Application Analysis of Power System Control and Fault Diagnosis Based on Ant Colony Algorithm

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Abstract. Due to the frequent occurrence of power system faults and the complexity of fault types, the speed of traditional control methods is slow, so a power system control method based on ant colony dispersion walk algorithm is proposed. Artificial neural network is a method and technology in machine learning, which has been widely used in engineering and technology. The problem of power system fault diagnosis is complex and changeable, so it is difficult to achieve accurate diagnosis by conventional methods. At present, the commonly used neural networks include perceptron, single-layer network, BP network and radial basis network, each of which has different characteristics and uses. BP network and radial basis network are commonly used in power system fault diagnosis. The network can be created, trained and simulated in MATLAB, and the power system fault model can also be established and simulated. According to the characteristics of the system nodes, a nonlinear control model composed of a set of differential-algebraic equations is established to establish the steady-state model of the power system structure, and the ant walk algorithm is used to solve the model and analyze the node information of the power system. The control output principle of power system power node is set to judge whether the operation state of power system is normal or not, so as to complete the design of power system control method based on ant colony dispersion walk algorithm. The experimental results show that the proposed method has fast control speed for power system faults. The synchronous frequency signal and voltage signal provided by the power system are extracted, the characteristics of the power system signal are classified, and the hidden fault location is determined by the time-frequency characteristic of the power system voltage signal. The experimental results verify the robustness of the above methods for fast hidden fault location.

Keywords: Positioning detection, Ant Colony Scattering and Wandering Algorithm, Fault diagnosis.
1. Introduction

Power system control method is the effective measure to ensure efficient and practical power system, because the power system control node has dispersion features, to realize the control of information fusion of multiple nodes has the certain difficulty, thus lead to the traditional methods in process control of power system, showing the fault control the low speed, low efficiency of fault diagnosis, the control effect is not obvious, such as faults, traditional methods have been unable to meet the demand of electric power system control [1]. Therefore, this paper proposes a power system control method based on ant colony scattering and wandering algorithm to realize the effective control of power system faults and provide a good environment for the stable operation of power system.

At present, EMS system and SCADA system are widely used in power grid. This method mainly relies on reading the alarm information, but it is difficult to analyze the alarm information, and it is difficult to accurately and quickly determine the cause and location of the fault [2]. Therefore, some efficient and practical intelligent fault diagnosis systems are needed to help workers quickly and accurately identify the fault areas and types. Cheng Lin Lin established a fault diagnosis model based on fuzzy neural network method in Matlab, used sequence current and sequence voltage algorithm to identify fault phase and type of ground fault, established series model, and reduced the network training pressure, and the experiment showed that the expected goal was achieved [3]. Lv Xuefeng applied the improved fault analytic model to carry out online fault diagnosis research, and used genetic algorithm to search for the optimal solution of the model, which solved the problem of incomplete information in the diagnosis process. Artificial neural network has strong ability of learning and adaptation. Multi-layer neural network includes input layer, output layer and hidden layer. Now, it is more and more widely used in engineering, such as various intelligent control equipment based on neural network algorithm, IC chip (NPU) designed based on neural network, etc.

2. Power System Control Method Based on Ant Colony Scatter-walk Algorithm

According to the node distribution characteristics of the power system, the steady state model of the power system structure is established, and the ant colony scattering and wandering algorithm is used to solve the model to determine whether the system operating parameters are reasonable. If not, the system failure is indicated, and the coordinated control is carried out to realize the remote control of the power system [4].

2.1. Steady-state model of structure

This study does not consider the transfer conductance of the power system, so the model of the ith generator of the power system is as follows:

$$\psi = (T_1 - T_2) E_y \cdot t_0 (D + P)LH$$  \hspace{1cm} (1)

$T_1$ represents the horizontal axis current of the power system generator; $T_2$ is the longitudinal axis current of the power system generator; $E_y$ is the resistivity of the longitudinal shaft of the generator; $T_0$ is the closed circuit time constant of the longitudinal axis of the generator; $D$ is the generator open-circuit time constant; $P$ is the damping coefficient; $L$ is the potential after synchronous reactance of the generator proportional to the excitation voltage; $H$ is the mechanical power and set as a constant.

At the ith generator node, the active power and reactive power are balanced; At the ith load node, the active power and reactive power are balanced, and the structural model of the power system is formed through the balance relationship:

$$x = f(x,z)$$  \hspace{1cm} (2)

$F$ is the state differential vector; $Z$ is the constraint vector; $X$ is the output vector. The establishment of power system structure of the steady state model is a kind of typical differential mathematical model -
algebra, differential equation can calculate the state of power system operation parameters of the generator, the algebraic equation can calculate the trend parameter state power system, power system variables, node voltage to the power system structure model is established in this paper.

