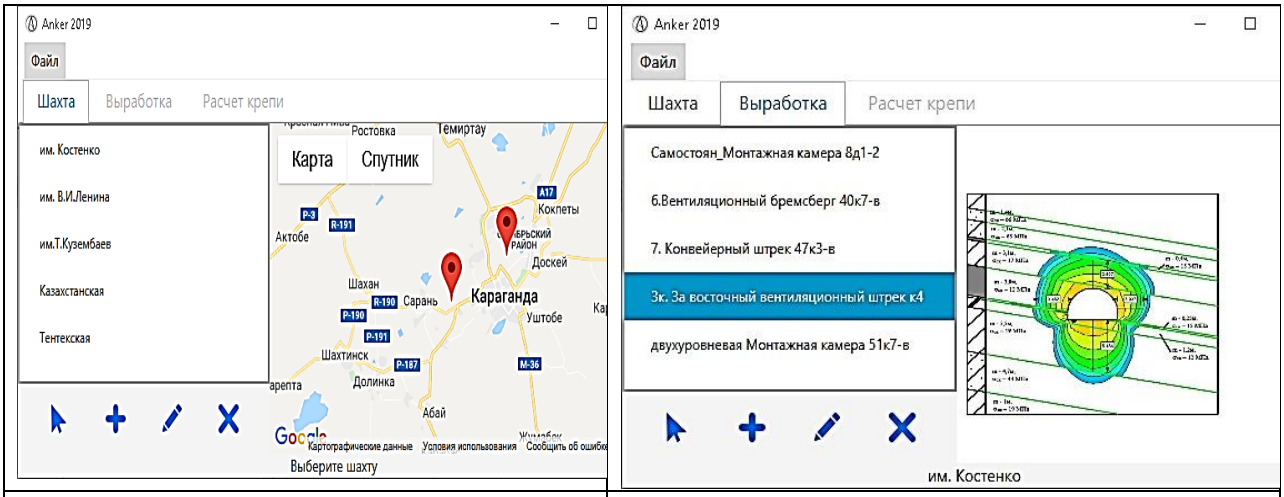
Expected and achieved results

The main result of the project implementation is the creation of a domestic expert system aimed at presenting solutions on issues of fastening and maintaining mine workings using both heuristic and algorithmic methods. Cloud technologies are supposed to be used to host the knowledge base and the main software of the expert system. The result of using the expert system will be the proposal of optimal parameters of various types of support for any sections of mine workings, parameters and methods of protecting mine workings, determining destruction zones in the vicinity of workings taking into account changes in mining and geological and mining conditions for the development of mineral deposits, taking into account the time factor, allowing you to determine the expected displacements and loads. The modular structure of the expert system suggests further expansion to solve a wide range of geomechanics problems.

There was developed software for a working prototype of the expert system consisting of modules: a knowledge base, a knowledge base editor, a system solver and a solution output. The expert algorithms are based on artificial intelligence and machine learning methods, which ensures the processing and analysis of data on the state of mine workings, forecasting the state of the support and generating recommendations. The knowledge base is filled with information about fastening systems, mining characteristics and mining and geological parameters. The solver uses this data to forecast and generate recommendations. A stack of modern technologies, including Laravel and PostgreSQL, was used to develop the system, which guarantees the reliability and performance of the expert system.

The purpose of the developed software (SW) module of the knowledge base is to accumulate data on support systems, mining and geological characteristics of rocks, mining and technical features of workings, as well as rules and patterns necessary for the correct operation of the expert system. To enable users to add, edit and update information, adapting recommendations depending on changing conditions and accumulated experience.

Figure 1 shows the algorithm for selecting a mine, workings and calculating the roof bolting.



Defining mines	Defining mine workings

Figure 1 – The process of defining mine workings

Figure 2 shows roof displacement nomograms: these are graphical tools that allow quick determining the values of various parameters using graphical dependences.

