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Application of Artificial Intelligence Technology in Coal Mine Mechanical and Electrical Equipment

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Abstract: ***This article explores the application of artificial intelligence technology in coal mine electromechanical equipment. Firstly, the definition and development history of artificial intelligence were outlined. Then, the advantages of its application in the coal mining industry were elaborated, including improving equipment operating efficiency, enhancing fault diagnosis capabilities, improving safety assurance levels, and optimizing equipment maintenance management. Specific applications include unmanned coal mining, coal mine safety monitoring, intelligent power supply, ventilation and belt conveyor systems, as well as mechanical and electrical equipment fault diagnosis and maintenance. Although there are still areas for improvement in the application, it is expected to promote the intelligent, efficient, and safe production of the coal mining industry in the future, which will contribute to energy security and economic development.***

Keywords: Artificial intelligence; Coal mine electromechanical equipment; Fault diagnosis; Run optimization.

1. INTRODUCTION

In China's energy structure, coal has made significant contributions to the national economy. Ensuring the safe and efficient operation of the electromechanical system is crucial in coal mining operations. In the past, the mechanical and electrical management of coal mines relied on manual inspection and intuitive judgment, which was inefficient and prone to errors. With the rise of artificial intelligence, its application in the coal mine electromechanical field is increasingly deepening, opening up innovative paths for improving equipment performance, safety standards, and operational efficiency. This article will delve into the specific applications and advantages of artificial intelligence technology in coal mine electromechanical equipment, providing theoretical support and practical references for promoting the intelligent development of the coal mining industry. Jin (2025) proposed a PSO-enhanced ensemble model integrating LightGBM, XGBoost, and deep neural networks to optimize retail sales forecasting, demonstrating improved predictive accuracy[1]. In cybersecurity, Liu et al. (2025) developed a privacy-preserving hybrid ensemble model for network anomaly detection, addressing the trade-off between security and data protection[2]. For urban sustainability, Zhou et al. (2024) optimized a garbage recognition system using ResNet-50 and weakly supervised CNNs, enhancing waste management efficiency[3]. Wang and Liang (2025) applied reinforcement learning with graph neural networks and self-attention mechanisms to optimize supply chain routes, showing significant logistical improvements[4]. In computational efficiency, Xie et al. (2025) introduced RTop-K, a GPU-accelerated method for rapid top-K selection in neural networks, boosting training speeds[5]. Healthcare applications include Lin et al. (2025)'s study on intelligent exercise monitoring for ADHD children, which improved executive function[6], while Peng et al. (2025) examined how aerobic exercise intensity affects cognitive performance and sleep[7]. Xu et al. (2025) designed AI tools for cross-cultural game development, facilitating collaborative character design[8]. Lastly, Shen et al. (2025) explored an LSTM-based AI system for anesthetic dose management in cancer surgery, enhancing clinical precision[9]. These works collectively highlight ML's versatility in solving real-world challenges.

2. OVERVIEW OF ARTIFICIAL INTELLIGENCE TECHNOLOGY

Artificial intelligence refers to the ability of computer systems to possess human like intelligence, enabling them to engage in activities such as learning, reasoning, decision-making, perception, and language comprehension. It aims to simulate human cognitive processes, enabling computers to autonomously handle various complex tasks and provide more efficient and intelligent services for humans. The development of artificial intelligence can be traced back to ancient Greece, when people began to try to create machines that could simulate human intelligence. However, the true research on artificial intelligence began in the mid-20th century. In 1950, Alan Turing proposed the famous "Turing Test", which laid the theoretical foundation for the development of artificial intelligence. Afterwards, artificial intelligence mainly adopted symbolic methods to achieve intelligent behavior by writing

rules and logic. Machine learning enables computers to automatically learn patterns and patterns from data, enabling intelligent decision-making and prediction; Deep learning is a machine learning method based on neural networks, which can automatically extract features from large amounts of data and achieve modeling and analysis of complex data.

