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Discussion on the Informatization Development of Building Electrical in China under the Background of AI Technology

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Abstract: *This paper discusses the development of building electrical informatization in China under the background of AI technology. It elaborates on its applications in fields such as intelligent lighting, power load forecasting and energy management, and fault diagnosis and predictive maintenance of electrical equipment, analyzes the problems such as data security and privacy protection, technical integration and system compatibility, and shortage of professional talents, proposes corresponding solutions, and looks forward to the future development trend.*

Keywords: *AI technology; building electrical informatization; power load forecasting and energy management; fault diagnosis and predictive maintenance*

1. Introduction

With the rapid development of science and technology, artificial intelligence technology has been widely infiltrated into various industries, and the building electrical industry is no exception. The application of AI technology in building electrical is gradually changing the traditional design, construction, operation and maintenance modes, bringing new opportunities and challenges to the informatization development of building electrical [1].

The building electrical system, as an important part of modern buildings, the efficient and stable operation of its multiple subsystems including power supply and distribution, lighting, fire protection, security, elevators, and communication is the key to ensuring the normal function of the building as well as the comfort and safety of users. In the current construction industry, the informatization of building electrical has become an irresistible development trend. It can not only improve the intelligent level of the building, realize the integration and collaborative work of various systems, but also improve energy utilization efficiency, reduce operating costs, and enhance the competitiveness of the building.

In-depth research on the development of building electrical informatization in China under the background of AI technology has important theoretical and practical significance. On the one hand, it helps to enrich the theoretical system in the field of building electrical, and explore innovative models and methods for the integration of AI technology and building electrical; on the other hand, it can provide practical guidance for practitioners in the building electrical industry, promote the technological upgrading and transformation of the industry, improve the performance and quality of building electrical systems, promote the sustainable development of the construction industry, and thus better meet people's needs for high-quality building environments and promote the construction process of smart cities.

Foreign countries started earlier in the research on the combination of building electrical informatization and AI technology and have achieved relatively fruitful results. Many universities and research institutions in developed countries have carried out in-depth research in fields such as intelligent building control systems, energy management systems, and fault diagnosis and prediction, and widely applied the research results to actual engineering projects.

Compared with foreign countries, China started relatively late in the research of building electrical informatization, but it has developed rapidly in recent years and has achieved many remarkable results [2]. Many domestic universities and research institutions have carried out relevant research one after another, and have made certain breakthroughs in intelligent building integration technology, optimization of building energy management systems, and fault diagnosis of electrical equipment, and gradually formed a research system and application model with Chinese characteristics.

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However, there are still some deficiencies in the development of building electrical informatization in China. For example, in the research of the core algorithms of AI technology and the development of high-end equipment, there is still a certain gap compared with the international advanced level; the application of some research results in actual projects is not extensive and in-depth enough, and there is a phenomenon of disconnection between technology and practice.

2. Application Fields of AI Technology in Building Electrical

2.1 Intelligent Lighting System

The intelligent lighting system is one of the typical applications of AI technology in the field of building electrical. By installing various sensors in the building, such as light sensors, human infrared sensors, and motion sensors, it can collect data such as ambient light intensity and personnel activity in real time and transmit these data to the AI control system. The AI control system uses machine learning algorithms to analyze and process these data, and thus automatically adjusts the brightness, color, and switch status of the lighting fixtures according to different scenarios and needs. For example, in commercial buildings, during the day when there is sufficient natural light, the system can automatically dim or turn off some fixtures to reduce energy consumption; and in the evening or on cloudy days when the light intensity decreases, it automatically increases the fixture brightness to ensure appropriate indoor lighting. When there is no human activity in the office area, the system can automatically turn off the lighting to achieve "lights off when people leave", further saving energy.

The intelligent lighting system can also be linked with other intelligent systems in the building. For example, it can be linked with the security system. When an abnormal situation is detected, it automatically turns on the lighting fixtures in specific areas to assist in security monitoring; it can also be linked with the curtain control system. According to factors such as light intensity and indoor temperature, it automatically adjusts the opening and closing degree of the curtain and the lighting brightness to achieve more intelligent indoor environment control. Through these applications, the intelligent lighting system not only improves the comfort and flexibility of lighting, but also significantly reduces the energy consumption of the building, making an important contribution to achieving the goal of green buildings.

2.2 Power Load Forecasting and Energy Management

In the building electrical system, power load forecasting is of great significance for rationally arranging power supply, optimizing energy distribution, and reducing operating costs. The application of AI technology provides a more accurate and efficient means for power load forecasting [3]. Taking office buildings as an example, by collecting and analyzing historical electricity consumption data, including electricity consumption in different time periods, types and usage frequencies of electrical equipment, seasonal factors, weather conditions, and holidays, the AI algorithm can mine the potential laws and correlations behind these data. Some common AI prediction models, such as artificial neural networks (ANN), support vector machines (SVM), and long short-term memory networks (LSTM), can effectively handle the nonlinear and time-varying characteristics of power load data and improve the accuracy and reliability of prediction. The prediction results can not only help the power department to reasonably arrange the power generation plan and ensure the stability of power supply, but also provide a decision-making basis for building managers to optimize the energy distribution strategy.