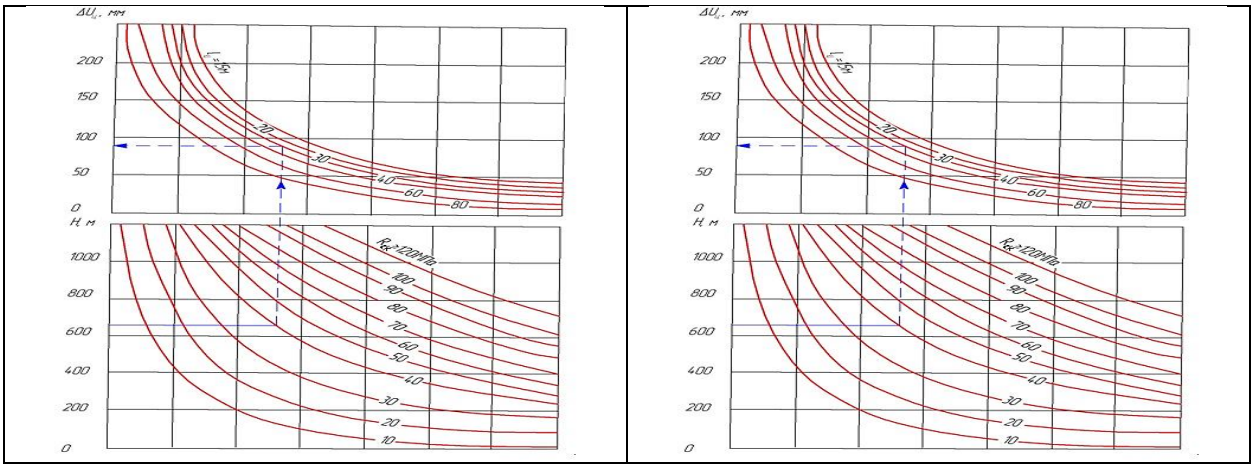


Figure 2 – Nomograms of determining the roof displacements

Figure 3 shows the Graph Grabber program. To get numerical data from graphs, one needs to upload an image of the graph from which one wants to extract data for further use in scientific research.

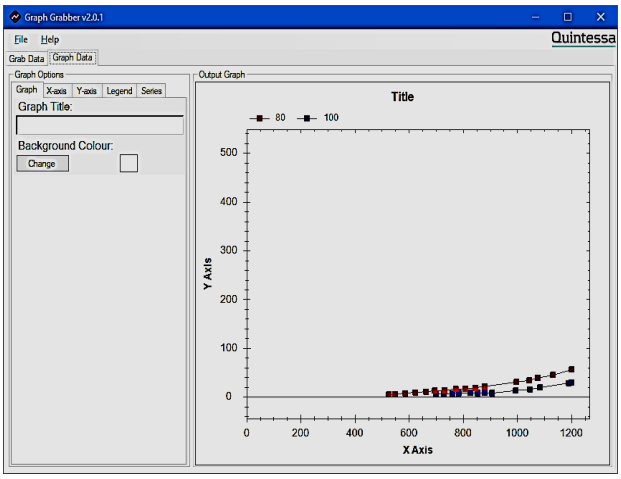


Figure 3 – Graph built in the *Graph Grabber* program

Figure 4 shows the operation diagram of the artificial neural network algorithm, including the stages of forward and backward error propagation.

