Study on Intelligent Mine Based on the Application of 5G Wireless Communication System

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Abstract. In the traditional industrial sector, mining plays an important role. The development of a century-old industry is inseparable from the development and utilization of mineral resources. Mining is not only about the economy, but also about safety. In the past 100 years, dangerous mines have brought enormous challenges to the world's industrial safety. Mine safety has always been a major concern of all countries in the world. People are constantly looking forward to and exploring, looking forward to safer, smarter, more automated, unmanned mining methods. With the rapid changes in the era of artificial intelligence and the era of all things connected, the new era of intelligent mines is really coming. Currently, 5G business is getting closer. Exploring and promoting 5G typical applications has become the key to successful 5G operations. With the acceleration of the commercialization of 5G technology, the application of 5G technology in the coal mining industry and the underground working face has achieved a seamless docking between the underground and the underground, which helps the operation of unmanned mining equipment and realizes unmanned mining. Fundamentally avoiding casualties has gradually become a reality. This paper starts with the concept of intelligent mine, summarizes the construction significance of intelligent mine construction and intelligent mine structure, and introduces in detail the application of 5G wireless communication system in intelligent mines. The 5G era is coming, it will bring huge changes to people's lives.

1. Introduction
Since China's reform and opening up in the 1980s to the present, China's high-tech industry has developed unprecedentedly. Many aspects have been at the forefront of the world and become the "leader" of developing countries in the 21st century. With the development of high-tech, the equipment box of China's coal industry has been greatly improved than before, no longer relying solely on manpower to complete. With the application of 5G communication technology in more and more fields, the demand for the application of 5G technology in the coal industry has made great progress. The application of 5G communication technology in the coal industry has well satisfied the urgent problems in the coal industry. It can give the coal industry more accurate and convenient management in terms of digital management. The combination of wired and wireless methods can better solve a series of problems such as the integration of China's coal mine industrial communication system and the unified
transmission of voice data. It provides a high-performance and unmanned integrated communication data network for coal mine work.

2. Overview of Intelligent Mine

2.1. Concept of intelligent mine
In recent years, with the continuous expansion of coal mining area, more and more accidents have been caused. Among them, many accidents can be avoided by relying on the latest communication system, therefore, the application of convenient and efficient mine communication technology has become an urgent problem to be solved. The mining industry has developed from empirical and traditional to scientific, quantitative and intelligent. Digital management of the entire mine not only provides the mine with "eyes" and "ears" but also provides mines with "intelligent brains". 5G network technology is fully applied in coal production and operation, which can help practitioners know the danger in advance and deal with it in advance, so as to make the mine production safer.

2.2. Significance of intelligent mine construction
The intelligent mine based on 5G will adopt advanced network technology, comprehensively considers various factors, comprehensively realizes informatization, visualization, and automation, and promote the scientific management with informatization, which fundamentally avoids or eliminates the occurrence of malignant safety production responsibility accidents, so as to save costs and strengthen the management of production safety. With the development of society and people's emphasis on safety, the problems of high labor cost and difficulty in recruiting employees have emerged in coal mines. Therefore, it is urgent to solve the problem of unmanned mining areas. The emergence of 5G will be an important means to realize safe production in mines, ensure sustainable development of enterprises and improve market competitiveness. And through the 5G network slicing technology and MEC (edge technology), the "brain" of unmanned and automated machine equipment can be placed in the ground MEC center to achieve shared computing and shared processing units, which can effectively solve the problems of short battery life and high cost. Therefore, 5G technology brings a new solution to the situation of coal mines where production resources are not moving and production equipment is moving.

3. Intelligent Mine Architecture
Intelligent mines can also be understood as making the entire mine system sense the surrounding environment and then make corresponding and appropriate behaviors and actions. Therefore, smart mines need to have a universal perception of nerve endings; general thinking like the brain; general expression like the mouth and limbs; general movement like the hands and feet.

Figure 1. Architecture diagram of intelligent mine
4. Application of 5G Wireless Communication System in Intelligent Mines

4.1. Digital management of 5G+ mining area

(1) Real-time monitoring of the mining area environment through a large number of sensors to realize mine digitization and dataization.

![Mining area environmental sensors](image1)

**Figure 2.** Mining area environmental sensors

(2) Realize high-precision positioning of underground mobile equipment such as mine cars and underground workers through 5G+MEC.