3. THE APPLICATION ADVANTAGES OF ARTIFICIAL INTELLIGENCE IN THE COAL MINING INDUSTRY

3.1 Improve equipment operating efficiency

In coal mine production, the efficient operation of mechanical and electrical equipment is the key to improving output and efficiency. Taking the coal mining machine as an example, different coal seam conditions have different requirements for the working parameters of the coal mining machine. Machine learning algorithms can be used to optimize and adjust the cutting speed, feed rate, and other parameters of the coal mining machine based on real-time coal seam data, so that it always operates in the best state, reducing equipment wear and energy consumption. For other key equipment such as ventilation fans and elevators, their operational requirements often change with changes in production conditions. Artificial intelligence dynamically adjusts the operating parameters of devices based on actual needs to achieve efficient energy utilization. During peak production periods, the ventilation fan automatically adjusts the ventilation volume based on real-time monitoring data of underground air quality, ensuring the safety of the underground environment while reducing energy consumption.

3.2 Enhance fault diagnosis capability

Traditional fault diagnosis of coal mine electromechanical equipment mainly relies on manual inspection and empirical judgment, which is inefficient and prone to missed detections. Relying on experience to diagnose faults often carries the risk of misjudgment, which may result in the failure to receive timely and accurate handling. The application of artificial intelligence technology can effectively solve these problems by installing various sensors on mechanical and electrical equipment to monitor real-time parameters such as temperature and pressure. Once these parameters are abnormal, the system can quickly capture changes and analyze them through deep learning algorithms. It also learns fault patterns from a large amount of historical fault data, quickly and accurately identifies fault types and locations, and provides detailed maintenance suggestions based on the fault situation to help maintenance personnel quickly develop solutions.

3.3 Enhance the level of security assurance

The production environment of coal mines is complex and the safety risks are high. Ensuring the safety of personnel and equipment is the primary task of the coal mining industry. Artificial intelligence technology can be combined with video surveillance and sensor data to comprehensively monitor the underground environment and equipment operation in coal mines, and use image recognition technology to monitor the behavior of underground personnel in real time, determining whether they are correctly wearing safety equipment and complying with operating procedures. Once personnel violate regulations, the system can immediately issue a warning to remind relevant personnel to correct them in a timely manner and avoid accidents. At the same time, intelligent sensors are used to monitor hazardous factors such as gas concentration and dust concentration in real time. When these factors exceed the safety threshold, the system can automatically start ventilation, dust reduction and other equipment to ensure the safety of the underground environment. For the safe operation of electromechanical equipment, real-time monitoring and analysis of equipment operating parameters can also be used to promptly identify safety hazards such as overheating and abnormal vibration.

3.4 Optimize equipment maintenance management

Good equipment maintenance management is the key to ensuring the long-term stable operation of coal mine electromechanical equipment. Artificial intelligence technology can provide scientific and efficient solutions for equipment maintenance management to avoid resource waste caused by excessive maintenance, and also prevent equipment failures caused by insufficient maintenance. At the same time, maintenance personnel can monitor the real-time operation status of the equipment in the remote monitoring center, and perform remote diagnosis and debugging of the equipment. When equipment malfunctions, maintenance personnel can use remote control technology for initial handling, buying time for on-site repairs. This improves maintenance efficiency and ensures timely repair and normal operation of equipment.

4. SPECIFIC APPLICATIONS OF ARTIFICIAL INTELLIGENCE TECHNOLOGY IN COAL MINE MECHANICAL AND ELECTRICAL EQUIPMENT

4.1 Application of Unmanned Coal Mining

4.1.1 Intelligent Mining Technology Solution

Intelligent mining is the future development direction of the coal mining industry, and artificial intelligence technology achieves automation and unmanned coal mining processes by constructing intelligent mining technology solutions. This plan includes multiple stages such as geological exploration, equipment selection, and mining planning. For example, artificial intelligence technology is used to analyze geological data, predict the distribution and thickness of coal seams, and provide accurate basis for mining planning; And optimize the performance of coal mining equipment through machine learning algorithms to improve the reliability and stability of the equipment.

4.1.2 Remote device positioning and control technology

In unmanned coal mining, remote equipment positioning and control technology utilizes global positioning system (GPS), wireless sensor network, etc. to achieve precise positioning and remote control of coal mining equipment. Operators can operate the equipment in the remote monitoring center, avoiding the harm of harsh underground environment to personnel. Real time acquisition of equipment position, speed, attitude, and other information through sensors installed on the coal mining machine, and transmission of this information to a remote monitoring center. Operators can remotely control the coal mining machine based on this information, adjust cutting parameters, and achieve efficient coal mining.

