Education Reform and Development, 2024, Volume 6, Issue 5
https://ojs.bbwpublisher.com/index.php/ERD
Online ISSN: 2652-5372
Print ISSN: 2652-5364

Discussion on the Application of Artificial Intelligence Technology in Mining Geological Exploration

Xiuliang Zhang, Tadiwa Elisha Nyamasvisva, Chuntao Liu*

Infrastructure University, Kuala Lumpur, Malaysia

Corresponding author: Chuntao Liu, 232924053@s.iukl.edu.my

Abstract: With the rapid development of science and technology, artificial intelligence technology has been widely used in various fields, including mining geological exploration field is no exception. Artificial intelligence technology has brought revolutionary changes to mining geological exploration, its application in mining geological exploration, not only can improve the efficiency and accuracy of mining geological exploration, but also greatly reduce the cost of mine exploration, and improve the safety and reliability of exploration. At present, the application of artificial intelligence technology in mining geological exploration, mainly three-dimensional visual technology, machine learning algorithm, remote sensing image recognition technology, natural language processing technology, intelligent data analysis technology, and so on, has provided strong support for mining geological exploration work.

Keywords: Artificial intelligence technology; Mining geological exploration; 3D visual technology; Machine learning algorithm

Online publication: June 20, 2024

1. Introduction

With the development of the global economy, the exploitation and utilization of mine resources are becoming increasingly important. However, at present, the geological exploration of mines still faces a series of challenges such as complex site environments, bad climatic conditions, and high exploration costs. Therefore, for the mining industry, ways to improve the efficiency and accuracy of mining geological exploration, reduce the exploration cost, and improve the exploration safety and reliability, have become an urgent problem to be solved. In recent years, the rapid development of artificial intelligence technology has provided more possibilities for the development of mining geological exploration. With its powerful data processing ability and self-learning ability, artificial intelligence technology has shown great potential in the field of mining geological exploration. In mining geological exploration, the introduction of artificial intelligence technology can realize more accurate data collection, processing, and analysis, thus greatly improving the efficiency and accuracy of exploration work.

2. The application advantages of artificial intelligence technology in mining geological exploration

2.1. Improve the exploration efficiency

Traditional mining geological exploration often relies on manual field survey and data processing, the overall work efficiency is low, and the exploration results are easily affected by human factors. However, the application of artificial intelligence technology can realize the rapid processing and analysis of massive data, and automatically complete part of the exploration work, thus greatly improving the exploration efficiency [1]. For example, the calculation and analysis of geological data through a machine learning algorithm can realize the automatic identification and prediction of ore body distribution, ore body shape, and other characteristics, thus greatly reducing the exploration cycle [2].

2.2. Enhance the exploration accuracy

In mining geological exploration, the application of artificial intelligence technology can analyze relevant data through methods such as big data analysis and pattern recognition to find geological features that are difficult to detect by traditional exploration methods. In addition, the use of three-dimensional visualization technology in mining geological exploration can also visually present geological data in the form of three-dimensional models, helping explorers to more accurately understand the distribution and characteristics of underground ore bodies, to improve the exploration accuracy.

2.3. Reduce the exploration cost

The application of artificial intelligence technology in mining geological exploration can reduce the human, material, and financial input in the exploration process in a more automated and intelligent way, thus reducing the exploration cost. For example, the use of unmanned aerial vehicles and remote sensing technology to quickly survey and monitor the entire mining area, thus greatly reducing the time and labor costs of field exploration [3]. In addition, through intelligent data analysis technology, survey data can be accurately screened and optimized, reducing unnecessary survey work and further reducing survey costs.

3. The application of common artificial intelligence technology in mining geological exploration

3.1. Three-dimensional visual technology

In mining geological exploration, 3D visual technology is an important form of artificial intelligence technology application. Through the use of 3D visual technology, surveyors can more intuitively and comprehensively understand the geological structure of the mining area and the distribution of mineral resources [4]. 3D visualization technology can convert a large number of geological data into 3D images so that the exploration personnel can more clearly observe the form, occurrence, spatial distribution, and other information of the underground ore body. In addition, 3D visual technology can also be combined with geographic information systems to realize the comprehensive management and visual display of geological information in mining areas, thus greatly improving the efficiency and accuracy of exploration work.

In mining geological exploration, 3D visual technology can be applied in many aspects. For example, in the initial stage of mine exploration, surveyors can use 3D visual technology to simulate and analyze the geological environment of the entire mining area, to provide reliable support for high-quality follow-up exploration work. In addition, in the process of mine exploration, surveyors can use 3D visual technology to monitor and analyze the form and specific distribution of underground ore bodies in real time to discover changes and anomalies of

ore bodies in time and provide timely and accurate information support for exploration work [5]. At the end of the exploration, the surveyor can also use three-dimensional visual technology to summarize and display the exploration results and provide comprehensive data support for mine development and resource utilization.

