Application of Electromechanical Automation Technology Based on Computer Virtualization in Coal Mine

Lijun Sun
Yantai Vocational College , Yantai, Shandong, China

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Abstract: As we all know, the environment of coal mines is a complex time-varying environment that is intertwined due to many factors such as human, environment and machinery, and the various data of each coal mine will show heterogeneous, unstructured and multi-source characteristics. Furthermore, the underground environment is often semi-closed, so many traditional coal mine technology cannot be effectively applied. This paper studies the application of electromechanical automation technology based on computer virtualization in coal mines. First, design the automation system, and introduce the virtualization technology into the automation control system, and then conduct experimental testing on the designed system. The experimental results show that the design of this article the status monitoring of the downhole by the system is not much different from the actual situation, and the error is controlled within 20%.

1 INTRODUCTIONS

Coal is the main source of energy in our country. Supporting our country's industrialization process and supporting our country's national economy are the foundation of social development (Wang and Shi, et al. 2018). Although the country is also committed to the development of new energy sources, there are few results (Li and Sun, et al. 2020). In the absence of cheaper and more environmentally friendly alternative energy sources, coal will remain the main energy source in our country for a long time to come (Wang and Li, et al. 2018). In the process of coal mining, the underground environment is complex and various factors are interrelated. The basement is a semi-enclosed environment (Liu and Wu, et al. 2020). There are not many traditional technologies that can be applied. Therefore, some researchers have proposed to introduce modern technologies in coal mining (Willand and Mccravy, et al. 2018).

Aiming at the application research of electromechanical automation technology in coal mines, some researchers took large-scale electromechanical equipment in coal mines as the research object, and design a set of scene simulation of roaming system using virtual technology, and realized the equipment virtualized assembly and maintain, and apply virtual technology to the virtual simulation of coal mining face (Li and Ji, et al. 2017). Experiments have proved that the virtual system improves equipment and maintenance efficiency (Tizado and NúEz-Pérez, et al. 2016). There are also researchers who use the principle of Voronoi diagram in geometry to analyze the relationship between coal mine tunnel nodes and Voronoi, and propose a new method of node layout of coal mine tunnels (Craig, et al, 2016). Without increasing network costs, the use of virtual technology increases a large number of virtual anchor nodes communicate with sensor nodes through anchor nodes, and combined with range-free DV-Hop algorithm, the location of roadways is proposed (Roy and Gautam, et al, 2016). There are also researchers who use the Internet of Things technology to establish a coal mine dynamic information platform, which can monitor and record the underground equipment of the coal mine production system and the location of the miners (Adiansyah and Haque, et al, 2017).

This article researches the application of electromechanical automation technology in coal mines based on computer virtualization, and summarizes the application research of electromechanical automation technology in coal mines on the basis of reference to relevant literature materials (Strong, 2020). Then put forward the application of virtualization technology to the coal mine automation system, then design the coal mine

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automation system, and test the designed system through experiments, and draw relevant conclusions.

2 RESEARCH ON THE APPLICATION OF ELECTROMECHANICAL AUTOMATION TECHNOLOGY IN COAL MINES

2.1 Application of Electromechanical Automation Technology in Coal Mines

(1) Caving mining is a special coal mining technology. Workface automation has the same control functions and controls as general workflow automation. Only in the coal placement part, the control and return machine control are added. In summary, the control of the carbon leveling surface mainly includes the following procedures: coal cutting control, front conveyor movement, coal loading hydraulic support movement, coal loading lowering and rear conveyor traction (Daniels and Zipper, et al, 2016). Coal output consists of two parts: coal shearer cutting coal and top coal caving. In order to increase the rate of coal adoption and increase the efficiency of coal mining face in caving coal, the principle of maximum parallel operation of the coal mining process has been improved, and the impact time of the process on the coal processing process has been minimized to ensure that the system and coal mining equipment compatible with production capacity.

