Research On the Application of Intelligent Technology in Mining Safety Monitoring

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Abstract. Safe mining of mineral resources is of great practical significance to energy supply, industrial production and social and economic development. With the development of science and technology, mining innovation is the necessary measure and development trend to solve the safety problem. In order to reduce the occurrence of risks, the intelligent mining platform is used to improve the production safety factor of mining. Based on the integration of modern information technology and mining safety, this paper mainly analyzes the application of intelligent mining safety risk technology in the background of intelligent mine construction. The research results show that: based on building information model (BIM), Internet of Things (IOT) and artificial intelligence technology, intelligent identification, tracking and positioning, monitoring, remote control, establishment of emergency rescue model to assist decision-making, disaster warning and other functions are realized. The application of intelligent technology in mining safety monitoring has greatly improved the level of mining safety information and intelligence.

Keywords: Intelligent technology; mining safety; BIM; artificial intelligence.

1. Introduction

Mining, as one of the main sources of energy acquisition, provides a large number of raw materials such as coal, iron ore, natural gas, oil, etc., providing strong support for the country's energy supply and industrial production. In recent years, China's mining industry has developed rapidly, and the market size has been continuously expanding. As of the end of 2019, the total output value of China's mining industry reached 10.75 trillion yuan. The country is continuously increasing investment in traditional energy sources such as coal, oil, and natural gas to ensure energy security, which will bring more opportunities to the Chinese mining industry. According to data from the National Bureau of Statistics, the added value of China's mining industry in 2022 increased by 7.3% compared to the previous year, accounting for 7.3% of the gross domestic product [1]. According to data from the General Administration of Customs, the total import and export volume of China's mining industry in 2022 was 1.23 trillion US dollars, an increase of 6.5% compared to the previous year. Among them, the export value was 0.49 trillion US dollars, an increase of 8.9%; The import value was 0.74 trillion US dollars, an increase of 4.8%; The trade deficit was 0.25 trillion US dollars, expanding by 15.7%.

From miners to mine safety management personnel, from mechanical equipment manufacturing to service personnel, the mining industry provides many job positions for society, which not only alleviate employment pressure but also promote the development of related enterprises. Mining has also made tremendous contributions to economic development, and some cities have become prosperous areas due to the mineral industry. Many institutions and companies have also been able to operate due to mineral mining. The cross-border trading of minerals brings economic benefits to the country and also provides support for national output and taxation. Therefore, the safe mining of minerals is of great practical significance for energy supply, industrial production, social and economic development.

There are many dangers in the mining process. Whether it is natural disasters such as earthquakes or mine collapses, inadequate personnel safety awareness, or inadequate management systems, they will pose a threat to the personal safety of workers. In the past few decades, traditional mining techniques have mainly used methods such as blasting, which poses significant safety hazards. With the development of science and technology, the mining industry must innovate to address these safety

issues. Therefore, focusing on the main problems of mining safety in China, this paper integrates modern information technology with mining safety and proposes the application research of intelligent technology based on text research in safety detection.

2. Application of Intelligent Technology in Mining Safety Monitoring

The smart mining platform utilizes information technology to actively perceive, automatically analyze, and quickly process production activities such as mining and processing, business management, environmental protection and safety, and logistics support, in order to achieve efficient, safe, and clean mining operations. A smart mine is an intelligent mine that actively perceives, automatically analyzes, and quickly processes production, occupational health and safety, technology, and logistics support. The digitization and informatization of mines are the prerequisite and foundation for the construction of smart mines. Fig. 1 shows the technical features of smart mining.

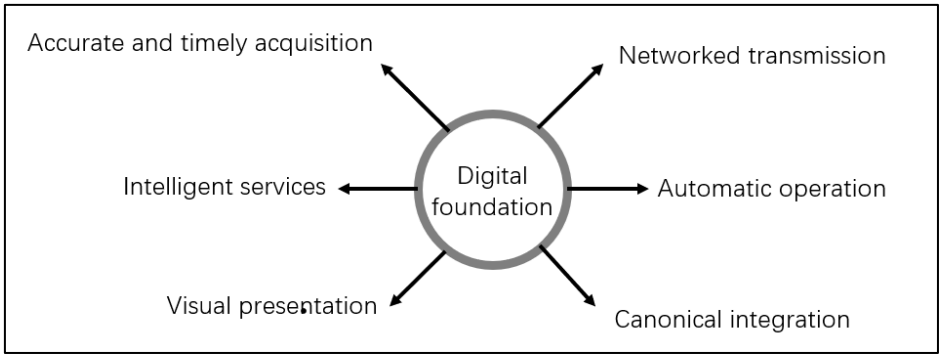

Fig. 1 Characteristics of Smart Mining Technology [2]

2.1. Application of Building Information Modeling (BIM) Technology in Smart Mines

BIM was first proposed by the American company Autodesk in 2002. BIM technology integrates various engineering information into a three-dimensional model information database throughout the entire lifecycle of a building and provides a virtual scientific collaborative management platform for managers through digital models. This enables the entire engineering project to effectively save resources, reduce costs, improve efficiency, and prevent pollution at all stages, promoting sustainable development [3].