![High-precision positioning of mine cars and underground workers](image2)

**Figure 3.** High-precision positioning of mine cars and underground workers

In the traditional concept of people, communication technology is mainly used to transmit information, but 5G can do much more, it can also be used for the perception layer. Through the real-time monitoring of the regional environment, monitoring the displacement, pressure, temperature and humidity, vibration, power parameters, gas and other parameters of the mine can ensure the safety of the surrounding environment and improve the production efficiency of the mine.

4.2. 5G+AR patrol inspection/remote expert guidance

In the past, traditional O&M personnel needed to search one by one and manually copy inspection record reports, which was inefficient and required a lot of manpower. The intelligent patrol inspection uses the characteristics of large 5G bandwidth and low delay, and displays device data in real time through AR to help O&M personnel timely understand the status of the device and provide corresponding solutions when a fault occurs. The system can also dispatch commands in real time according to the operating status of the equipment, and match the corresponding processing personnel for different faults, greatly improving the work efficiency and accuracy of the operation and maintenance personnel. Wear special virtual reality glasses, scan your eyes to the server on the rack, and the virtual operation bar will appear quickly.
At the same time, the virtual floating frame content can also use gestures for real-world and virtual interactive operations. If on-site operation and maintenance personnel encounter technical difficulties, they can also provide remote support. In the process of remote support and maintenance by experts: the device data on the rack changes, the system issues an alarm, and the operation and maintenance personnel wear AR glasses to locate and navigate the fault location, quickly find the faulty device and find the cause of the fault. When on-site operation and maintenance personnel encounter technical problems, as long as the operation and maintenance personnel open a dialog box and interact with the background in real time to assist. The background personnel can obtain the fault scene vision based on the information interaction between the AR glasses and the background system, get failure scenario vision, compare the data by obtaining the scene and background data, and accurately mark the position of the attachment to be replaced in the virtual "fault body". The point sent to the AR scene coincides with the real fault body, thus guiding the completion of fault handling.

Figure 5. 5G+AR patrol inspection/remote expert guidance

4.3. 5G+ working face unattended
The successful realization of remote control depends on the 5G network. The control signals and video signals of the field devices are directly transmitted to the control center platform through the 5G network. The overall technical indicators reach the air port delay of 1ms, the total control signal delay of 25ms, and the video signal delay of 30ms. It is far superior to 4G network in bandwidth and delay, ensuring the transmission quality of high-definition video signals and the transmission speed of signals and control signals, and its reliability reaches more than 99.999%, which can truly make the working face unattended.

Figure 6. 5G+ unattended working face

4.4. 5G+ unmanned driving/remote driving/robot

Figure 7. 5G+Unmanned Driving/Remote Driving/Robot
Based on 5G information technology, network technology and intelligent technology, the mine tunneling face robot group has the independent decision-making and control functions of the mine tunneling equipment group, which realizes the efficient cooperation of multiple robots such as face tunneling, temporary support, and drilling anchoring, and one-click start of traffic and automatic driving. Ensure the integrity of the work, reduce the number of people going down the well, increase the operability of unmanned/remote driving/robots, and ensure the safety of technicians.

In addition, the smart underground roadway is constructed based on 5G network, through the establishment of a perception system and a visual system interconnected with vehicles and robots, the vehicle command brain and robot decision-making system are placed in the edge computing center to share computing and share processing. Reduce energy consumption and cost of terminal equipment. And through the long-term data analysis of the edge computing center, the future mechanical intelligence can be realized.

5. Conclusion
Since the beginning of the 21st century, the modernization of the coal industry has entered a new stage, namely the construction of intrinsically safe, intelligent, and ecological mines. Intelligence is the core of coal mine modernization, a scientific and systematic concept, as well as a dynamic and continuous process. The concept of intelligent mine is of epoch-making significance for China's coal industry to implement the scientific development concept and take the path of sustainable development. Its successful implementation will play an active and important role in realizing the optimization and adjustment of China's coal resources industrial structure and responding to international market competition. Throughout the intelligent development process of some mining enterprises in my country, many mining units are using their own advantages to gradually realize intelligent development, and the achievements are obvious to all. I believe that in the near future, intelligent mines will bloom.

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