(2) If various types of underground sensors (gas concentration sensors, temperature sensors, wind speed sensors, etc) can be used, multi-sensor data fusion technology can be used before the occurrence of dangerous gas accidents in coal mines to timely and accurately detect different types of coal mine gas accidents. Comprehensive monitoring, analysis and analysis evaluation factor indicators (gas concentration, temperature, wind speed, etc) and early warning of possible gas disasters will be more conducive to coal safety production and the occurrence of disaster accidents. Therefore, the establishment of a sound early warning system for coal mine safety and the implementation of coal mine gas environmental assessment and early warning are of great significance for reducing the incidence of coal mine accidents.

(3) The system performs overall comprehensive control of the mine to achieve the best operation of the entire mine. It not only involves each process, but also involves the processing of production management information. In the production process, the system can automatically collect specific data, which can be geology, work site or a large amount of production condition information, which is processed and analyzed by the computer in order to receive decisions in time. Through the implementation of the mine automation central control system, the social prospects of the mining industry will be changed.

2.2 Introduction of Virtual Technology

Virtual technology is mainly used to show a model that is the same as the real situation. Virtual technology can be used to demonstrate the mining process in the mining process of coal mines. Through virtual mining demonstrations, the mining plan can be better displayed and the mining scheduling more effective.

2.3 PCL Control Algorithm for Electromechanical Automation

2.3.1 Traditional Control Algorithm

Although the research of various intelligent control algorithms by experts and researchers in the control field has become more and more mature in recent years, due to their application in actual production control, due to the following reasons, they cannot successfully get from the laboratory the stages are separated various complications. At present, the most widely used in the process control field is still the simple PID control algorithm. The PID control rules are shown in the following formula:(1)

$$u(t) = K_p[e(t) + \frac{1}{T_i}\int e(t) + T_d \frac{d}{dt} e(t)] \quad (1)$$

In the formula: K p --- proportional coefficient; Ti --- integral time constant; Td --- differential time constant

2.3.2 PID Parameter Optimization Method Based on Ant Colony Algorithm

2.3.2.1 Problem Description

Assume that the effective values of the three parameters Kp, Ti and Td are all 5 bits. According to experience, among the 5 significant figures of Kp,

there are 2 digits before the decimal point and 3 digits after the decimal point; among the 5 significant digits of Ti and Td, there are 1 digit before the decimal point and 4 digits after the decimal point. Therefore, a set of parameters (Kp, Ti, Td) corresponds to a sequence of 15 digits.

2.3.2.2 Define the Objective Function

Reasonable selection of target operations can ensure that the system runs well. The main performance indicators of the system include stability, accuracy and speed. In order to obtain better system control results, we also consider the restrictions on the system control amount, control error and increase time. Therefore, use the following performance indicator function (target function).As shown in the(2).

$$J = \sum_{i=1}^{\infty} (w_1 |e(i)| + w_2 u^2(i) + w_a t_u \quad (2)$$

2.3.2.3 Build the Path.

This step is the main step of the entire ant colony algorithm. First, assume that each artificial ant is at the starting point 0; then each ant at (xi-1, yj') climbs to the next node (xi, Yj), until each ant reaches (15, yj) , we assume that the time for each ant to climb from the previous node to the next node is equal to the previous two nodes, and the distance between the two points does not matter. In addition, each ant in (xi-1, yj') enters according to The next node of the random ratio rule (xi, yj)

2.3.2.4 Update of Pheromone

All ants start from the initial point, after 15 time units, climb to the end and complete a cycle, the amount of information on the node (xi, yj) will change

3 DESIGN OF COAL MINE AUTOMATION SYSTEM BASED ON VIRTUAL TECHNOLOGY

3.1 The overall Structure of the System Function

The built-in automation software system is a complete data operation software that integrates data communication, processing, acquisition, control, setting, integrated intelligent judgment and graphic display, as shown in Figure 1. According to different environmental changes, timely processing and normal system operation, it can adapt quickly and efficiently, and play a real-time monitoring role. The integrated automation system adopted this time is easy to use and can be integrated monitoring and management. At the same time, based on system software upgrades, the system can maintain stable and efficient operation through multiple links such as technology, design, development, and maintenance to meet the needs of current mine management and development. Therefore, the overall structure of the coal mine system includes data display, data collection and storage, equipment access, infrastructure, and users log in.

