Research on Application of Artificial Intelligence Technology in Electrical Automation Control

Chao Jiang\textsuperscript{1}, Xiaorui Xiong\textsuperscript{2}, Tanqing Zhu\textsuperscript{3},*, Jiajia Cao\textsuperscript{1}, Jiahao Yu\textsuperscript{4}

\textsuperscript{1}Jiangsu Frontier Electric Technology Co., LTD, Nanjing, 211000, China
\textsuperscript{2}School of Network & Communication Engineering, Chengdu Technological University, Chengdu, 611730, China
\textsuperscript{3}School of public health, Xiamen University, Xiamen, 361005, China
\textsuperscript{4}School of Electronic Information and Electrical Engineering, Shanghai Jiao Tong University, Shanghai, 200240, China

*Corresponding Author’s E-mail: zhutanqing2000@163.com

Abstract. Among the evaluation indicators of national development level, the degree of power system development is one of the important indicators. Economic and social needs have gradually expanded the scale of the power grid, and many distributed renewable energy sources are continuously connected to the power grid system, making the power system more and more complex; the data generated during the application of the power system presents typical big data characteristics, such as presenting large, heterogeneous, and multi-source characteristics. Faced with the new characteristics of power data, the requirements for methods of analyzing and processing power data problems have increased. The current research on artificial intelligence (AI) in the computer field is getting deeper and deeper, and the application of AI in various industries has made greater research progress. It is the key to future scientific and technological progress. In my country's development strategy, it is clearly required to promote the development of AI and regard the power system as one of the main application areas of AI. The rapid development and advancement of artificial intelligence can provide powerful tools in many aspects of the power system, including power system planning and design, coordinated control, simulation, prediction and estimation, diagnosis and identification. This article first analyzes the artificial intelligence technology, introduces the two mainstream artificial intelligence technologies in the current situation, and analyzes the power system, and then studies and analyzes the application of artificial intelligence technology in the electrical system.

1. Introduction

In the field of power grids, the requirements for cutting-edge science and technology have gradually increased. Automation technology and intelligent technology have become the mainstream application technology in response to the needs of the development of the times. Experts, scholars and technicians in related fields have researched and discussed the application of artificial intelligence technology in power systems, resulting in more research literature and achieved certain results. In many research projects, many artificial intelligence methods have been introduced into electrical automation control, including expert systems, pattern recognition, genetic algorithms, neural networks, and fuzzy recognition. The introduction of artificial intelligence technology in power system automation control
can improve the efficiency of electrical automation management, minimize the probability of electrical accidents, and enable the power system to run smoothly for a long time, thereby reducing the cost of power system operation and maintenance. In the relevant research on the application of artificial intelligence technology in electrical automation control, the basis is to grasp the research status of electrical automation control technology, artificial intelligence technology and related application fields, and analyze the basics of combining artificial intelligence technology with electrical automation control condition.

Automation technology is a new technology, which combines computer, electronic technology and network technology, can improve the level of process production, and is applied in the military field, industrial production and social life and other fields. It is related to human production and industrial production. Electrical automation control technology is a specific application of automation technology in the electrical field, which can improve the production efficiency of power-related enterprises, reduce labor costs, and improve the production efficiency of enterprises. In electrical automation control, manual operations are replaced by machines, freeing manpower from tedious and complicated daily operations. Using machine operation, it can work continuously for a long time, and can obtain high accuracy and timeliness.

Among the key research areas of artificial intelligence, power systems are one of the important areas for the breakthrough development of it. Since the introduction of the expert system method, the application of artificial intelligence algorithms in power systems has been in constant exploration. However, in the traditional artificial intelligence method, in most cases, there are problems such as long cycle time, complicated calculation, and difficulty in learning. With the continuous improvement of artificial intelligence algorithms in recent years, the efficiency has been greatly improved. Gradually formed a multi-source heterogeneous big data model, the amount of data continues to accumulate, the application of artificial intelligence in the power system has entered a new stage, will usher in new opportunities and challenges.

2. Artificial intelligence technology
Artificial intelligence is the use of computers to imitate human thinking logic and advanced wisdom. Its intelligence can be divided into three levels: intelligent computing, perception, and cognition. Computational intelligence means that when processing massive amounts of data, the computer has super computing power; perceptual intelligence is to enable the machine to perceive like humans from the aspects of vision, hearing, and touch when facing the surrounding environment. Both speech recognition and image recognition belong to this category; Cognitive intelligence is to enable machines to be able to make the right decisions and judgments just like humans in rational thinking. The fusion of the three capabilities of artificial intelligence will eventually enable the computer to realize human-like intelligence and assist or replace human work in all aspects.

