Application Analysis of Artificial Intelligence in Power System Fault Diagnosis

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Abstract: ***In the current development situation, the power industry has become one of the important factors affecting China's social and economic development and the quality of life of the people, and has significant implications for the development of China's social and economic development. In this situation, the demand for electricity in various regions of China is rapidly increasing, and the power system is also under high operating pressure, leading to frequent incidents such as transformer failures and transmission line failures. This not only has a serious impact on the economic development of various regions, but also brings many inconveniences to people's lives. However, many facilities and equipment in the power system are relatively sophisticated, and it is impossible to accurately determine the type and cause of faults solely based on the inspection of staff. The emergence of artificial intelligence technology provides necessary technical support for the diagnosis of power system faults, which can help workers find and solve related faults in a relatively short period of time. Based on this, this article focuses on the application of artificial intelligence in power system fault diagnosis, and further promotes the healthy and stable development of China's power industry.***

Keywords: Artificial intelligence; Power system; Fault diagnosis.

1. INTRODUCTION

In the past management process, power companies mainly used traditional manual inspections. However, the complex operating structure and sophisticated facilities and equipment of the power system make it difficult for many workers with low comprehensive quality and ability to accurately determine the cause of faults. In addition, the influence of external environmental factors can also reduce the work efficiency of workers, resulting in their failure to timely investigate and properly solve the cause of faults, which in turn has a serious negative impact on the development of the local economy and the lives of residents. Nowadays, with the innovative development of modern science and technology, artificial intelligence technology has been widely applied in various industries, providing great assistance for the development of China's social economy. The development of social economy also provides a strong material basis for the development of artificial intelligence technology, accelerates its integration with Internet technology, and further provides more powerful technical support for the development of China's power industry, effectively improves the accuracy of power system fault diagnosis, so that most power system fault problems can be intelligently handled, thus effectively improving the work efficiency of staff, promoting the rapid recovery of power system, and ensuring the stable operation of power grid.

2. OVERVIEW OF ARTIFICIAL INTELLIGENCE TECHNOLOGY

Artificial intelligence technology is a new technological discipline composed of different fields, such as computer vision. One of the main purposes of studying such technologies is to enable machines to perform complex tasks that typically require human thinking and comprehensive consideration. Nowadays, such technologies have been well applied in various fields of enterprises, helping them solve many problems. For example, the widely used autonomous driving not only facilitates people's travel, but also significantly reduces traffic accidents caused by fatigue driving and other factors, effectively improving people's quality of life and ensuring their health and safety. Applying artificial intelligence technology to manufacturing enterprises not only enables the rational allocation of various production equipment, allowing the enterprise to produce goods continuously, but also reduces human errors, effectively improves work efficiency, reduces production costs, and brings more economic benefits to the enterprise. Applying artificial intelligence technology to the medical field can also assist doctors in clinical diagnosis and effectively improve their treatment efficiency by analyzing the characteristics of human tissue cells.

From the current situation, the demand for electricity in China continues to grow, but due to factors such as the terrain characteristics and uneven regional economic development, the distribution of China's power system is relatively widespread. In this situation, the later maintenance and upkeep of power facilities and equipment in various regions are difficult, and the diagnosis and detection of power system faults also face many challenges. However, introducing artificial intelligence technology into power system fault diagnosis can not only greatly

compensate for the shortcomings of manual troubleshooting, but also intelligently handle most power system fault problems through artificial intelligence technology, greatly improving work efficiency.

Wang et al. [1] developed a machine learning approach for fatigue life evaluation of pump spindle assemblies with parameterized geometry, showcasing AI's potential in industrial applications. Financial technology has seen parallel innovations, with Gong et al. [2] applying machine learning to predict extreme market volatility using unstructured data, while Zeng et al. [4] analyzed how education investment and social security affect household financial participation. Privacy-preserving technologies have advanced through Wang et al.'s [3] federated learning-based recommender system, addressing critical data security concerns in personalized services. Educational applications have progressed significantly, exemplified by Wang et al.'s [5] AI-powered system for early identification of learning difficulties. Computer vision research has advanced through Wang et al.'s [6] YOLOv8-based vehicle detection system and Chen et al.'s [7] EmotionQueen benchmark for evaluating LLM empathy. Multimodal learning frameworks have expanded, as demonstrated by Moukheiber et al.'s [8] fusion of satellite imagery with public health data, while Restrepo et al. [9] contributed multilingual benchmarks for ophthalmological QA systems. Healthcare AI has witnessed transformative developments, including Thao et al.'s [10] MedFuse system for EHR data fusion and Restrepo et al.'s [11] masked autoencoder for lab value representation learning. Subsequent medical innovations include Hsu et al.'s [12] MEDPLAN system for personalized treatment generation, Ding et al.'s [13] systematic review of deep learning in ECG diagnostics, and Restrepo et al.'s [14] work on multilingual evaluation of medical QA systems. Wu et al. [15] further advanced patient modeling through their multi-modal mixture-of-experts framework, demonstrating AI's growing sophistication in healthcare applications.