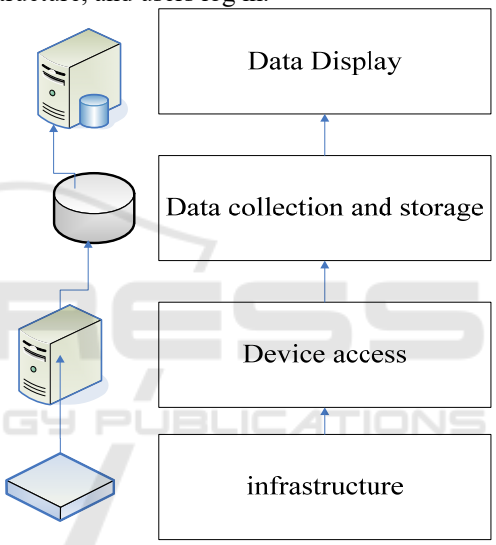

Figure 1: System function overall architecture

3.2 Data Display

This module is mainly for the display of some equipment status data and virtualized on-site display. The equipment status and downhole data are mainly collected by sensors. In the virtualized site, it is made according to the 1:1 ratio based on the camera collection and modeling software, can be used to demonstrate underground mining experiments.

3.3 Data Collection and Storage

3.3.1 Spindle Lifting System

In the process of completing the coal mining automation system, the spindle lifting system is an important production subsystem. The data must be

true, accurate and reliable. In the data collection process, it is mainly the elevator speed and the missing position. The elevator is in normal operation or correction mode, and the operation mode is monitored, such as start, stop, fault, etc. Finally, these data are displayed on the operator's work interface through the configuration interface.

3.3.2 System Modeling

The use of system template modeling can be quickly developed through multiplexing. System modeling is based on the variable table provided by the underlying equipment supplier and rearranged in accordance with the OPC communication standard into monitoring points that comply with the OPC data collection standard.

3.4 User Login

The system divides users into different work groups according to the data requirements of different users. Different working groups have different rights. The server confirms that it is a legitimate user according to the authentication and password entered by the user, and then opens the relevant subsystem according to its authority. In this way, it can prevent illegal users from "invading" the system.

3.5 Device Access

3.5.1 Hardware Device Access

1) Server access method

For an automated system, it is relatively simple. It does not have an Ethernet interface, but only has one host. It can be added to the host in the Ethernet communication card to physically connect to a nearby switch.

2) PLC access method

For an automation system that uses a plc for control, you can consider adding an Ethernet module to the plc to connect it naturally with the switch.

3) Subnet access method

The automation system is very mature, has its own network, integrates an external Ethernet interface, and can be physically connected to the switch through this RJ45 port.

3.5.2 Software Access

Since each automation system will be connected to the built-in Gigabit Ethernet for automation, the next job is to solve the data communication problem through this software. Each enterprise's automation system can choose to use the following four communication modes: opc communication, movement mode and development model, dde / netdde mode and independent development model, but it is best to use the opc communication mode, and the original factory must provide it with opc interface.

4 SYSTEM DETECTION

4.1 System Testing Design

Since the system designed in this paper is a highly comprehensive system, including field equipment monitoring and communication structure layout, the actual field test of the system is a bit large and difficult to implement, so the test is only for one of them. The experiment is to monitor the gas concentration underground, and the experiment site is in a well-known coal company in this city.

