International Journal of Web-Based Learning and Teaching Technologies
Volume 18 • Issue 2

Application Analysis of Artificial Intelligence Technology in Electrical Engineering Teaching

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ABSTRACT

This article combines the characteristics of artificial intelligence technology and educational technology to realize the possibility of application in electrical automatic control systems, and applies artificial intelligence and educational technology to electrical engineering examples such as monitoring fire alarm open circuit design and smoke box appearance inspection in power transformation and distribution systems. Analyze the impact of artificial intelligence on electrical automation technology. The research results show that artificial intelligence and education can make electrical automation technology have the characteristics of simplification, distribution, informatization, diversity, flexibility, continuity, real-time and control complexity. Use artificial intelligence technology and educational technology to effectively analyze and process electrical engineering related parameters and data, reduce the use of lines and transformers, simplify work procedures, reduce error rates, save manpower, material resources and costs, and improve the accuracy of automatic control.

KEYWORDS

Artificial Intelligence, Artificial Intelligence and Education, Automation Technology, Control System, Electrical Engineering

INTRODUCTION

With the rapid development of the economy, the demand in the electrical market has increased sharply, and the role of electrical engineering in the electrical market is increasing day by day (Lee, 2020; Sami, 2022). Automation is a key link in electrical engineering, and automation control technology plays a key role. Traditional automation technology has low efficiency, which is not conducive to the rapid development of electrical engineering and education (Hua et al., 2021). With the rapid development of science, artificial intelligence (AI) technology has been applied to electrical engineering teaching due to its unique advantages (Chen, 2019; Feng, 2018). AI technology refers to the research and development of how to simulate and expand human intelligence, mainly simulating human intelligence

DOI: 10.4018/IJWLTT.334111 *Corresponding Author

to generate functions and apply them. AI technology can achieve intelligent effects through machine equipment, and can replace human beings to complete dangerous and hard work (Ahmad et al., 2021). AI technology realizes AI control with the help of computer technology, which greatly promotes the healthy development of electrical engineering and improves the efficiency of automation control (Ali & Choi, 2020). Introducing AI technology into the automation control of electrical engineering will not only increase the stability of automatic control, but also reduce the operating cost of the control system and improve the economic and social benefits of the industry (Richter et al., 2022). Therefore, it is key to study the influence of AI technology on electrical automation control (Sahoo & Lo, 2022).

At this stage, electrical automation still needs electrical automation systems to control. Among them, information collection and system operation are the most important and basic functions of these systems. In the actual operation process, relevant terminals are necessary for the electrical automation control system. It is necessary to accurately grasp the operation, fault, time, information temperature, and other pieces of information of the equipment, so that relevant personnel can understand the true status of the equipment. The current information control and monitoring can intelligently analyze and process the information transmitted, compared with the automatic control system. After the information processing, it can feedback the terminal equipment. The information that AI cannot process at present needs to be handled manually.