3.2. Machine learning algorithm

In mining geological exploration, the machine learning algorithm is also an important embodiment of the application of artificial intelligence technology. During the exploration process, by training a large amount of geological data, the machine learning model can predict the distribution, mineralization degree, and mining value of the ore body. For example, classification algorithms based on support vector machines (SVM) or Random Forest can automatically identify and classify different ore body types based on characteristics such as the physical properties, chemical composition, and geophysical data of rocks [6–7]. Deep learning algorithms such as convolutional neural networks (CNN) and recurrent neural networks (RNN), which perform well in processing image and sequence data, can be applied to tasks such as remote sensing image analysis and groundwater table prediction [8].

3.3. Remote sensing image recognition

In mining geological exploration, remote sensing image recognition is another important application of artificial intelligence technology. In mining exploration work, surveyors can obtain key information such as surface morphology, vegetation coverage, and water system distribution in mining areas through high-resolution satellite or aerial remote sensing images. The combination of remote sensing image recognition and machine learning algorithms can automatically interpret and recognize these images, quickly discover geological features such as mineralization outcrop, ore body outcrop, and alteration zone, and provide strong technical support for mining geological exploration [9]. The practical application of remote sensing image recognition technology can assist surveyors in quickly determining the exploration area and exploration route, and reduce the blindness and uncertainty of field exploration. At the same time, through the continuous monitoring and analysis of remote sensing images, environmental changes and resource changes in mining areas can also be found in time, which provides an important basis for mine resource management and environmental protection.

3.4. Natural language processing

Natural language processing (NLP) technology also has potential application value in mining geological exploration. Although mine exploration work mainly relies on geological data and image analysis, a large number of exploration reports, technical documents, and communication information still exist in text form [10–11]. NLP technology can automatically extract and analyze these textual data, extract key information, identify geological features, and even predict the distribution and mining value of ore bodies. For example, through NLP technology, a large number of exploration reports can be automatically summarized and classified, helping surveyors quickly understand the geological conditions and exploration progress of various regions [12]. In addition, NLP can also be used for automatic retrieval and information extraction of geological literature, providing a rich knowledge base and reference information for exploration work.

3.5. Intelligent data analysis

In mining geological exploration, intelligent data analysis is another important application of artificial intelligence technology. Intelligent data analysis includes deep mining, pattern recognition, and predictive analysis of massive geological data. Through intelligent data analysis, geological patterns that are difficult to detect by traditional methods can be found, and the potential distribution and resource reserves of ore

bodies can be predicted, providing a scientific basis for mine planning and mining [13]. In mining geological exploration, intelligent data analysis can also be applied to many aspects. For example, in the pre-processing stage of mining geological survey data, technologies such as data cleaning, de-noising, and normalization can be used to improve the quality and availability of data. In the mining exploration pattern recognition stage, cluster analysis, classification algorithm, and association rule mining can be used to find potential patterns and association relationships in geological data, to provide important guidance for mine mining and resource management [14–15]. In addition, in the predictive analysis stage, it can use time series analysis, regression analysis, and neural network models to predict and analyze the distribution of ore bodies, mining value, and resource utilization trends, to provide support for the long-term planning and decision-making of the mine.

4. The specific application cases of artificial intelligence technology in mining geological exploration

4.1. Project overview

The following is a specific introduction through a practical case to show the application of artificial intelligence technology in mining geological exploration more specifically. This case is located in a large iron ore deposit in southwest China, where the exploration work is faced with a complex geological environment and harsh climatic conditions. To improve the efficiency and accuracy of the exploration, the exploration unit introduced a variety of artificial intelligence technologies, including three-dimensional visual technology, machine learning algorithms, remote sensing image recognition, natural language processing, and intelligent data analysis.

4.2. Application process

4.2.1. Application of 3D visual technology

In the early stage of exploration, the exploration unit used 3D visual technology to conduct a comprehensive simulation and analysis of the geological environment of the mining area. By collecting and integrating a large amount of geological data, including strata structure, rock type, orebody distribution, and so on, a three-dimensional geological model was established. The model can intuitively show the geological structure and mineral resource distribution of the mining area, and provide strong decision support for the subsequent exploration work. In the process of exploration, surveyors use 3D visual technology to monitor and analyze the form and distribution of underground ore bodies in real time, find the changes and anomalies of ore bodies, and provide timely and accurate information support for exploration work. At the end of the exploration, the exploration unit uses three-dimensional visual technology to display and summarize the exploration results, providing comprehensive data support for mine development and resource utilization.

4.2.2. The application of machine learning algorithms

During the exploration, the exploration unit used the machine learning algorithm to predict the distribution, mineralization degree, and mining value of the ore body. By training a large amount of geological data, the machine learning model can automatically identify and classify different ore body types, and predict the spatial distribution and mining value of the ore body. These prediction results provide a scientific basis for mine planning and mining and effectively improve the efficiency and economic benefits of mine production.

