Application of Artificial Intelligence in Electrical Automation Control

Wei Xie*

Middle Bar Mill of Nanjing Iron and Steel Co., Ltd., Nanjing 210035, Jiangsu Province, China

Corresponding author: Wei Xie, xwei@163.com

Abstract:

With the rapid development of artificial intelligence (AI) technology, its applications are becoming increasingly widespread across various fields. In the realm of electrical automation control, AI is transforming traditional control methods and operational models. By emulating human intelligence and learning abilities, AI brings higher intelligence and adaptability to electrical automation control systems. This paper delves into the key aspects of AI applications in electrical automation control, analyzing its role in fault diagnosis and electrical control while exploring the future of AI in this field. Studying AI's application in electrical automation control can further advance the development of electrical automation technology, enhancing system efficiency and reliability.

1. Introduction

The widespread adoption of artificial intelligence (AI) technology has established it as an indispensable emerging technology in modern society's progress [1]. In industrial automation control processes, AI technology demonstrates its value, significantly improving electrical automation control outcomes, reducing overall operating costs, and enhancing efficiency in electrical automation control. From the perspective of electrical automation control, large-scale research, and application of AI technology hold considerable significance.

2. Overview of AI technology

2.1. Definition of AI technology

AI is a prominent and advanced technology in modern computer science, representing a comprehensive discipline that integrates both practical and theoretical aspects. AI encompasses various specialized computer science areas, characterized by its innovative and interdisciplinary nature. Moreover, AI technology rapidly evolves and is widely applied across multiple domains. Fundamentally, AI technology involves machine-based simulation of human thinking to accomplish complex tasks through efficient computation.

2.2. Impact of AI technology on electrical automation

Compared to traditional technologies, AI can process and respond to diverse information data. Traditional, complex manual operations can be replaced by AI, effectively advancing electrical automation and refining production and distribution within enterprises [2]. Additionally, AI's application in electrical automation control can efficiently conserve resources such as manpower, materials, and finances, boosting production efficiency and reducing significant costs. AI technology can also adjust related industry structures to further optimize electrical automation processes.

2.3. Advantages of AI technology

2.3.1. Broad applicability

Traditional electrical automation control methods generally transmit information within only a specific part of the control system. While this allows effective management of particular segments, it lacks control across other areas of the system. With AI applied in electrical automation control, the previous one-way data transmission approach shifts to network-based data transmission, enabling comprehensive system control. Even in emergencies, AI can coordinate with data from relevant decision-making entities to promptly resolve system issues, thereby ensuring operational stability and safety.

2.3.2. Simplified operational processes

To ensure the optimal performance of conventional electrical automation control systems, it is essential to understand the principles of the electrical system and its components comprehensively. This involves analyzing and comparing large amounts of data, a labor-intensive and time-consuming process. By applying AI, complex data analysis becomes visualized, enabling technical staff to promptly identify and correct connection errors within the system, reducing time and labor costs associated with troubleshooting. In practice, complex tasks are simplified through visualization, facilitating easier access to operational parameters.

2.3.3. Enhanced stability and reliability

Integrating AI technology with computer and internet technologies enables the development of intelligent electrical digital systems within electrical automation control. Utilizing AI in conjunction with traditional equipment stabilizes power system operations, significantly enhancing the system's operability and further improving the accuracy and efficiency of electrical automation control.

2.3.4. Standardization and uniformity

The full implementation of AI in electrical automation control achieves standardization and uniformity in system operations. During system processes, external factors do not impact the consistency or uniformity of operational parameters in electrical automation devices, allowing for a repetitive and cyclical production process that effectively ensures product quality.

3. Key applications of AI technology in electrical automation control

3.1. Fault diagnosis

Electrical automation engineering is highly intricate, making fault diagnosis challenging when issues arise; traditional diagnostic methods often fail to meet the requirements effectively. To detect fault areas and identify root causes promptly, AI can replace manual inspections, thus preventing extended downtimes that could disrupt electrical automation workflows. Effectively integrating AI in electrical automation control can help promptly detect and diagnose faults. The key benefits of AI include high efficiency and precise fault detection rates, which provide significant assistance to human operators. Various diagnostic methods exist, such as expert system detection, fuzzy logic diagnosis, and neural network detection. When using AI for fault detection, the actual context and specific type of fault should guide the choice of diagnostic approach, minimizing financial losses due to malfunctions and reducing fault detection and repair time to the greatest extent.

3.2. Electrical control

The broad application of AI in electrical automation has introduced greater convenience to the field, encouraging companies to capitalize on its potential. Electrical automation control operations are inherently complex,

and human errors in operation can interrupt progress or pose safety risks. Traditional electrical automation control requires significant human involvement, demanding extensive training for both design and operational staff. This training incurs high costs, and without sufficient training, the safety and functionality of automation control cannot be guaranteed. By applying AI technology extensively within electrical automation control, system management, and logical operations can be optimized, reducing reliance on human input [3]. Advanced intelligent systems can monitor and manage the entire control process, thereby diminishing human-induced errors, enhancing risk management, and capitalizing on the stability and high processing speeds of computers. This application effectively compensates for the limitations of manual work.