Some research results have been obtained on the application of AI technology in electrical engineering. Some researchers have combined computer technology with field bus control technology and applied it to the field of electrical automation (Talaviya et al., 2020). For the process control process of increasingly complex industrial production, the computer control system can effectively improve product quality and reduce production costs (Abdalla et al., 2021). In the industrial production process, the complexity of the distributed control system makes the continuous iteration of the distributed control system (Liu & Zhao, 2022). Some researchers have divided the distributed control system into decentralized process control level, monitoring level, and production management level (Kanase-Patil et al., 2020). The decentralized process control mainly completes data collection and distributed control in the production process to avoid the control failure of the centralized control system. The monitoring level mainly monitors and executes operations on production process data, and provides data to directly intervene in the system (Chou & Hsu, 2022). As the center of the entire control system, the management level provides production tasks, compiles system work reports, reviews control plans, establishes mathematical models, and formulates optimal control (Clark et al., 2020). Some researchers have summed up the shortcomings of distributed control systems, such as the specificity and nonopenness of the software and hardware of the human-machine interface, the inability of each control system software to interoperate, and the third-party communication (Ahmed et al., 2021). Through the development of general-purpose driver software, the server enters the field of industrial control with the help of Ethernet, and realizes the connection between the man-machine interface and the controller and the connection with the third-party equipment. Some researchers have applied AI technology to the field of electrical automatic control through learning algorithms, and have used AI image recognition technology to set up a debris recognition device in the middle of the shredded tobacco conveyor belt in cigarette factories to realize rapid identification of debris (Kuang et al., 2021). Some researchers have applied AI technology to the factory fault diagnosis process. When the electrical automatic control equipment of the factory breaks down, it can use the powerful diagnosis and analysis ability of intelligent technology and computer system to accurately predict the system failure and effectively improve the early warning and troubleshooting ability of the electrical automatic control system (Zhang, 2019). Some researchers have compared traditional electrical automatic control technology with intelligent electrical automatic control technology. AI technology has pushed the field of electrical automatic control into the next stage (Sodhro et al., 2019). Modern factories will gradually realize full automation and unmanned production process from manned, monitoring, operation, and maintenance, and automatic repair and maintenance of equipment, greatly liberating productivity and improving labor efficiency.

The application of AI technology in electrical automation mainly includes two stages: 1) The application of expert system and artificial neural network system and 2) primarily the application of AI technology. Since the 1980s, expert systems have been widely used in the power industry, mainly considering static and dynamic security analysis, power alarm processing, power fault diagnosis, power operation load processing, power operation economic cost, and other research. In recent years, with the continuous development of AI technology, its application to the power industry has entered the second stage. In addition to taking into account the previous economic operation, it has also added problems such as multiple energy sources and multiple loads, making the field of electrical automation more intelligent. In this study, the authors' research object was the application of AI in electrical automation technology; they analyzed the application examples of AI technology in electrical engineering, and studied the impact of AI on electrical automation technology by summarizing the characteristics of AI technology. The study provides theoretical data support for the application of AI in electrical automation engineering.

MATERIALS AND METHODS

Technical Characteristics of Electrical Automation

Electrical automation is a discipline that studies system operation, automatic control, power electronics technology, information processing, test analysis, research and development, and electronic and computer applications related to electrical engineering. Realizing automation means reducing human capital investment and improving operation efficiency. Electrical automation control technology realizes automatic acquisition of information through various sensors, software, and systems, and simultaneously processes and makes decisions on various information, thereby improving factory production efficiency and labor productivity (Chen et al., 2019). Electrical automation technology is to convert various production analog signals into electrical signals, and input them into the automatic control system through different types of sensors (e.g., flow, liquid level, temperature, and pressure) to achieve data acquisition, logic circuit or programmable logic controller control, process and calculate the collected information, and process and execute the procedures of motors, solenoid valves, and switches(Zahraee et al., 2016). Through various execution function programs, the electrical control is completed and the factory production automation is realized. Table 1 shows the technical characteristics of electrical automation control.

The electrical automation technology itself has certain protection functions. When the electrical equipment fails for some reasons, the electrical automation control technology can protect the electrical equipment. In the process of electrical engineering production, it is difficult to judge whether there is current in the control system through vision, and it is also difficult to analyze the electrification of electrical equipment. Thus, it is necessary to develop the signal identification corresponding to the problem; for example, the fault signal lamp can be used to control and manage the electrical automation control equipment, and grasp the actual situation during the operation of the equipment. The automatic control function is mainly used to control the bulky current switchgear and high-voltage switchgear. During the operation of electrical equipment, decentralized operation is generally adopted. The decentralized operation mode can improve the reliability, expandability, and flexibility of the system, reduce the impact of single point of failure, and enable equipment to operate and control independently of each other, thus improving the stability and safety of the entire electrical system. Especially when electrical equipment fails, the system will conduct circuit cut-off operation.