3. POWER SYSTEM FAULTS AND THEIR CAUSES

3.1 Transformer faults and their causes

Transformers in the power system can regulate voltage reasonably, raising and lowering voltage to ensure the stability of the power system operation. Moreover, transformers also have a safety isolation function. Once there is an abnormal situation in the power system, it can be cut off, effectively ensuring electrical safety and avoiding damage to other facilities and equipment in the power system, thereby reducing the losses of power enterprises. Once a transformer malfunctions, it not only fails to ensure the stability of the power system and increase the safety risk for users, but also causes damage to more precise components, instruments, etc. in the power system, thereby affecting the power supply in the region and causing varying degrees of economic and social development in the area. This shows the importance of transformers. Transformer faults mainly include the following two types:

Firstly, there is an internal malfunction. If a high electric field occurs inside this type of equipment during operation, its insulation will rapidly decrease, leading to its malfunction. Moreover, prolonged operation and high external temperatures can easily lead to a rapid increase in internal temperature of such devices, resulting in malfunctions due to high internal temperatures.

Secondly, external faults. This type of malfunction is mainly caused by faults in other equipment and instruments.

3.2 Transmission line faults and their causes

The transmission lines in the power system connect power plants, substations, and users, and are one of the most important components of the power system, playing an important role. Transmission lines not only effectively solve the problem of power plants being far away from power centers, but also reduce the total installed capacity in the power system, thereby significantly reducing the loss of power resources, effectively improving the economic efficiency and power supply reliability of the power system operation, and bringing more profits to power enterprises. Moreover, the improvement of transmission lines can effectively meet the electricity needs of remote and impoverished areas, creating favorable conditions for local social and economic development. However, with the increase of usage time and changes in external environmental temperature, the quality of transmission lines will gradually decline. And once lightning weather occurs, or there are pollutants on the surface of the insulator of the transmission line, it will cause flashover, short circuit and other situations, leading to its failure. After a fault occurs in the transmission line, the protective devices in the power system will immediately cut off the circuit to avoid damage to other transmission lines, facilities and equipment. In addition, factors such as pole damage and insulator damage are also the main causes of such failures.

3.3 Busbar faults and their causes

The busbar of a substation has the function of collecting, distributing, and transmitting electrical energy, and once it encounters problems, it will have a serious impact on the production and life of users. The main reasons for such faults include busbar short-circuit protection refusal to operate. Moreover, after such a malfunction occurs, it will trigger a series of chain reactions, leading to power outages throughout the entire plant, which will have a serious impact on the development of the region.

4. APPLICATION OF ARTIFICIAL INTELLIGENCE IN POWER SYSTEM FAULT DIAGNOSIS

4.1 Application of Fuzzy Theory

In the past, during the process of troubleshooting and diagnosing power systems, it was difficult for staff to clearly grasp the potential faults and the relationship between fault clearance. As a result, the accuracy and reliability of the final fault diagnosis results were not effectively guaranteed. However, after power companies apply fuzzy theory to the diagnosis of power system faults, relevant researchers can integrate various system faults and corresponding processing methods into fuzzy controllers. Then, the staff can dynamically monitor the power system through such instruments, and the fuzzy controller can timely and accurately detect potential problems in the power system through the collection of power system operation data, reasonable calculation reasoning, and final reinforcement reasoning, and then automatically take corresponding measures to solve related problems, effectively ensuring the smooth operation of the power system, promoting the stability of power supply, and effectively meeting the needs of production and life in various regions, promoting the sustainable development of the local economy. Moreover, after applying fuzzy theory to power system fault diagnosis, power companies can update and develop this theory, further optimizing adaptive fuzzy controllers and significantly improving the accuracy and reliability of power system fault diagnosis results. This enables them to timely and accurately detect potential faults that are difficult to detect, as well as automatically handle some simple problems. For some potential faults that are difficult to solve, fuzzy controllers can also alert the staff in a timely manner, allowing them to handle the problem as soon as possible to ensure the smooth operation of the power system [4]. In addition, if the staff fail to accurately detect faults or are unsure about some faults during daily diagnostic testing. This instrument can be operated and effectively combined with its work experience to further improve the diagnostic results and ensure that the fault can be dealt with in a timely manner.