In terms of energy management, AI technology can also realize the real-time monitoring and intelligent control of the building energy system. By installing various smart meters and sensors in the building, it can collect the consumption data of electricity, water, gas and other energy in real time and transmit these data to the energy management system (EMS). The EMS uses AI algorithms to analyze and process these data to achieve fine-grained management of the energy system [4-8].

AI technology can also be combined with renewable energy power generation systems, such as solar photovoltaic power generation and wind power generation systems. By real-time monitoring and analyzing weather data, light intensity, wind speed and other information, the AI system can predict the power generation capacity of renewable energy and optimize the distribution and use of energy according to the prediction results, increase the proportion of renewable in the building energy supply, further reduce the building's dependence on traditional fossil energy, and achieve the goals of energy conservation, emission reduction and sustainable development of the building.

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2.3 Fault Diagnosis and Predictive Maintenance of Electrical Equipment

In the building electrical system, the fault diagnosis and maintenance of electrical equipment is a key link to ensure the normal operation of the system. The introduction of AI technology has brought revolutionary changes to this field, making fault diagnosis more accurate and efficient, and at the same time enabling predictive maintenance, reducing equipment failure rates and maintenance costs [9].

Taking the electrical equipment in large industrial buildings as an example, such as transformers, motors, switch cabinets, etc., the operation status of these equipment directly affects the power supply and production activities of the entire building. The AI-based fault diagnosis model can monitor and analyze various parameters of the equipment in real time during the operation process, detect potential faultin advance, and take corresponding maintenance measures in a timely manner. Specifically, by installing various sensors on the electrical equipment, such as temperature sensors, vibration sensors, current sensors, voltage sensors, etc., it can collect the operation data of the equipment in real time. After these data are transmitted to the AI fault diagnosis system, the system uses machine learning algorithms to perform feature extraction and pattern recognition on the data. For example, for transformers, the AI system can analyze the changing trends of parameters such as oil temperature, winding temperature, and load current, and combine historical data and fault case libraries to judge whether the transformer has risks such as overheating, insulation aging, and short circuit. For motors, by monitoring parameters such as vibration amplitude, frequency, and current fluctuation, it can timely detect problems such as bearing wear, rotor imbalance, and winding short circuit.

This predictive maintenance model has significant advantages compared with the traditional regular maintenance and post-fault repair. The traditional regular maintenance often has problems of over-maintenance or under-maintenance, resulting in waste of resources or sudden equipment failure. And post-fault repair may cause long-term shutdown and production stoppage, bringing huge economic losses to the enterprise. Through the predictive maintenance realized by AI technology, it can carry out precise maintenance intervention before the equipment fails, avoid the occurrence of equipment failure, or minimize the impact of the failure, thereby improving the reliability and availability of the equipment, extending the service life of the equipment, reducing maintenance costs and production losses, and providing a strong guarantee for the production and operation of the enterprise [10].

3. Main Problems Facing Building Electrical Informatization

3.1 Problems of Data Security and Privacy Protection

In the process of building electrical informatization, data security and privacy protection are of utmost importance. The building electrical system involves a large amount of sensitive information, such as users' electricity consumption habits, personnel activity patterns in the building, and operating parameters of electrical equipment. This data is not only related to users' privacy, but also closely related to the safe operation of the building.

With the deep integration of the building electrical system and the Internet, the data faces many risks during transmission, storage, and processing. In terms of data transmission, if an insecure communication protocol or network environment is adopted, the data is easily stolen or tampered with by hackers. For example, the intelligent lighting system of some buildings is connected to the control system through a wireless network. If the wireless network is not encrypted or the encryption strength is insufficient, hackers may intercept the control instructions of the lighting system, turn the lights on or off at will, or even modify the lighting scene settings, which not only affects the user experience, but may also cause energy waste or safety hazards. In the data storage link, if the security of the storage device is insufficient, such as the server does not take effective access control measures and the data is not stored encrypted, once the storage device suffers physical damage, loss, or is illegally accessed, the data stored in it will be at risk of leakage. For some key data in the building electrical system, such as the load data of the power system and the fault diagnosis data of electrical equipment, the leakage of this data may be exploited by criminals, posing a serious threat to the power supply and equipment operation of the building. In the data processing process, if there are software vulnerabilities or malicious code, it may also lead to data theft or tampering. For example, the data analysis software in some building electrical management systems may have security vulnerabilities, and hackers can use these vulnerabilities to obtain system permissions and then access and tamper with the data, causing abnormal operation of the building electrical system and even triggering safety accidents.