2.1.1 Mining simulation

BIM can use 3D technology to create a three-dimensional model of the mining work area, achieving visualization of the mining process. In BIM software, designers can design drawings and construction technology plans, construct a 3D model, annotate all process parameters and related information in the model, and demonstrate the construction process in an animated format. This helps construction personnel to have a more intuitive understanding of the construction process and intention, master the key points of construction operations and correct process practices, accumulate experience, and reduce safety risks caused by unfamiliarity with the work process. The simulation function module of BIM technology can also maximize the analysis of emergency rescue models, demonstrate corresponding emergency rescue scenarios, and minimize the adverse effects caused by safety hazards.

2.1.2 Disaster warning

BIM technology supports the setting and processing of industrial equipment pipeline networks. By using simulation analysis and visualization modules, dynamic operation trajectories and status can be displayed, and even dynamic monitoring data can be summarized in a timely manner as a safety warning result, which can better guide relevant operators to carry out standardized maintenance and repair work, improve the comprehensive operation level of equipment, and reduce safety problems caused by improper maintenance and repair processing. BIM technology supports rehearsal analysis

of potential hazards, establishes an integrated processing system using the Revit platform, and creates a complete safety management system. With project information management, hazard source analysis management, safety information summary, and sub functions as the core, a complete real-time analysis and control system for various on-site elements is constructed, and real-time tracking and management of on-site safety signs, hazardous materials, and large machinery are carried out.

2.2. Internet of Things (IOT) Technology

IOT is a network composed of peripheral technologies such as radio frequency identification and information sensing, which connects information and items. It also has multiple functions such as intelligent identification, tracking and positioning, supervision, and remote control, freeing itself from the limitations of time and space on information exchange. Workers can remotely observe the real-time status of connected devices and items in the IOT and issue control commands remotely. In mining activities, IOT technology is mainly used for quality inspection, equipment and material tracking and positioning, and on-site monitoring scenarios.

2.2.1 Remote control

Considering that the existing equipment management system of the coal mine is too affected by human factors to know the status of all equipment in time, Zhang Han and others have established a dynamic management system of coal mine equipment based on "Internet plus" on the Internet of Things platform of the mine. In response to the characteristics of large-scale collaborative control of mining IOT production equipment, strict temporal constraints, and local control [4]. Li Xueen et al. established a multi-level collaborative control model for mining IOT production equipment and constructed a collaborative control system for mining IOT production equipment based on parallel management [5]. Wang Haijiang utilized mining Internet of Things technology to build an automated equipment management inspection system for coal preparation plants, which monitors the real-time operation status of key equipment and transmits it to the centralized control OA system to guide equipment maintenance and repair work [6]. Gao Bin et al. designed an underground material management system based on the Internet of Things (IOT) to address issues such as chaotic material management and labor waste in coal mines. The system utilizes web technology to achieve real-time monitoring and management of the lifecycle of underground materials [7].

2.2.2 Security monitoring

The intelligent security system in the IOT provides human resource data, device information, and data from the six major systems through data center collection and processing. This mainly includes historical safety production data, mining personnel information, organizational data, and real-time data of mining tunnels. Building a unified identification system for mining equipment and locations based on the IOT platform and conducting on-site safety monitoring based on the identification information provided by the system. Integrate monitoring data from ventilation automation, dust detection equipment, noise detection equipment, etc., intelligently match relevant protective measures with possible occupational disease information based on employee positions and achieve precise prevention of occupational diseases. The organic integration of safety production information analysis and visualization in different media, diverse and heterogeneous safety risk information, realizes the entity and systematization of data analysis and visualization functions, and provides strong data support for different levels of safety management in mines. Security risk information analysis and visualization interface. Zhao Anxin and others combined the current application needs of mining enterprises and designed a detection platform for mining electromechanical equipment using IOT technology and cloud computing platform. This platform can remotely monitor the operation status of mining electromechanical equipment and perform fault diagnosis [8]. Fig. 2 shows the framework of the intelligent mining control system.