Application Advantages of Artificial Intelligence Technology

At present, AI algorithms applied to electrical engineering automation include neural network algorithms, Bayesian network algorithm, and support vector machine. Neural network algorithms are widely used in electrical engineering automation, such as power load forecasting, fault diagnosis,

Table 1. Technical characteristics of electrical automation control

Development trend	Features
Simplify	Electrical automation technology realizes manual to human-machine collaborative operation, simplifies the electrical automatic control system program, and reduces the maintenance process and the amount of manpower.
Distribution	Automatic control technology application equipment such as inverters, motor starters, and computer systems integrate operating information, store it in the central control center, and use radiation distribution to control equipment to improve the efficiency of equipment on-site control.
Informatization	The electrical automatic control technology have horizontal and vertical factory applications. Horizontal applications cover the automation control system of the whole factory, improve the configuration quality of the automation system. Vertical applications mine the data of various departments of the factory and save the data information of all parties.
Continuity	The production process of the enterprise is continuous, and its control steps are also continuous.
Variety and flexibility	Different automatic control equipment and different programming methods provide variety and flexibility, and the operation interface of the touch screen allows to realize the flexibility of the automatic control technology.
Real time	The programmable logic controller adopting the cycle scanning method shortens the one-week time to about tens of milliseconds to hundreds of milliseconds, and collects the input variables in real time; the execution time of the input to output program is at the millisecond level, which is real-time output.
Complexity	With the refinement of the production process and the increase of control requirements and variables, the automatic control technology will continue to iterate, showing the characteristics of complexity.

and smart grids. Bayesian network algorithm is often used in power systemic risk assessment, equipment condition monitoring, and fault diagnosis. Support vector machine algorithm is used for tasks such as power load forecasting, power grid safety assessment, and power equipment fault classification. Modeling traditional electrical automation controllers produces undetermined effects due to changes in parameter settings and value types. The controller of AI technology, instead, allows to directly build a dynamic model, and does not require to set parameters and value types, reducing the influence of external factors on the simulation results (Behara & Saha, 2022). At the same time, big data modeling based on AI technology can present the status of electrical automation equipment in multiple dimensions, effectively reduce data acquisition errors, and improve the scientificity and rationality of data information.

With the help of computer AI technology, we can analyze and process big data related to electrical engineering parameters and data, thereby improving efficiency. At the same time, it can also set language and response information for data, and realize information storage and processing in the form of text, language, and graphics. The AI controller realizes easier and faster operation according to simple modification and expansion of parameters (Pan & Zhang, 2021).

Traditional electrical engineering is composed of machines, lines, transformers and other facilities and equipment, which consumes much manpower and material resources in operation, and makes the work efficiency low. With the application of AI technology in electrical automation systems, the use of lines and transformers is greatly reduced. Through the intelligent control of computers, complex tasks can be completed, work procedures can be reduced, error rates can be reduced, manpower, material resources, and costs can be saved, and self-control can be greatly improved (Ansari et al., 2022).

AI technology greatly simplifies the problem feedback process, autonomously intervenes in equipment failures, and improves troubleshooting efficiency by analyzing the causes of electrical automation equipment failures. The scientific application of AI technology can help electric power enterprises complete the real-time analysis and processing of internal data information, and feed back

the problems to the control and management personnel in time, so as to ensure the safety and stability of the automatic production process, and maximize the quality and efficiency of the production of electric power enterprises (Khaleel et al., 2023).