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3.2 Difficulties in Technical Integration and System Compatibility

Building electrical informatization involves the integration of multiple technologies and systems, such as automation control systems, communication systems, and information systems. However, electrical equipment and software systems produced by different manufacturers often adopt their own independent technical standards and communication protocols, which makes the compatibility between systems poor and data exchange and sharing difficult. Taking the building automation system (BAS) in intelligent buildings as an example, BAS usually needs to integrate multiple subsystems, such as lighting systems, air conditioning systems, elevator control systems, and security systems. However, since different subsystems may be provided by different suppliers, the communication protocols and data formats they adopt are different. For example, some adopt the BACnet protocol, some adopt the Modbus protocol, and some adopt proprietary protocols. This leads to the need to invest a lot of manpower, material resources, and time in protocol conversion and interface development when integrating the system, increasing the complexity and cost of system integration, and at the same time reducing the reliability and stability of the system. In addition, with the continuous development and updating of building electrical technology, new equipment and systems are constantly emerging. How to ensure the compatibility of these new technologies with the existing system is also an urgent problem to be solved in the process of building electrical informatization. If the problems of technical integration and system compatibility cannot be effectively solved, it will limit the further development of building informatization and hinder the overall performance improvement and function realization of intelligent buildings.

4. Countermeasures to Solve the Problems of Building Electrical Informatization

4.1 Strengthening Data Security Management Measures

In view of the problems of data security and privacy protection in the process of building electrical informatization, a series of measures to strengthen data security management should be taken to ensure the confidentiality, integrity, and availability of data.

First, in terms of data transmission, advanced encryption technologies, such as the SSL/TLS encryption protocol, should be adopted to encrypt the data in the building electrical system during transmission to prevent the data from being stolen or tampered with during network transmission. Second, a strict access control mechanism should be established to classify and manage various data resources in the building electrical system, and grant different levels of access permissions according to the roles and permissions of users. Only authorized users can access specific data, thus preventing illegal users from obtaining sensitive information.

In addition, a sound data backup and recovery strategy should be formulated. The important data in the building electrical system should be regularly backed up, and the backup data should be stored in a safe and reliable location, such as an off-site disaster recovery center. When the data is lost, damaged, or leaked, the backup data can be used in time for recovery to ensure the normal operation of the building electrical system. For example, for historical power load data and electrical equipment fault diagnosis data, a full backup should be carried out once a week, and the backup data should be transferred to the off-site disaster recovery center for storage at the end of each month to prevent the local data from being lost due to natural disasters, hardware failures, or human attacks.

At the same time, the security protection of various software and equipment in the building electrical system should be strengthened, and regular security vulnerability scanning and repair should be carried out to prevent hackers from invading the system through software vulnerabilities and stealing or tampering with data. For example, the servers, workstations, and other equipment in the building electrical management system should be scanned for security vulnerabilities once a month, and the security patches of the operating system and software should be installed in time to ensure the security of the system.

Finally, for data interaction involving third-party service providers, a strict confidentiality agreement should be signed to clarify the data security responsibilities and obligations of both parties, ensure that the third-party institutions comply with relevant data security regulations and standards during data use and storage, and prevent data leakage incidents.

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4.2 Unifying Technical Standards and Specifications

To solve the problems of technical integration and system compatibility, the formulation and unification of technical standards and specifications for building electrical informatization should be strengthened. Relevant government departments should take the lead in organizing industry experts, enterprise representatives, and scientific research institutions to jointly formulate unified technical standards and specifications for building electrical informatization, covering all aspects such as system architecture, data interfaces, communication protocols, and equipment selection.

In addition, detailed standards and specifications should also be formulated for the design, construction, and acceptance of building electrical informatization systems to ensure the implementation quality of the project and the stability of the system. For example, in the design stage, it is required to design the system architecture and function planning according to unified standards to ensure the scalability and compatibility of the system; in the construction stage, the construction specifications should be strictly implemented to ensure the installation quality of equipment and the rationality of wiring; in the acceptance stage, the system should be comprehensively tested and evaluated according to unified acceptance standards to ensure that the system meets various performance index requirements. Through the unification of technical standards and specifications, not only can the integration efficiency and compatibility of building electrical informatization systems be improved, the construction and maintenance costs of the system be reduced, but also the healthy development of the building electrical industry can be promoted, and the wide application and popularization of intelligent building technology can be driven.

5. Conclusion

The application of AI technology in building electrical informatization has brought significant changes and opportunities for the development of the industry. Through the practice in application fields such as intelligent lighting, power load forecasting and energy management, and fault diagnosis and predictive maintenance of electrical equipment, the intelligent level, energy utilization efficiency, and operation reliability of the building electrical system have been effectively improved.

However, in the process of development, it also faces many problems such as data security and privacy protection, technical integration and system compatibility, and shortage of professional talents. In response to these problems, taking measures such as strengthening data security management, unifying technical standards and specifications, and strengthening talent cultivation and introduction will help promote the healthy development of building electrical informatization.

The deep integration of AI technology with building electrical and green and sustainable development will become the main trends in the future. With the continuous progress and innovation of technology, building electrical informatization will play a more important role in improving building quality, reducing energy consumption, and promoting the construction of smart cities. However, it is also necessary to continuously pay attention to the industry dynamics, constantly improve and perfect the technical and management systems to adapt to the changing market demands and social development requirements, realize the sustainable prosperity and development of the building electrical industry, and create a more comfortable, convenient, efficient, and green building environment for people.

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