4. Effective applications of AI technology in electrical automation control

4.1. Applications of AI in electrical automation control

4.1.1. Fuzzy control

Fuzzy control enhances system structure by transforming it into a closed-loop system, drawing upon theories like fuzzy inference and fuzzy language from computer science. This approach enables effective control over electrical automation. The fuzzy controller, which forms the backbone of fuzzy control in computer-based closed-loop structures, can manage various control targets, including linear and nonlinear, single-variable and multi-variable, as well as steady and dynamic control objects. Core fuzzy control components employ devices like hydraulic valves and DC motors. The fuzzy controller, central to the process, uses rule-based reasoning, integrated with measurement tools, input-output interfaces, and A/D conversion equipment, to handle fuzzy logic operations. By basing fuzzy control systems on AI, the majority of control objects become observable, enabling effective simulation. The distinction lies in the variability of control values across different AI and fuzzy control applications.

4.1.2. Expert control

Expert control uses reasoning mechanisms supported by knowledge databases and AI technology, combined with industry-specific experience in electrical automation. This system adjusts automatically through self-regulation and logical learning to select suitable rules, achieving effective reasoning processes. Knowledge databases can be reconfigured as needed, allowing skilled operators to adapt to diverse automation environments. Expert control systems continually adjust, automatically adapting to an object's core properties and ensuring stability across varied conditions. This adaptability makes expert control especially valuable in nonlinear environments and widely accepted in automation.

4.2. Use of AI in electrical fault diagnosis

Electrical motor control often poses challenges for fault diagnosis. Traditional methods struggle with prompt identification of fault causes, whereas AI offers rapid diagnostic capabilities, efficiently detecting issues that manual methods may miss [4]. AI can employ neural networks to quickly identify fault locations and causes, streamlining troubleshooting and significantly alleviating personnel workload.

4.3. Application of AI in electrical equipment

Electrical automation systems are complex and technically advanced, often spanning multiple fields of expertise. Applying AI in automation requires knowledgeable operators to ensure systematic production and control. AI aids in managing control processes, verifying code accuracy, and enhancing operational speed. Detailed monitoring of equipment status also helps to reduce human and material costs in enterprise automation investments.

5. Prospects of AI technology in electrical automation control

5.1. Enhanced functional diversity

Integrating AI technology into electrical automation control can assist staff in handling and collecting relevant data, reducing task demands, and ensuring high work efficiency. In the future, AI is anticipated to have a comprehensive impact on automation control, leading to continuous upgrades and optimizations. This will support the shift toward machine-operated production

and fully automated processes, significantly raising the level and efficiency of automation control. Additionally, AI can optimize various automated production devices, simplifying traditional, complex operations, reducing unnecessary auxiliary equipment, and fundamentally lowering labor and material costs. As AI applications expand, their functionalities will diversify, helping resolve recurring issues in automation control and creating more value.

5.2. Optimized design capabilities

Traditional manual approaches to equipment modeling and electrical engineering product design are often limited by the operator's experience and subjective input. In electrical automation, AI can leverage knowledge databases to incorporate prior design experiences, enabling thorough analysis and informed decision-making to select optimal designs. Throughout the production process, AI continually enhances its self-learning abilities, improving the likelihood of innovative models and facilitating the discovery of top-tier design solutions [5].

Through data-driven simulations and computer logic, AI emulates human cognitive processes, enabling the efficient design of suitable electrical control products in minimal time, easing the workload for designers, and boosting productivity.

6. Conclusion

Traditional electrical automation control work often demands significant labor and material resources. The application of AI in this field can enhance production efficiency and effectively reduce these costs. Through methods like expert systems and fuzzy diagnostics, enterprises can further improve productivity, creating additional economic benefits under equivalent equipment and personnel configurations. The future development of electrical automation control will require the expanded use of AI technology to create more advanced devices and intelligent management systems with powerful processing capabilities, strongly advancing the field of electrical automation control.

Disclosure statement

The author declares no conflict of interest.

References

[1] Liu B, 2019, Design and Implementation of Electrical Automation Control Systems Based on Artificial Intelligence. Electrical Technology Applications, 38(3): 66–70.

[2] Chen X, 2018, Research on Electrical Equipment Fault Diagnosis Based on Deep Learning. Power System Automation, 42(4): 90–95.

[3] Zhang G, 2020, Design and Application of Electrical Control Systems Based on AI Technology. Automation Instrumentation, 41(8): 89–93.

[4] Li M, Zhao W, 2020, Research on Electrical Automation Fault Diagnosis and Prediction Methods Based on Artificial Intelligence. Electrical Automation, 42(6): 101–107.

[5] Dong L, Liu Y, 2022, Research on Optimization of Electrical Control Systems Based on Machine Learning. Automation Instrumentation, 43(2): 65–70.