4.2 Analysis of Experimental Results

In this paper, the results of the downhole gas concentration detected by the system are compared with the actual gas concentration results, and the gas concentration at 5 moments is randomly selected for experiments to verify the accuracy of the system's monitoring. The relevant data results are shown in Table 1:

Table 1: Analysis of results

	Actual gas concentration	Monitoring gas concentration
t1	0.65	0.643
t2	0.6	0.567
t3	0.5	0.67
t4	0.675	0.71
t5	0.7	0.74

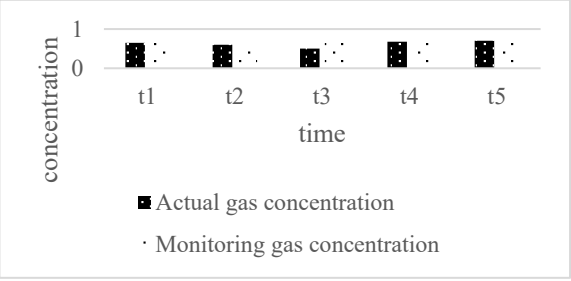

Figure 2: Analysis of results

It can be seen from Figure 2 that the coal mine gas concentration monitored by the system is not much different from the actual gas concentration. By calculating the maximum error value of 0.17, it can be seen that the monitoring accuracy of the system is relatively high.

5 CONCLUSIONS

This paper aims at the application research of electromechanical automation technology based on computer virtual technology in coal mines. Through the design of coal mine automation integrated control system, and virtual technology modules are added to the system, the automation system can better realize the comprehensive control and dispatch of coal mines. In the research process of this article, due to the lack of literature on the introduction of virtual technology into coal mine automation, the relevant conclusions presented in this article may be biased.

REFERENCES

Wang F , Shi L , Fan W , et al. Application of computational geometry in coal mine roadway 3D localization[J]. The international arab journal of information technology, 2018, 15(4):668-674.

Li M , Sun Z , Jiang Z , et al. A Virtual Reality Platform for Safety Training in Coal Mines with AI and Cloud Computing[J]. Discrete Dynamics in Nature and Society, 2020, 2020(3):1-7.

Wang S , Li X . Bauxite orebody demarcating and virtual mining for mining optimization within an underground bauxite seam, Southwest China[J]. Environmental earth sciences, 2018, 77(6):221.1-221.14.

Liu G , Wu C , He Z , et al. Data model for geological spatiotemporal big data expression and storage management[J]. Dizhi Keji Qingbao/Geological Science and Technology Information, 2020, 39(1):164-174.

Willand J E , Mccravy K W . Variation in diel activity of ground beetles (Coleoptera: Carabidae) associated with a soybean field and coal mine remnant[J]. Great Lakes Entomologist, 2018, 39(3):141-148.

Li H , Ji H , Shi C , et al. Distribution of heavy metals and metalloids in bulk and particle size fractions of soils from coal-mine brownfield and implications on human health[J]. Chemosphere, 2017, 172(APR.):505-515.

Tizado E J , E Nú?Ez-Pérez. Terrestrial Arthropods in the Initial Restoration Stages of Anthracite Coal Mine Spoil Heaps in Northwestern Spain: Potential Usefulness of Higher Taxa as Restoration Indicators[J]. Land Degradation & Development, 2016, 27(4):1131-1140.

P, Craig, S, et al. Investigations into the corrosive environments contributing to premature failure of Australian coal mine rock bolts - ScienceDirect[J]. International Journal of Mining Science and Technology, 2016, 26(1):59-64.

Roy D , Gautam S , Singh P , et al. Carbonaceous species and physicochemical characteristics of PM10 in coal mine fire area—a case study[J]. Air Quality Atmosphere & Health, 2016, 9(4):429-437.

Adiansyah J S , Haque N , Rosano M , et al. Application of a life cycle assessment to compare environmental performance in coal mine tailings management[J]. Journal of Environmental Management, 2017, 199(sep.1):181-191.

Strong, D. F . Rare Earth Elements and Yttrium (REY) in coal mine drainage from the Illinois Basin, USA[J]. Canadian Journal of Earth ences, 2020, 21(7):775-780.

Daniels W L , Zipper C E , Orndorff Z W , et al. Predicting total dissolved solids release from central Appalachian coal mine spoils[J]. Environmental Pollution, 2016, 216(sep.):371-379.