The current AI algorithms lack a deep understanding and modeling ability for complex circuit systems in terms of electrical fault mechanisms, and are unable to accurately predict and explain the specific causes and mechanisms of electrical faults. To this end, new AI algorithms are proposed, mainly including transfer learning, reinforcement learning and other machine learning algorithms. At present, the new AI technology is mainly represented by deep learning, and its application in electrical engineering is mainly manifested as follows: The existing electrical engineering management system has provided data sources for AI, and can provide stronger data processing capabilities for electrical engineering management through in-depth analysis of massive data. The existing electrical management adopts distributed management, which can carry out equipment fault diagnosis and data collection. The use of new AI methods can improve the quality of fault diagnosis. The traditional electrical engineering physical model is relatively complex, which leads to large error in the analysis results. Contemporary electrical engineering physical models can accurately describe complex physical phenomena and interactions in power systems, providing accurate mathematical descriptions and simulation tools for system design, analysis, and optimization, thereby improving system reliability, stability, and efficiency.

RESULTS

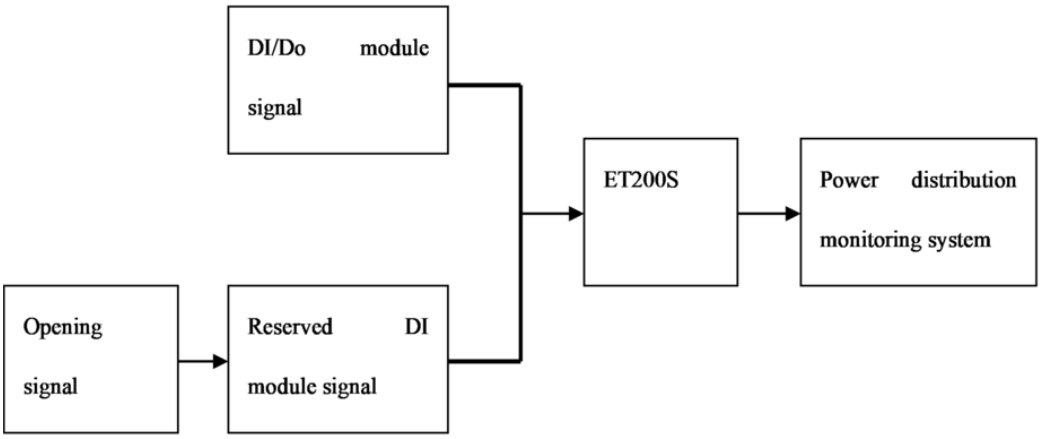
Application of Artificial Intelligence Electrical Automation Technology in Fire Monitoring

When carrying out fire alarm and fire extinguishing in electrical factories, the automatic fire alarm and linkage control system play an important role to ensure the safe production of the factory. When a fire breaks out in the fire control room, the non-fire power supply should be cut off immediately, and the alarm device, emergency lighting and evacuation indicator should be connected immediately. In this study, the authors divided an electrical factory into 29 fire compartments, and distributed the non-fire protection power switches in four power distribution rooms. When the non-fire protection power supply is cut off, the circuit breaker in the power distribution room will open. When the fire linkage system carries out the non-fire power supply cut-off test, after the circuit breaker is opened, the electrical monitoring system can only distinguish the opening alarm, and cannot issue alarms or signal instructions for other faults, which may easily cause panic among personnel. Due to the complexity of the circuit and the numerous locations where faults occur, it is difficult for maintenance personnel to carry out troubleshooting work. Generally, it takes more than 30 minutes from opening alarm to troubleshooting, which greatly affects the continuity of production.

In order to solve the problem of troubleshooting efficiency of the electrical monitoring system, engineers attach great importance to the automatic design of AI for the monitoring system of the non-fire-fighting power circuit opening of the power distribution system. The implementation of an AI fire automatic control system allows to quickly cut off the nonfire protection power supply circuit, and receive alarm signals and prompts. At the same time, the troubleshooting time is reduced from 30 minutes to 15 minutes, which greatly improves the work efficiency, reduces the downtime, and ensures the continuous production of the factory. Through on-site investigation, the authors found reserved digital input (DI) modules in the power distribution room. Figure 1 shows a schematic diagram of the reserved DI module.

