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Artificial intelligence and electrical automation

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Abstract:

The introduction of artificial intelligence technology has brought new opportunities for the field of electrical engineering automation. This study mainly discusses the application of artificial intelligence in electrical automation, especially in the diagnosis of power system, summarizes several ways of power system diagnosis, and further explores a new way of power system diagnosis.

Keywords: artificial intelligence, electrical automation, power system diagnosis,power system control,PID algorithm

1. Introduction

With the continuous development of science and technology, artificial intelligence technology has gradually become a research hotspot. Artificial intelligence technology has been widely used in many fields, including the automation of electrical engineering. As an important part of modern industry, the development of electrical engineering automation is of great significance for improving production efficiency and product quality. The introduction of artificial intelligence technology has brought new opportunities in the field of electrical engineering automation.

2. The research significance of artificial intelligence for electrical automation

First, the introduction of artificial intelligence improves the efficiency and accuracy of electrical engineering automation. The traditional electrical engineering automation control system needs a lot of manpower and material resources and time to debug and maintain, and due to the influence of various environmental factors, low efficiency and accuracy is difficult to guarantee. Artificial intelligence technology can automatically identify and adjust the parameters and states of the system through machine learning, neural network and other algorithms, making the system more stable and reliable, but also greatly improving the work efficiency and production quality.[1]

Secondly, the introduction of artificial intelligence has improved the intelligent level of electrical engineering. Modern industrial production has higher and higher requirements for the intelligent level, and artificial intelligence technology can realize intelligent control, intelligent diagnosis and intelligent maintenance, etc., which provides strong technical support for the intelligent development of electrical engineering. For example, through the application of artificial intelligence technology, the fault diagnosis and prediction of electrical engineering can be realized, and the potential problems can be found in advance and timely maintenance, reducing the loss and impact caused by the fault.

At present, the application of artificial intelligence in

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electrical automation is as follows: 1: design of electrical automation equipment; 2: diagnosis of power system; 3: design of electrical control process.

3. Design of electrical automation equipment by artificial intelligence

Artificial intelligence algorithms can be used for the structural design and parameter optimization of electrical equipment, such as genetic algorithms that can optimize the structural parameters of transformers and improve their performance and efficiency. In addition, the artificial intelligence technology can be used to conduct a more accurate simulation analysis of the electrical automation system, such as the establishment of a digital twin model of the power system, to simulate the operation of the system under different working conditions.

4. Artificial intelligence for the diagnosis of the power system

For electrical equipment, when there is a failure, there will be certain signs, that is, the different signs indicate that the failure of the equipment is different, and the signs are non-linear and uncertain. Therefore, before the equipment now fails, we should effectively predict the symptoms, judge the type of the equipment failure, and realize the positioning and maintenance of the fault, which is particularly important for the operation of the equipment. The use of artificial intelligence technology can accurately realize the positioning, repair and isolation of electrical equipment faults, so that the effective and stable operation of electrical equipment.

At present, the expert system, neural network, Petri network, fuzzy logic and genetic algorithm in artificial intelligence technology are widely used in the fault diagnosis of electrical equipment.

4.1 Expert System (ES system)

Artificial intelligence technology is the earliest and most mature development of ES. By combining the theoretical knowledge of relevant professional power and the practical operation experience of power supervision and management, taking reasonable methods to deal with various power failure problems is the so-called ES principle.

For example, for the ship power system, with the help of the human-computer interaction interface, the fault parameters and other data are input into the control system, the fault reasoning and diagnosis are realized according to the knowledge base and reasoning rules, and the matching information is transmitted into the knowledge database, and finally feedback to the user.[2] The working mode of expert system is mainly to find problems-diagnose problems- -solve

Problem, form a knowledge base for the expert system with fault diagnosis as the content, and then reason about the contents of the knowledge base according to the received alarm information more deeply, so as to obtain the correct result of diagnosis.

4.1.1 Limitations of the expert systems

First of all, the expert system is a system with a lot of knowledge and requires years of accumulation and collection of experts. For a specific system, it is necessary to collect and process the state and results of the system in previous years, and then determine and reason the new state of the system according to this knowledge base.

Given the difficulty of acquisition and sorting of expert knowledge, on the other hand, poor adaptability to new faults beyond the knowledge base, and the power system with high computing power and processing speed.

4.2 artificial neural network

As one of the current mainstream AI technologies, artificial neural network technology is a computational model that simulates the working mode of the human nervous system. It is composed of many interconnected neurons and can realize complex non-linear mapping and self-learning functions. In the real-time monitoring of the power equipment status, the artificial neural network technology can monitor and diagnose the status of the equipment in real time by processing, analyzing and learning the operation data of the equipment, and provide a reliable basis for the power system control.