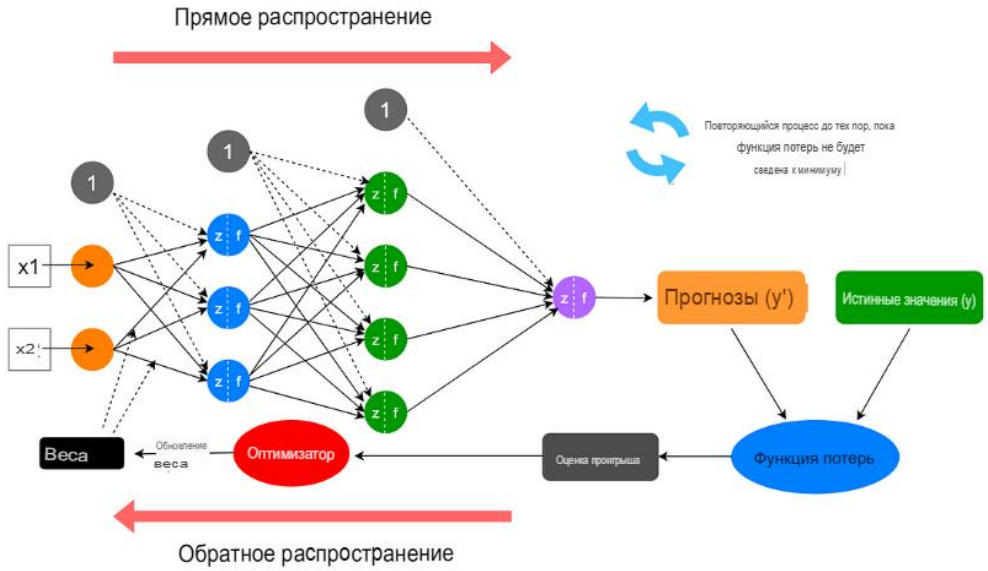


Figure 4– The process of learning an artificial neural network

Figure 5 shows the architecture of an artificial neural network (ANN), showing its key elements and operating principles.

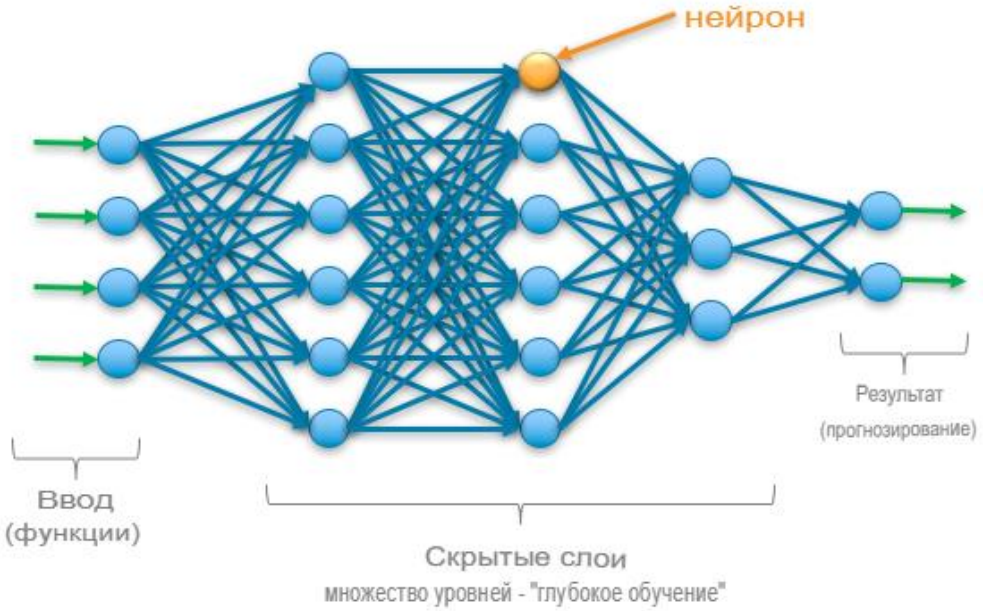


Figure 5 – Deep learning architecture with a multilayer neutral network

Figure 6 shows the ETL (Extract, Transform, Load) process diagram, one of the key methods of processing data for subsequent analysis or storage..