The authors combined the ET200 system in the power distribution room with the reserved DI module to collect the signal from the fire automatic control system, and uploaded the switch data of the power distribution room to the power distribution monitoring system through programmable controller (PLC). After determining the AI automation scheme, the authors designed the drawings

Figure 1. Schematic diagram of the reserved DI module



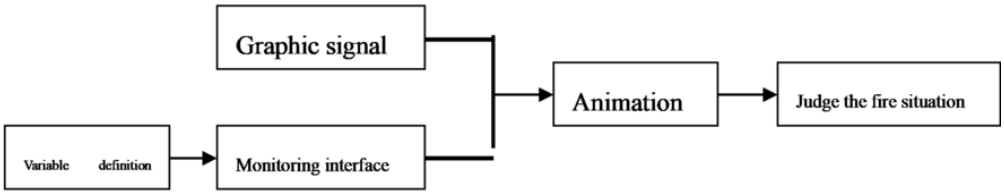
of the fire protection and power distribution system to ensure that the wiring was as simple as possible and the monitoring is in place. According to the switchgear space and the number of reserved modules, the authors used the intermediate relay to connect the opening signal to the DI reserved module. By connecting the passive contact of the intermediate relay with the DI module of the power distribution monitoring system, the monitoring of the fire opening signal is realized. According to the layout of the switch cabinet in the power distribution room, the authors selected the appropriate switch cabinet for the intermediate relay to install. Table 2 shows the installation list of the intermediate relay.

After collecting the DI module signal at the bottom of the PLC, the researchers used the Wine software to realize the monitoring interface display of the upper computer. In the Wine software, they configured the DI/digital output (DO) module, they imported the IO(Input/Output) point table summary into the Wine background variable, and imported the defined variables into the alarm record. When a signal is received, an alarm prompt can be issued. Figure 2 shows the Wine software operation process. When the software receives the red flashing signal, it can report the fire or alarm, and the staff can quickly determine the location of the fire and the false alarm of the

Table 2. Intermediate relay installation list

Serial number	Fire district	Partition list	Intermediate relay position
1	01	North 1st and 2nd floor, Area A	3AA1
2	03	South 1st and 2nd floor, Area A	2AA3
3	04	District B, 1st floor, Division 04	2AA9
4	06	District B, 1st floor, Division 06	2AA6
5	07	Zone 07 on the second floor of Area B	3AA2
6	11	Area A, 3rd floor, Division 11	3AA4
7	15	Zone B, 1st floor, Division 15	4AA6
8	18	Area A, 3rd floor, Division 18	3AA5
9	20	Area A 2nd floor, Division 20	3AA2
10	21	District B, 1st floor, Division 21	2AA1

Figure 2. Wine software usage process



fault. The electrical self-control technology of AI is applied to the fire alarm system, which greatly reduces the maintenance and troubleshooting time by at least 10 minutes, greatly improves work efficiency, reduces equipment downtime, and ensures the reliability and safety of power supply for factory equipment.

Application of Artificial Intelligence Electrical Automation Technology in Box Shape Detection and Product Transportation

In the product production plant, the produced products need to be packaged in bags, packed into strips and then packaged into boxes. In order to save the cost of the cabinet and meet the requirements of environmental protection, the cabinets packaged into boxes will be recycled as recycled products, and the recycled boxes may have wrinkles, slack or shape defects. Manual selection of cabinets with defective shapes increases the labor intensity, and at the same time, manual selection has a certain degree of subjectivity. This paper proposes the technology of AI electrical automation control, which automatically selects the box with defective shape, removes it from the transportation channel, and sends out an alarm at the same time.