The biggest feature is that only the operation and maintenance personnel can provide a large number of and effective fault instance data, and as the training set of the neural network, the training can predict the current fault state of the power grid, and finally get the fault element.

In addition, it has the parallel processing capability, which can process multiple input data at the same time, quickly evaluate and diagnose the overall state of the power system, and improve the diagnostic efficiency. It also has good fault tolerance. Even if some data is noisy or incomplete, it can still give more reasonable diagnosis results by relying on its distributed information storage and processing methods.

4.2.1 Limitations of artificial neural network

Although the artificial neural network is very self-taught, it also depends on the quality and quantity of the training data. If the data is not comprehensive, it may lead to the deviation of the diagnostic results. Secondly, it is difficult

for the analysis based on this AI technology to actually explain, which also brings some difficulties to our analysis and understanding in practical application.

4.3 genetic algorithm

Genetic algorithm is a stochastic search and optimization algorithm inspired by biological evolution. In power system diagnosis, it uses the basic principles of biological genetics to find the optimal solution of problems by simulating natural selection and genetic mechanisms, which is used to handle complex problems such as fault diagnosis in power system. It is formed by simulating the phenomena of reproduction, hybridization and so on. The hierarchical information of the power system is transformed into chromosomal coding sequence, and the solved chromosomes are operated by genetics, crossover and variation, and constantly produce more excellent chromosomes. Through continuous iteration, the optimal solution that meets the requirements is finally obtained. This algorithm is often used for fault diagnosis, power system status assessment, protection device configuration optimization, etc.

The advantages of this algorithm are that it has strong global optimization ability, deals with optimization problems, and can globally search in a complex space to effectively avoid falling into the local optimal solution. Secondly, it has parallelism and can handle multiple possible solutions simultaneously, which is suitable for large-scale power networks.

4.3.1 Limitations of the genetic algorithm

Large computational amount: especially when dealing with large-scale power systems, large population size and many iterations will lead to long calculation time and affect the diagnostic efficiency.

Sensitive parameter selection: parameters such as coding mode, population size and cross variation probability have a great impact on the performance of the algorithm, including a lot of experiments and experience.

Precocious convergence: it may converge prematurely when the global optimal solution is not found, making the diagnosis results not accurate or incomplete. This problem mainly stems from the genetic evolution, there may be competitive individuals, and the control operation can only get the local optimum rather than the global; and it may not operate in the global situation because of the unreasonable crossover and variation probability.[3] Of course, the algorithm is also being improved one after another, so that the genetic algorithm can get rid of the influence of precocious convergence.

4.4 Petri algorithm

In 1962, a scientist in Hamburg, Germany, proposed a tool for discrete event models on dynamic models. In recent years, the graphical description of petri-based fault diagnosis on the power grid is more and more simple, fast and image, and the algorithm is easy to accept by the public, which has been favored by a wide range of knowledge scholars.[4]

The Petri network is a combined model that constructs a directed graph, and then abstracts the constructed model to form a relevant mathematical object, which can be described in detail using rectangular operations.

The structure of Petri network is mainly composed of library, change and directed arc. By abstracting the power system into mathematical objects, it can make qualitative analysis and quantitative analysis of the system, and finally it can effectively reflect the final results of the system when the conditions change. According to the accessibility analysis and status equation of Petri network, combined with the detected fault information, the fault location can be quickly determined. For example, when the system is abnormal, by analyzing the flow situation in the Petri network, quickly determine which line or which component has failed.

4.4.1 Limitations of the Petri algorithm

The bottlenecks restricting the development of Petri algorithm are as follows: First, it is difficult to model complex systems, The large-scale power system structure is complex, Containing a large number of node components and the existence of complex connection relations are easy to produce state space explosion because of the large network, the correlation matrix dimension over ambassador calculation greatly increased; Is the weight of the network depends on artificial experience to give the existence of artificial subjective uncertainty, which increases the uncertainty of the results; [5] Second, The algorithm has a limited description of its dynamic properties, The Petri network focuses on describing the logical relationships and discrete state changes of the system, To some continuous dynamic characteristics in the power system, Such as the continuous change of the electrical quantity, the aging process of the equipment, Difficult to characterize precisely, May bias the diagnosis, So you may need to rebuild the network.