2.2. Fault location estimation method

Power system fault type, location, season, resistance is decided to power grid short-circuit fault point voltage of three basic variables, multi-source information fusion provides the power grid operation state before the power system, selection of method of sequence component [5], the grid node impedance matrix $U = ZI$ is calculated under different short circuit in the power system fault types of node voltage:

\[
\begin{align*}
U_{mi}^{(1)} &= U_{mi}^{(0)} - Z_{mi}^{(0)} I_f^{(1)} \\
U_{mi}^{(2)} &= -Z_{mi}^{(2)} I_f^{(2)} \\
U_{mi}^{(0)} &= -Z_{mi}^{(0)} I_f^{(0)}
\end{align*}
\]

In terms of hidden fault location, the least square state estimation model is built by taking the voltage $U_{mi}$, A, $U_{mi}$, B, $U_{mi}$, C of each phase at the monitoring point of hidden fault as the quantity measurement, and the distance $P$ and resistance $Z_f$ of the hidden fault of power system as the state quantity:

\[
\min J(p, z_f) = \left[U_m - U(p, z)\right]^T \left[U_m - U(p, z_f)\right]
\]

2.3. Ant Colony Scattering and Wandering Algorithm

Considering the distribution characteristics of the whole power system and the solution process of the model, the ant colony walking walk algorithm is adopted to solve the model, and the node distribution of the power system is divided in the form of random distribution [6]. Form the structure of power system steady state model and the algorithm of matching with each other, the combination node in the steady state model of distribution power system, using the algorithm on all nodes in the steady state model parameter information processing and analysis, provide the basis for judging power system operation state is normal, to achieve the effective control of the whole power system, the algorithm model is shown in figure 1.

![Model diagram of ant colony dispersion and migration](image)

Fig. 1 Model diagram of ant colony dispersion and migration

A complete ant colony is composed of two parts: the ant colony and the migratory route. An ant colony is a collection composed of ants with different numbers, i.e., $S = \{v_1, v_2, ..., v_n\}$ $n$ represents the number of ants in the ant colony. The set of ant colony migratory routes is $W = \{r_1, r_2, ..., r_m\}$ $m$ is the number of ant colony migratory routes. For each element of ant colony migratory route set $W$, there is a starting point and an end point corresponding to it.

Set the power node control output principle of the power system as
\[ u = Me + Ne \]  \hspace{1cm} (5)

The establishment of the control output principle shall meet the following requirements:

\[ \| f(Z) - f(V) \| \geq \| K \| \]  \hspace{1cm} (6)

The power system data monitored by the ant colony dispersion set is put into the above formula. If the formula holds, it indicates that the task distribution of power system nodes is reasonable. If the formula is not valid, it indicates that the task allocation of power system nodes is unreasonable and the principle of coordinated control needs to be implemented. Then, the power system is controlled by the result of formula (5), so as to realize the power system control.

3. Result analysis

3.1. Fault location

According to the analysis of the relevant literature, although the method has a certain clustering effect on two short-circuit fault data, there is a nonlinear data boundary in the two states of interphase short-circuit fault and hybrid line fault, so it is difficult to segment linearly. By using the minimum distance criterion, the hidden fault data can be accurately divided into the corresponding region, and it can be seen that the number of pseudo-fault points is zero. It shows that the proposed method is accurate for different types of hidden faults.

![Fig. 2 Methods Recessive fault location results](image)

![Fig. 3 Implicit fault location results](image)
Methods the time of locating short-line fault is 1.58s, and that of hybrid line is 0.89s. It can be seen that the fault location time of this method is faster than that of interphase short-circuit fault and short-line fault. In terms of the overall location time, the proposed method is far less than the method mentioned in the literature for the overall location time of the hidden faults in the above three power systems, and has obvious advantages in the location time.

3.2. Algorithm evaluation

Based on the power quality monitoring system to provide detailed information on the network voltage sag, using multi-source information fusion for recessive fault model of electric power system fault before, on the basis of power system fault remembrance function to determine the hidden fault lines.

This method is susceptible to the influence of power transformers and power supply voltage, which leads to inaccurate location of hidden faults. This paper proposes a method for fast location of hidden fault in power system. It is of great significance for reducing the time and scale of power outage and improving the reliability of power supply system to locate the recessive fault section accurately and quickly and deal with the fault in time.

4. Conclusions

Power system fault diagnosis plays an important role in power system design and analysis. This paper discusses the concept of power system fault, common fault types, short-circuit fault types and causes, and obtains the diagnosis method of circuit system fault through fault information. This time, the ant colony dispersion algorithm is applied to the power system control to form a new control method. As the infrastructure of people's life, the stable operation of electric power system can bring great convenience to human life, and the effective control of power system has always been the goal of optimizing the global efficiency of the system. The proposed method has important application value for the realization of this goal.

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