4.2.3. Application of remote sensing image recognition

In the early stage and process of exploration, the exploration unit used remote sensing image recognition technology to extract and analyze key information such as surface form, vegetation cover, and water system

distribution of the mining area. Through high-resolution satellite or aerial remote sensing images combined with machine learning algorithms, surveyors quickly discovered geological features such as mineralized outcrop, orebody outcrop, alteration zone, and so on, providing strong technical support for mining geological exploration. At the same time, through the continuous monitoring and analysis of remote sensing images, the exploration unit also found the environmental changes and resource changes of the mining area in time, which provides an important basis for mine resource management and environmental protection.

4.3. Application effect

Through the introduction and application of various artificial intelligence technologies, remarkable results have been achieved in the exploration of ore deposits. On the one hand, the exploration efficiency and accuracy have been greatly improved, the exploration cycle has been shortened, and the exploration cost has been reduced. On the other hand, through 3D visual technology and intelligent data analysis technology, surveyors have a more comprehensive understanding of the geological structure of the mining area and the distribution of mineral resources, providing more accurate and comprehensive data support for mine development and resource utilization. In addition, through remote sensing image recognition technology and natural language processing technology, the exploration unit also found the environmental changes and resource changes in the mining area in time, providing strong support for mine resource management and environmental protection.

5. Conclusion

With the continuous development and application of artificial intelligence technology, its application in the field of mining geological exploration will be more and more extensive and in-depth. In the mining exploration work, through the introduction and application of a variety of artificial intelligence technologies, such as three-dimensional visual technology, machine learning algorithm, remote sensing image recognition technology, and so on, it can not only improve the efficiency and accuracy of mining geological exploration, shorten the exploration period, reduce the exploration cost, but also allow a more comprehensive understanding of the geological structure of mining areas and the distribution of mineral resources, thus providing more accurate and comprehensive data support for mine development and resource utilization.

Disclosure statement

The authors declare no conflict of interest.

References

[1] Li G, Li ZW, Chen H, et al., 2024, Application Analysis of Edge Computing in Smart Mine Construction. Journal of North China University of Science and Technology, 21(01): 1–11.

[2] Liu ZH, Yu QM, Niu JQ, et al., 2023, Impact of Big Data and Artificial Intelligence on the Development of Geological Prospecting and Industrial Prospecting Technology. Digital Technology and Application, 41(12): 58–60.

[3] Huang YG, 2023, Research on Methods and Techniques of Geological Exploration for Mines. World Nonferrous Metals, 2023(21): 103–105.

[4] Chen ZM, 2023, Application of Surveying and Mapping Geographic Information Technology in Geological Exploration. Information Systems Engineering, 2023(10): 47–50.

[5] Wang MG, Xu LN, Wang CB, et al., 2023, Construction Practice of Geological Prospecting Information Service

Platform in Yunnan Province based on Big Data Technology. Proceedings of the Second National Mineral Exploration Conference.

[6] Cui JH, 2023, Research on Exploration Technology and Method Innovation in Geological Prospecting. Metallurgy and Materials, 43(08): 124–126.

[7] Bai LJ, 2023, Application of Computer and Artificial Intelligence Technology in Mining Geological Exploration. World Nonferrous Metals, 2023(15): 16–18.

[8] Wang XF, 2023, Research on Development Strategy of Intelligent Construction of Green Mine based on Artificial Intelligence Technology. World Nonferrous Metals, 2023(15): 196–198.

[9] Wu ZL, 2023, The Role of UAV and Artificial Intelligence in Mine Topography Survey and Analysis. World Nonferrous Metals, 2023(13): 40–42.

[10] Liu C, Li Q, Li X, et al., 2023, Development Trend of Modern Mineral Geological Exploration and Prospecting Technology. World Nonferrous Metals, 2023(13): 76–78.

[11] Zhang L, 2023, Digital Transformation and Intelligent Management of Mines. World Nonferrous Metals, 2023(12): 232–234.

[12] Liu M, 2022, Application of Artificial Intelligence Technology in the Design of Mine Electrical Automation Control System. Mining Equipment, 2022(05): 131–133.

[13] Chi WJ, 2022, Application of Remote Sensing Technology and GIS in Geological Exploration. Engineering Construction and Design, 2022(18): 85–87.

[14] Li FY, Ji XW, Zhang WG, et al., 2022, Development and Application Scenario Analysis of 5G Technology in Smart Mine. China Mining Engineering, 51(04): 89–92.

[15] Wan ZZ, 2022, Application of New Geophysical Exploration Technology in Complex Geological Exploration. Western Resources, 2022(04): 90–92.