Through the analysis of the economic cost and control effect of various sensors, the authors selected the DI and DO module controllers of Siemens 300PLC, the through-beam type photoelectric switch with small installation difficulty and good effect, and the diffuse reflection type alarm photoelectric switch with easy installation. The photoelectric sensor is usually carried by an aluminum alloy frame, and a detection distance of 5-20cm is maintained between the sensor and the sensor. It should be installed as close to the rejection port as possible to maintain overall stability. In this study, the authors selected a three-dimensional rectangular frame and installed the photoelectric sensor in a suitable position to form a three-dimensional rectangular detection device. The length of the box exceeding the passing time of the photoelectric sensor inspection will be regarded as the box flanging out.

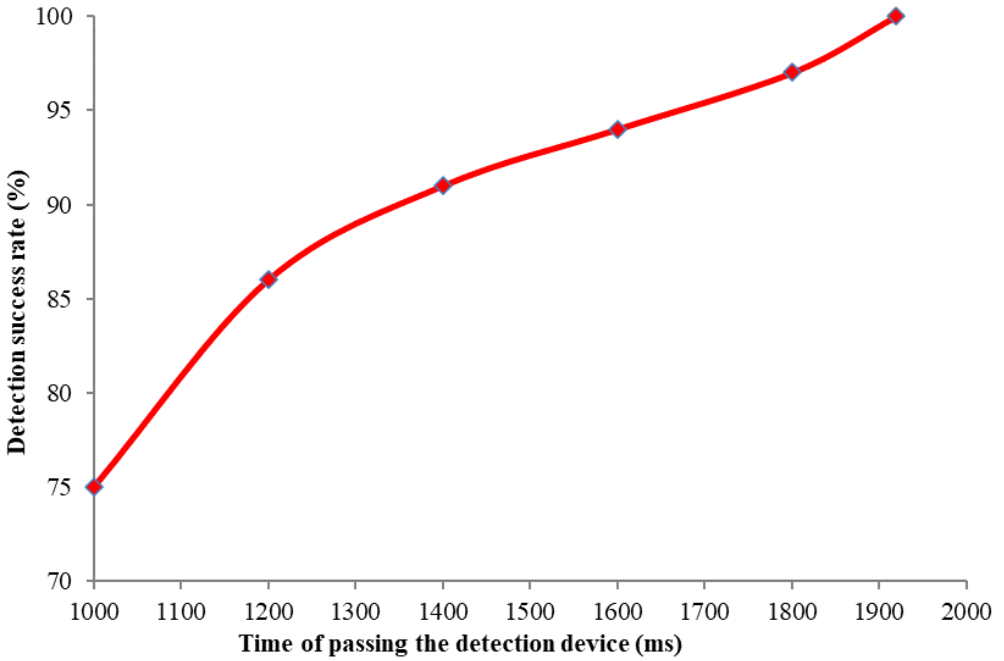
According to the detection function, the photoelectric switch is divided into four groups: The opening degree of the long and short folds at the bottom of the box, and the opening degree of the long and short folds at the top of the box. As to the alarm device setting, when only one box is rejected, the alarm device will send out a continuous sound and light alarm for 5 seconds to remind the operator. When multiple boxes are rejected, the alarm and alarm prompt will become a high frequency, twice per second. In order to distinguish the causes of unqualified cabinets, the authors used the Wine software to refine the alarm records. By refining the alarm records, it is convenient for the staff to check and judge the specifics of the cabinets in time.

The researchers set the gradient test by time; Table 3 and Figure 3 show the detection success rate of the box at different times of passing through the detection device. Table 3 and Figure 3 evidence that, as the time for the box to pass the detection device increases, the detection success rate of the box defect increases gradually. When the time for the box to pass the detection device is 1920ms, the detection success rate reaches 100%. Therefore, the time for the box to pass through the detection device should be set to 1860ms, and the effect of automatic control and elimination can be achieved by writing the PLC program. The authors recorded the rejection rates of the cabinet shape detection

Table 3. The detection success rate of different time passing through the detection device

Variable	Values					
Time to pass the detection device (ms)	1000	1200	1400	1600	1800	1920
Detection success rate (%)	75	86	91	94	97	100

Figure 3. The detection success rate of different time passing through the detection device



and rejection devices from October to December 2021; they were 98%, 99%, and 98%, respectively, exceeding the expected 96%.