4.1.3 Unmanned mining practice of fully mechanized mining face

At present, some coal mines have started unmanned mining practices in fully mechanized mining faces, which have achieved automated collaborative operations of equipment such as coal mining machines, hydraulic supports, and scraper conveyors through the introduction of artificial intelligence technology. In the process of unmanned mining, equipment can automatically operate according to preset programs to complete tasks such as coal mining, support, and transportation. If artificial intelligence algorithms are used to control the movement of hydraulic supports and achieve automatic follow-up support; And through the coordinated control of the coal mining machine and scraper conveyor, efficient coal mining and transportation can be achieved.

4.2 Application of Intelligent Technology in Coal Mine Safety Monitoring

4.2.1 Construction of Intelligent Monitoring and Control System for Coal Mine Safety

Build an intelligent monitoring system for coal mine safety, using sensors, communication technology, artificial intelligence and other technologies to monitor and analyze real-time environmental parameters and equipment operation status underground. Once abnormal situations are detected, automatic warnings can be issued to remind relevant personnel to take timely measures. By installing gas sensors, carbon monoxide sensors, etc. underground, real-time monitoring of environmental parameters such as gas concentration and carbon monoxide concentration can be achieved. When these parameters exceed the safety threshold, the system can automatically issue a warning, activate ventilation equipment, and ensure the safety of the underground environment.

4.2.2 Application of sensors and monitoring equipment

In the intelligent monitoring system for coal mine safety, various sensors can be used to obtain real-time environmental parameters such as temperature, humidity, pressure, and gas concentration underground, as well as information on the operation status and location of equipment; The monitoring equipment can transmit this information to the remote monitoring center, achieving real-time monitoring of the underground environment and equipment. If temperature sensors are used to monitor the temperature of underground electrical equipment in real time, the system can automatically issue warnings when the temperature is too high, avoiding equipment fires. At the same time, using video surveillance equipment to monitor the behavior of underground personnel in real time, timely discovering illegal operations and safety hazards.

4.2.3 Establishment of Real time Monitoring and Early Warning Mechanism

The intelligent monitoring system for coal mine safety can analyze the data collected by sensors and monitoring equipment in real time, and timely discover safety hazards and abnormal situations underground. When the system detects abnormal situations, it can automatically issue warnings to remind relevant personnel to take timely measures. If artificial intelligence algorithms are used to analyze gas concentration data, when the gas concentration exceeds the safety threshold, the system can automatically issue a warning and activate ventilation equipment to reduce the gas concentration.

4.3 Intelligent power supply

4.3.1 Application of Grid Intelligent Technology in Coal Mine Power Supply System
The intelligent technology of power grid can achieve real-time monitoring and control of power load and optimize power supply schemes through intelligent transformation of the power supply system. And use intelligent protection devices to achieve rapid fault diagnosis and isolation of the power supply system, improving the safety of the power supply system. If smart meters can be used to monitor changes in power load in real time, automatically adjust the power supply plan according to the load situation, and achieve energy conservation and consumption reduction; And the use of intelligent protection devices can quickly and accurately determine the type and location of faults in the power supply system, isolate and repair them, and shorten the power outage time.

4.3.2 Data Detection and Fault Analysis

In the coal mine power supply system, data detection and fault analysis are the use of sensors and monitoring equipment to collect real-time voltage, current, power and other data of the power supply system, analyze and process these data, timely discover potential faults in the power supply system, and issue warnings and treatments. If current transformers and voltage transformers are used to monitor the changes in current and voltage of the power supply system in real time, the system can automatically issue warnings when there are abnormal fluctuations in current or voltage, reminding relevant personnel to inspect and handle them. Alternatively, artificial intelligence algorithms can be used to analyze historical fault data, establish fault diagnosis models, and improve the accuracy and efficiency of fault diagnosis.