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4.5 Summary

Table 1 Boundedness and merit of various methods

	Expert algorithm	artificial neural network	genetic algorithm	Petri algorithm
merit	The earliest and most mature development	Self-study ability, parallel, fault tolerance	Global optimization ability is strong, with parallelism	Fast and concise analytical techniques
boundedness	It is difficult to acquire and organize expert knowledge and has poor ability to deal with new faults	Relying on the quality and quantity of training data and existence abstraction are not easy to explain practically	Large computation, sensitive parameter selection, and premature convergence	It is very difficult to model complex systems, have uncertain weights, and has limited dynamic characteristics

5. Design of the electrical control process

Electrical control process often involves complex systems and a large number of variables, and the traditional control methods are difficult to deal with this complexity. Neural network, deep learning and fuzzy logic methods in artificial intelligence technology can deal with large-scale and non-linear systems, and model and analyze the complexity of the system. This enables the electrical control system to better cope with the management and control requirements of the complex systems.

The PID algorithm is often used in the control design. However, the anti-interference ability of the power system is poor, and the volatility will be relatively large due to the influence of the external environment. The implementation of PID algorithm is relatively easy to achieve, for small-scale power control system, PID algorithm can obtain better control results. However, with the continuous expansion of the scale of modern power system and the continuous addition of different types of loads, the power system becomes very complex, with certain nonlinearity and time delay. The defects of PID algorithm are more and more obvious, and the control error of the power system is large.

5.1 PID algorithm

The PID algorithm, namely the proportional-integral-differential control algorithm, is a commonly used feedback control algorithm. Its working process is to:

The system first obtains the set value and the actual output value, and calculates the deviation.

The proportion link immediately produces the corresponding control effect according to the deviation size.

The integral link accumulates the deviation over time, and the control amount is constantly adjusted to eliminate the steady-state error.

According to the deviation change speed, the differential link will intervene in advance when the deviation just has a change trend, correct the control amount, and make the system stable as soon as possible.

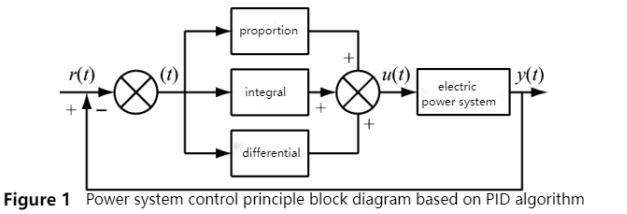

Figure 1 Power system control principle block diagram based on PID algorithm

$$u(t) = K_{\mathrm{p}}\left[e(t) + \frac{1}{T_{\mathrm{i}}}\int_0^t e(t)\,\mathrm{d}t + T_{\mathrm{o}}\,\frac{\mathrm{d}e(t)}{\mathrm{d}t}\right]$$

However, because the PID algorithm assumes that the power system is a linear change system, which is not consistent with the change characteristics of the actual power system, the actual control effect is not good.

5.2 Fuzzy Theory

Fuzzy theory is a kind of mathematical theory dealing with uncertainty and imprecision. It was proposed by the American expert in cybernetics Zad in 1965. The core concept is fuzzy set, which mainly includes fuzzy set theory, fuzzy logic, fuzzy reasoning, etc. Fuzzy theory in power system is a way to apply fuzzy mathematics and logic to solve the complex problems of power system. The basic principle is shown as follows:

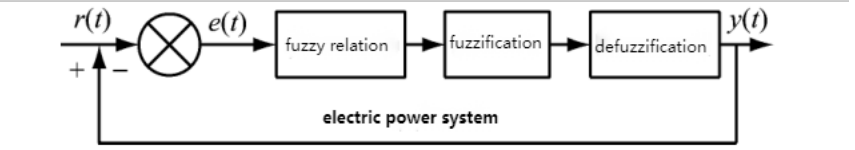

Figure 2 Block diagram of power system control principle based on fuzzy theory

However, due to the certain time delay of the power system, the control effect of the power system control method based on fuzzy theory is extremely unstable, and relatively large overregulation often occurs, which cannot meet the requirements of practical application.

5.3 PID algorithm and fuzzy theory

Since the PID algorithm is accurate but cannot overcome the influence of nonlinearity, the fuzzy theory can simplify the power system but it is not accurate enough. In this case, we can try to integrate the two methods, which satisfies both the nonlinearity of the power system and its time delay.

So how to integrate this method? I think you can use a weighted method, in a power system experiment first PID algorithm control, and then by fuzzy theory, respectively to the two sets of data weighted, through the deduction makes the weighted addition data more convergence in the predetermined data, make the control power system more stable. Of course, the components and structure of each power system are different, so each power system needs to be weighted out to get the weight ratio suitable for each power system. In this way, a set of system control algorithm can be obtained more consistent with the real power system.

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