Technologies such as fuzzy logic and machine learning are important aspects of the continuous evolution of the new generation of artificial intelligence.

2.1. Fuzzy logic
After the computer obtains accurate data input, it can understand the conventional logic block and output the logic processing result. The computer's handling of fuzzy logic mainly imitates human judgment and reasoning thinking from the concept of uncertainty. When performing fuzzy logic inference processing, fuzzy sets and fuzzy rules are applied to express qualitative knowledge experience or express transitional boundaries; It deals with the fuzzy information problems of rule models that are difficult to be solved by conventional thinking methods, implements fuzzy comprehensive judgment, and forms corresponding conclusions based on the results of inference. Compared with precise logic calculation, fuzzy logic is closer to human thinking logic.

The core elements of fuzzy logic include fuzzy linguistic variables, fuzzy rules, fuzzy reasoning, and fuzzy control. A typical fuzzy logic structure is shown in Figure 1.
2.2. Machine learning

In artificial intelligence, machine learning is a typical representative. The learning process is to improve the performance of the system itself on the basis of existing experience with the help of computing technology. The experience of machine learning is usually expressed in the form of data. Therefore, machine learning is the main technical way to transform from data to intelligence.

Machine learning is divided at different levels, including traditional machine learning, reinforcement learning, deep learning, and transfer learning. In the application research of this paper, it mainly discusses the deep learning which is widely used.

After extensive research, artificial neural networks have become the concept of deep learning. There are multiple hidden layers contained in these multiple levels of perception structure, which is more classic in the deep learning hierarchy. Among them, the hidden layer adopts an unsupervised way to learn, which can automatically construct new features from the data. By extracting features layer by layer, the implicit representation of the data is finally obtained.

Similar to traditional machine learning methods, deep learning can be divided into two categories: unsupervised learning and supervised learning. Among them, unsupervised learning models include machine learning models such as stacked autoencoders, deep belief networks, and restricted Boltzmann machines; Supervised learning models include machine learning models such as Convolutional Neural Network. A typical deep learning regression prediction model is shown in Figure 2.
3. Overview of the power system
The power system belongs to the system of producing and consuming electric energy, which is composed of multiple links, including power generation, transmission and consumption. The development scale and technical level of the power system can reflect the level of economic development. The concept of smart grid (smart grid) is proposed and gradually promoted, which puts forward new requirements for the operation of power systems, and has become the main direction of applying artificial intelligence methods in power systems. In the current application of artificial intelligence in power systems, a single application of artificial intelligence technology is gradually developing in the direction of diversified technology applications. Its application scenarios cover a variety of scenarios, including demand-side management, load, microgrid, new energy power generation, network security, power grid security and stability, and equipment management. In each scenario, a number of different research directions are derived. This paper mainly studies the three aspects of artificial intelligence technology in power system fault diagnosis, safety control and power inspection. Its main application direction framework in the electric power field is shown in Figure 3.

4. Application analysis of artificial intelligence technology in power system
4.1. Application in fault diagnosis
When a real-time fault occurs in a power system, it is generally in the process of the fault, and on this basis, the nature and cause of the fault of the system function are investigated. At present, the methods of artificial intelligence control mainly include the application of artificial neural networks, expert systems and fuzzy set theory. Artificial neural processing methods have powerful knowledge acquisition capabilities and are information processing systems that simulate human brain tissue structure and human cognitive processes. Using standard sample learning and training for automatic processing and automatic adaptation of information faults, each artificial neural process will be divided into corresponding parts, and each small part is responsible for a part of the fault diagnosis. Due to the fast processing ability and good classification ability of the artificial neural network, it is widely used in real-time control and fault diagnosis and status assessment of power systems. Therefore, artificial intelligence technology of neural network has become a relatively widely used technical method in
power systems. When the system fails, the relationship between the symptoms and the failure is mutually ambiguous. Therefore, to solve the failure, the relationship matrix in the fuzzy set theory of resume is needed. The application principle of the expert system is based on the experience and computer programs of experts in the field of systems. The expert system can be mainly used in system detection and diagnosis, system recovery and accident screening. The typical accidents in the fault and the diagnosis experience of the operating personnel are summed up to form the so-called Expert knowledge base system. The fault diagnosis process is shown in Figure 4.