After the product is produced, if the product is transported manually, it will bring high cost, high cost and low efficiency. In this research, the authors designed a transport vehicle controlled by AI, which is convenient to use and can meet the needs of efficient production. They wrote the PLC program through STEP software to realize the automatic transportation function of the vehicle. When the workflow is set to continuous or single loop, the vehicle stops at the loading bay and the trolley starts. In the PLC program design, the researchers put the continuous or single-cycle automatic program into FC1, put the manual operation mode into FC2, set an initial pulse; when FC1 is called for the first time, it will get a running cycle, and then it will be off. In the sequence function control, the flag bit is controlled so that the car completes a running cycle after the stop button is pressed. Table 4 shows the program input and output buttons.

After completing the initial setup of the transport, the authors applied the following sequential function programming to keep the transport vehicle in automatic continuous or single cycle operation. First, they set the waiting to realize self-locking; then, they set the loading of the vehicle to maintain continuous or single-cycle operation, set the forward control step, set the loading time to 15s, and, when the vehicle hit the unloading gear switch, they set the unloading

Table 4. Program input and output buttons

Input	Output
Start button 10.0	Back relay C1
Loading limit switch 10.1	Forward relay C2
Unloading limit switch 10.2	Charging relay C3
Back button 10.3	Unloading relay C4
Forward button 10.4 Load button 10.5 Unload button 10.6 Stop button 10.7 Manual switch 11.1 Single cycle switching 11.2 Auto switch 11.3	

time to 10s to complete the setting of vehicle loading and unloading; at the same time, they set the loading timing to move forward after 15s and the unloading timing to move backward after 10s, and wrote the automatic working mode program FC1; they set the output bit of the manual operation step to ensure that the vehicle is working manually. They completed the function in this way. Through the electrical automatic control programming and debugging optimization of the transportation vehicle, after the final test, the vehicle has completed the functions required for production through the AI electrical automatic control, realizing labor cost saving, high efficiency, and reliability.

CONCLUSION

In this study, the authors introduced the AI technology into the electrical automation control technology, summarized the characteristics of the AI technology, analyzed the possibility of the application of AI in the electrical automation control system, applied the AI technology to the fire monitoring system, box type detection, product transportation, and other electrical engineering examples, and analyzed the impact of AI on the electrical automation technology. Through the establishment of an AI fire automatic control system, they quickly cut off the nonfire power supply circuit, and reduced the troubleshooting time from 30 minutes to 15 minutes by using the Wine software and DI/DO module, ensuring the reliability and safety of power supply for plant equipment. Through the electrical automatic control programming of box shape detection and the time setting gradient test, the growth time of box shape passing through the detection device is obtained, and the success rate of box shape defect detection is gradually improved. When the box passes the detection device for 1920ms, the detection success rate reaches 100%. Statistics showed that the removal rate of box detection and removal device was 98%, 99%, and 98% in October, November, and December 2021, respectively. Through the programming, debugging, and optimization of the electrical automatic control of transportation vehicles, the use of AI to complete the electrical automatic control functions required for production has realized the cost saving, efficiency, and reliability.

However, intelligent dispatching management is still an urgent problem in the application of electrical automation engineering. In the future, there will be a new breakthrough in the use of AI technology for electrical engineering scheduling control. How to store and analyze massive data in electrical automation engineering still needs improvement. The application of AI technology to electrical automation project management is the future development trend.

DATA AVAILABILITY

The Figures and Tables used to support the findings of this study are included in this paper.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

FUNDING STATEMENT

This work was not supported by any funds.

ACKNOWLEDGMENT

The authors would like to show sincere thanks to those techniques who have contributed to this research.

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