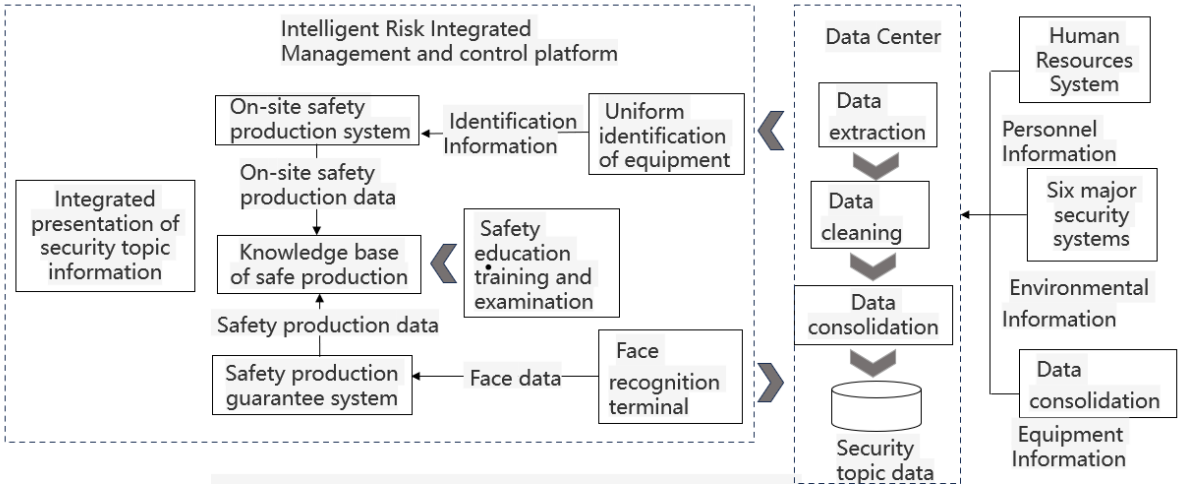

Fig. 2 Framework of Smart Mine Control System [9]

2.3. Artificial Intelligence Technology

Artificial intelligence refers to the ability of machines to make decisions and take action based on data analysis and trends. This field aims to develop systems that can learn and reason like humans, use experience to solve problems, compare data, and perform logical tasks [10]. In recent years, the application of artificial intelligence technology in the industrial field has gradually increased. Some enterprises have adopted artificial intelligence machinery to replace some manual operations. Applying artificial intelligence to the field of mine rescue will greatly improve the efficiency of mine emergency rescue work and enhance rescue safety.

2.3.1 Intelligent emergency rescue

In the emergency rescue process, artificial intelligence technology is used to analyze and evaluate the large amount of data collected and based on the comprehensive combat capabilities of the rescue team, intelligent suggestions are provided for on-site disaster emergency rescue decision-making. The use of artificial intelligence technology can comprehensively evaluate the real-time situation detected underground and the emergency rescue capabilities of mines and monitor the walking routes of economic personnel in real time, facilitating the formulation of more reasonable rescue decisions and achieving visualization and quantification of emergency rescue management work. If people are trapped due to the collapse of underground roof, water damage and other reasons, conventional detection methods are difficult to accurately locate the trapped people. Artificial intelligence robots can be used to accurately locate the trapped personnel, remotely analyze the data collected by the artificial intelligence robots, evaluate the threat of disasters, and develop rescue plans based on the positioning and evaluation results, thus achieving scientific rescue [11].

2.3.2 Monitoring personnel's physical condition

Equip personnel working on the front line of on-site rescue with explosion-proof smart watches, check the physical condition of rescue personnel at regular intervals, and collect real-time life and health data (pulse, temperature, blood pressure, etc.) of rescue personnel, and give real-time warnings based on the collection results. At the same time, smart watches can monitor the rescue environment in real time, timely issue threat reminders during the rescue process based on the rescue site situation, thereby improving the safety and security capabilities of rescue personnel.

3. Conclusion

In summary, mining is a high-risk work, with complex and ever-changing disaster situations and high safety risks. Intelligent technology has improved the effectiveness of emergency rescue in mines, provided technical support for scientific rescue decision-making in mines, and also provided safety

guarantees for rescue personnel. Safety production is a highly concerned theme in mining production and operation, and it is also an important part of the construction of intelligent mines. This paper starts from mining safety and analyzes the application of BIM, IOT technology, and artificial intelligence technology in mining safety. BIM technology systematically and multi-dimensionally simulates mining, analyzes work using emergency rescue models, and demonstrates corresponding emergency rescue scenarios to minimize the adverse effects caused by safety hazards. By utilizing the Revit platform to establish an integrated processing system, a complete security management system is created. IOT technology is used for remote control, and multiple usage functions such as intelligent identification, tracking and positioning, supervision, and remote control are used for security monitoring. This eliminates the limitations of time and space on information exchange. The system realizes on-site safety production system management, safety production guarantee, and dual safety prevention system control, effectively promoting real-time and accurate control of safety risks. Using artificial intelligence technology for emergency rescue intelligence, monitoring the physical condition of personnel and real-time monitoring of the rescue environment. Based on the situation of the rescue site, timely warning of threats faced during the rescue process is issued, thereby improving the safety and security capabilities of rescue personnel. In the application of safety risk control and mine rescue, there are drawbacks such as diversified safety subjects, unstable locations, uneven distribution, delayed data transmission, cumbersome management systems, and high requirements for personnel professionalism. In the subsequent research process, technical breakthroughs should be emphasized.

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