4.2. Application in electrical process control
Whether the power system can operate normally after being disturbed is the main consideration of the stability control of the power system. The development of the transmission and distribution network and the increasing participation of the power market have led to further increase in the uncertainties and difficulty of the stable control of the power system. In the electric automation control method, the traditional control method mainly analyzes the physical characteristics of the power grid. Due to the need to complete physical modeling according to different topological structures, operating modes and fault types, it has low adaptability to changes in the structure of the power grid and new types of power equipment, and it is difficult to meet the needs of power grid development. Using data-driven methods to replace process simulation, with the help of reinforcement learning's autonomous decision-making ability, fully excavate system environmental information, and directly obtain stable control strategies. At the same time, due to the weaker information perception and acquisition capabilities of reinforcement learning, in environmental analysis, use deep learning to extract the operating characteristics of the power grid; Use the extracted information as input data and use these input data for reinforcement learning to improve the accuracy of decision-making and control efficiency. In the control of power grid cutting machine, the application of enhanced Q learning method and deep convolutional neural network, directly map grid operation information in control.

4.3. Application of artificial intelligence technology in power inspection
Transmission lines are the main application of artificial intelligence in power inspection. During normal operation of the transmission line, it is easily damaged by human and natural factors, which affects the stable operation of the entire power system. In most cases, the transmission lines will be distributed in the wilderness. In such a harsh environment, traditional manual inspection and GPS inspection techniques are difficult to meet the needs of the work. The use of artificial intelligence technology to
achieve the organic combination of drone technology, intelligent robot technology and deep learning image recognition technology, to achieve unmanned inspection, to facilitate the inspection of electric power in harsh environments.

The intelligent robot integrates a fixed-point collection system, audio and video monitoring system, and host computer system set. The robot can collect audio and video at the corresponding position and transmit it to the control terminal. The staff can complete the inspection task by remotely operating the robot. In power inspections in recent years, using aerial images of drones as basic data to achieve image recognition has become the main development direction. In artificial intelligence data processing, the feature extraction and classification functions of the convolutional neural network are used to achieve a clear distinction between power equipment such as insulators, circuit breakers, transformers, transmission line towers and transmission line poles, auto recognition.

5. Conclusion
In summary, artificial intelligence technology is an innovative technology that leads the future, and its application in electrical control is becoming increasingly widespread. Compared with traditional technology, artificial intelligence technology has obvious advantages. The application of intelligent technology in electrical automation control systems can reflect the basic characteristics of high precision, high efficiency and high coordination. The application of this technology, while achieving automatic control, can greatly improve the operating efficiency and quality of the control system. At the same time, intelligent control of electrical engineering can also realize the optimal allocation of resources, reduce resource cost investment, improve the economic benefits of related companies, and promote the sustainable development of my country's electrical industry.

Reference
[1] Chen F, Wang W, Xu L J, et al. 2012 Analyzing the voltage variation of distribution network including distributed generation. Proceedings of the CSU-EPSA, vol 24, no 4, pp 145-149.
[2] Liu X J, Kong X B. 2013 Present situation and prospect of model predictive control application in complex power industrial process. Proceedings of CSEE, vol 33, no 5, pp 79-85.
[3] Valverde G, Cutsem T V. 2013 Model predictive control of voltages in active distribution networks. IEEE Transactions on Smart Grid, vol 4, no 4, pp 2152-2161.
[4] DAI J J, SONG H, SHENG G, et al. 2017 Dissolved gas analysis of insulating oil for power transformer fault diagnosis with deep belief network. IEEE Transactions on Dielectrics and Electrical Insulation, vol 24, no 5, pp 2828-2835.
[5] WANG T, HE Y, LI B, et al. 2018 Transformer Fault Diagnosis Using Self-Powered RFID Sensor and Deep Learning Approach. IEEE Sensors Journal, vol 18, no 15, pp 6399-6411.
[6] Niu Z H, Shi Y. 2018 Application of inspection robot in ultra-high voltage substation. Shandong Electric Power, vol 45, no 6, pp 74-77.
[7] Li J F, Wang Q R, Li M. 2017 Combining deep learning and random forest Image identification of power equipment. High Voltage Engineering, vol 43, no 11, pp 3705-3711.
[8] ZHANG S, WANG Y, LIU M, et al. 2018 Data-based line trip fault prediction in power systems using LSTM networks and SVM. IEEE Access, no 6, pp 7675-7686.
[9] BEDI J, TOSHNIWAL D. 2018 Empirical Mode Decomposition Based Deep Learning for Electricity Demand Forecasting. IEEE Access, no 6, pp 49144-49156.
[10] Wang X. 2018 Research status and prospects of power system robots. China Plant Engineering, no 13, pp 171-172.