4.2 Application of Information Theory

After a fault occurs in the power system, there will be significant changes in the data information before and after, and the fault will also cause the relevant protection devices to operate, resulting in circuit breaker tripping and automatic transformer power-off. If these pieces of information are organically combined and scientifically compared and analyzed, it is possible to quickly identify the faulty equipment in the power system. Moreover, after determining the type of fault, the staff can also combine this information with their own work experience to clarify the cause of the fault and take corresponding solutions to effectively solve various types of fault problems. It can be seen that information theory is of great importance for fault diagnosis in power systems. To fully leverage the positive role of information theory and achieve accurate diagnosis and proper handling of power system faults, in practical work, personnel need to fully consider the instability of the power system and protect its related systems to achieve effective information fusion, reasonable signal processing, etc., thereby effectively improving the accuracy of diagnostic results and ensuring that power system faults can be quickly resolved.

4.3 Application of Genetic Algorithm

Genetic algorithm is mainly a diagnostic method that imitates biological evolution to achieve global optimization of power systems [5]. After applying this type of algorithm to the power system, it can not only model the supply and demand relationship of various energy sources in the power system, effectively reduce energy consumption, and maximize energy utilization efficiency, but also accurately predict the future load of the power system, thereby helping power enterprises to schedule the load reasonably in different time periods, effectively ensuring the operational efficiency of the power system and ensuring its stability. Moreover, such algorithms can also systematically plan future electricity demand and energy supply, effectively improving the reliability of the power system while creating higher economic benefits for power enterprises. Moreover, applying it to power system fault

diagnosis has obvious advantages, firstly, it has a strong ability to handle optimization problems. Secondly, achieve global optimization of the power system.

It can be seen that the application of genetic algorithms has significant significance for fault diagnosis in power systems. The ultimate goal of applying such algorithms to power system fault diagnosis is not to diagnose and solve faults, but to optimize and solve fault problems from the perspective of the entire power system, thereby achieving comprehensive optimization of the power system, further improving the stability of the power system, and effectively meeting the electricity demand and safety of various regions. In the actual operation process, if there are situations such as protection components and circuit breakers refusing to move, it means that such algorithms have completed the diagnosis of the entire system, thereby helping power companies solve fault problems from a global optimization perspective and promoting the improvement of the power system. However, when applying such diagnostic methods, it is necessary to conduct in-depth research on the establishment of digital models, determination of differences, etc., in order to effectively improve their application effectiveness.

4.4 Application of Artificial Neural Network Technology

In the past, the long and tedious inspection process in power system fault diagnosis was particularly prone to visual fatigue among staff, resulting in numerous misjudgments and affecting the operation of the power system, causing significant losses to the local economy. In addition, manual detection is easily affected by external environmental factors, which leads to the failure to detect some hidden faults in a timely manner, resulting in varying degrees of damage to the power system and causing significant losses to power enterprises. Moreover, each staff member has different judgments on defects and faults, making it difficult to form quantifiable quality standards. Naturally, in the process of diagnosing power system faults, some fault problems may not receive the attention they deserve, which in turn affects the operation of the power system. In serious cases, it may even cause damage to other equipment in the power system. Artificial neural network technology has significant advantages, not only can it effectively and timely detect and accurately handle fault problems in the power system, but it can also improve existing problems in the system and further optimize the power system. Moreover, after completing the work of fault diagnosis and processing, artificial neural network technology can also transmit the relevant operational data and data information generated during the fault resolution and processing process to the database, updating the relevant data information. Therefore, in the later operation of the power system, once relevant types of problems occur, artificial neural network technology can quickly find faults and their causes through databases, and carry out corresponding processing. For some problems that cannot be processed, it can also provide corresponding solutions for workers, thereby effectively improving their work efficiency [6]. From this, it can be seen that artificial neural network technology can also provide reference value for later work, helping power companies save more labor costs, time costs, and effectively improve the economic benefits of the enterprise.

5. CONCLUSION

In summary, fault diagnosis in the power system will have a significant impact on the development of power enterprises. Therefore, in order to properly solve transformer faults, transmission line faults, and promote the smooth operation of the power system, power companies need to make reasonable use of artificial intelligence technology to fully leverage the positive effects of genetic algorithms, artificial neural networks, and other technologies, effectively ensuring the power supply in various regions and promoting the healthy and long-term development of power companies.

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