4.3.3 Data recording, follow-up and presentation

It records and revisits the operating data of the power supply system to understand the system's operation and fault occurrence patterns, providing a basis for system optimization and improvement. If a data logger is used to record and store real-time operational data of the power supply system, it will facilitate management personnel's follow-up and analysis; Alternatively, visualization software can be used to display the operational data of the power supply system in the form of charts, such as voltage curves, current curves, power curves, etc., to facilitate management personnel to intuitively understand the system's operating conditions.

4.4 Application in Ventilation System and Belt Conveyor System

4.4.1 Design of Energy saving Mine Ventilation Control System

The ventilation system is an important guarantee for coal mine safety production. It uses sensors and monitoring equipment to collect real-time environmental parameters such as gas concentration, carbon dioxide concentration, and temperature underground, and transmits these parameters to the ventilation control system. Based on these parameters, the speed and air volume of the ventilation fan are automatically adjusted to achieve intelligent control of the ventilation system. And using artificial intelligence algorithms to analyze the operating data of the ventilation system, optimize the operating parameters of the ventilation system, improve ventilation efficiency, and reduce energy consumption.

4.4.2 Research on Belt Conveyors Driven by Artificial Intelligence

It monitors and analyzes the operating status of the belt conveyor in real time, promptly identifies potential equipment faults, and provides early warning and handling. Simultaneously utilizing artificial intelligence algorithms to predict and optimize the transportation volume of belt conveyors can improve transportation

efficiency and reduce energy consumption. If sensors and monitoring devices are used to collect real-time parameters such as operating speed, current, temperature, etc. of the belt conveyor, and transmit these parameters to the belt conveyor control system. The control system of the belt conveyor can automatically adjust the operating speed and tension of the conveyor based on these parameters, achieving intelligent control of the belt conveyor.

4.4.3 Intelligent upgrade of mine hoist

Mine hoist is a key equipment in coal mine production, and the intelligent upgrade of mine hoist can be achieved through the use of artificial intelligence technology. By real-time monitoring and analysis of the operating status of the hoist, it can promptly detect potential equipment faults and provide early warning and handling. At the same time, it can optimize the operating parameters of the hoist, improve efficiency, and reduce energy consumption. By utilizing sensors and monitoring devices, real-time data on the operating speed, acceleration, current, and other parameters of the hoist can be collected and transmitted to the hoist control system. Based on these parameters, the hoist's operating speed and acceleration can be automatically adjusted, achieving intelligent control of the hoist.

4.5 Fault diagnosis and maintenance of electromechanical equipment

4.5.1 Application of Expert Systems in Fault Diagnosis

The fault diagnosis and analysis of electromechanical equipment can rely on expert systems, integrate the wisdom and practical experience of domain experts, build expert knowledge bases, and combine reasoning mechanisms to achieve rapid and accurate diagnosis of faults. If a coal mine electromechanical equipment fault diagnosis expert system is established, the knowledge and experience of domain experts will be organized into a knowledge base, and an inference engine will be used to analyze and diagnose the fault phenomena of the equipment. When the device malfunctions, the system can automatically search the knowledge base based on the fault symptoms, identify possible causes and solutions, and provide them to maintenance personnel for reference.

4.5.2 Practice of Neural Networks in Circuit Fault Diagnosis In the field of circuit fault diagnosis, neural networks are widely used

The construction of effective identification and prediction capabilities for complex system faults can be achieved through learning and training on large datasets. If a neural network-based circuit fault diagnosis model is established, the input and output data of the circuit will be used as training samples to train the neural network. When a circuit malfunctions, the input and output data of the faulty circuit is fed into a trained neural network, which can automatically identify the type and location of the fault and provide it to maintenance personnel for reference.

5. CONCLUSION

Against the backdrop of rapidly advancing technology, the coal mine electromechanical field is increasingly benefiting from the integration of artificial intelligence technology, demonstrating unprecedented potential. Artificial intelligence has brought new development opportunities to the coal mining industry by improving equipment operating efficiency, enhancing fault diagnosis capabilities, improving safety assurance levels, and optimizing equipment maintenance management. However, it should also be recognized that the application of artificial intelligence technology in coal mine electromechanical equipment is still in a stage of continuous development and improvement. I believe that in the near future, with the continuous maturity and widespread application of artificial intelligence technology, the coal mining industry will achieve more intelligent, efficient, and safe production, making greater contributions to China's energy security and economic development.

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