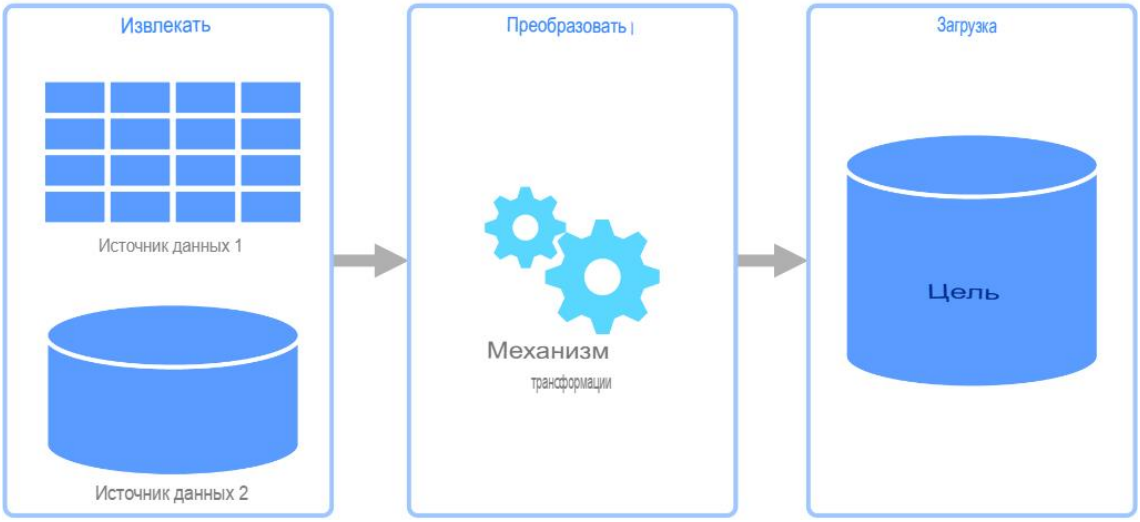


Figure 6 –The ETL diagram: (Data Extract, Transform, Load)

Research team

1. Tomilov Alexander Nikolaevich – project manager, PhD, head of the laboratory of the ICS Department. Hirsch index – 1, ORCID ID 0000-0002-0491-1640, Scopus ID 57201117035

2. Kalinin Aleksey Anatolyevich - responsible executor, PhD, head of the ICS Department. Hirsch index -2, ORCID 0000-0003-4699-7240, Scopus Author ID 57193550259

3. Demin Vladimir Fedorovich – Dr. Eng., Pofessor of the MDD Department. Hirsch index – 3, ORCID ID: 0000-0002-1718-856x, Scopus ID: 57212219714.

4. Tomilova Nadezhda Ivanovna - PhD, Associate Professor of the ICS Department. Hirsch Index – 1, ORCID ID: 0000-0001-8782-5627; Scopus ID: 57194212148

5. Mutovina Natalya Viktorovna - PhD, senior lecturer of the ICS Department. Hirsch Index – 1, Scopus ID: 57218196942 ORCID ID: 0000-0002-8116-9507, Researcher ID Web of Science: ABC-3961-2020

6. Smagulova Assemgul Serikovna - PhD, senior lecturer of the ICS Department. Scopus Author ID: 57216143249, Researcher ID: AGX-6097-2022 ORCID ID: 0000-0003-1534-1644

7. Shtefan Kirill Borisovich - M.Eng., Head of the Software Center. Hirsch Index – 1, ORCID 0000-0003-3174-7214

8. Nurtai Margulan Dauituly - M.Eng., lecturer of the ICS Department. Hirsch Index – 1, Scopus ID 57216143287

List of publications

Articles from the Scopus database having percentile no less than 65 (sixty five).

1. Vladimir Demin, Alexey Kalinin, Murat Baimuldin, Alexander Tomilov, Natalya Mutovina, Assemgul Smagulova, Denis Shokarev, Samat Aliev, Assem Akpanbayeva, and Tatiana Demina. Developing a Technology for Driving Mine Workings with Combined Support and Friction Anchors in Ore Mines https://www.mdpi.com/2076-3417/14/22/10344

2. Mutovina N., Smagulova A., Demin V., Baimuldin M., Tomilov A. Development of an Expert System for Fixing and Maintaining Mine Workings in the Mining Industry. University Proceedings, No.3, 2023. P.400-406. DOI 10.52209/1609-1825_2023_3_400

- 4 (four) articles and/or reviews will be published in peer-reviewed scientific journals indexed in Science Citation Index Expanded and included in the 1st (first) and/or 2nd (second) quartile by impact factor in the Web of Science database and/or having a CiteScore percentile in the Scopus database of at least 65 (sixty-five).

- 3 (two) articles or reviews will be published in a peer-reviewed foreign or domestic publication recommended by the CQASHE.

Information for potential consumers

The Mine Support Expert System can be useful for anyone working or researching in the field of mining and underground construction, providing analytical data on rocks, assessing the stability of mine workings and developing methods for their maintenance. Companies specializing in the construction of mines, tunnels, underground structures and mining facilities can use the system to develop and apply optimal methods of support and maintenance. The system provides the user with not only information and recommendations, but also tools for making informed and well-founded decisions, which helps improve the safety, efficiency and reliability of mining and construction projects.

Scope

Mine surveying and geotechnical services of mining enterprises, allowing them to make decisions on the support and maintenance of mine workings in a short time based on empirical and algorithmic methods. The regulatory methods of calculating the parameters of mine working included support in the knowledge base ensure compliance with all the safety rules for mining operations adopted in the Republic of Kazakhstan.

Date of information updating: 08/11/2024