Fault Diagnosis of Power System Based on Neural Network

Jingwen Liu, Xianwen Hu, Daobing Liu

Three Gorges University, College of Electrical and New energy, Yichang, 443000, China

Abstract

Using matlab for fault diagnosis simulation, analysis and comparison of different types of neural network algorithms, select a better training effect, the classification effect of a stable algorithm for fault diagnosis. And its fast convergence, accurate prediction, can have fault prediction function. Finally, the two types of functions can be combined to achieve pre-diagnosis of power system faults to reduce the failure rate as efficiently as possible.

Keywords

Power system; artificial neural network; fault diagnosis.

1. Introduction

With the strengthening of global environmental awareness and the improvement of science and technology, People are increasingly dependent on the power system, The stable and safe power environment becomes more and more important.ANN is an important research direction of current intelligent control and has good learning ability and adaptability. Compared with traditional manual fault diagnosis methods, ANN can realize long-term continuous monitoring of large-scale equipment, and perform state prediction and fault diagnosis based on real-time data. In the continuous and stable working environment, it avoids the subjective judgments of manual inspection and thus has obvious advantages.

2. Analysis of Common Faults in Power System

2.1 Fault classification

By analyzing the cause of the failure, the power system mainly includes four parts; they are power generation, transmission, substation, and power distribution. All links are stable to ensure the safety of the entire power system. Common power system failures can be mainly divided into equipment failures, line failures, and external forces. Equipment failure: The complexity and operational stability of the electrical equipment itself, the functional failure that occurs after long-term operation or component aging. Line faults: Most of the lines in China's power system are exposed for a long period of time, and their own aging damage and adverse natural environment effects lead to failure. Most of these types of faults occur in transmission and distribution systems. Influence of external forces: various human factors, such as the destruction of overhead lines and cables in the course of urban construction, and the theft of some electrical equipment.

According to the classification of fault features, it can be divided into short circuit fault, fault phase fault, complex fault and natural disaster. Short-circuit fault: The short-circuiting of the conductive parts at different points causes the voltage and current to exceed the normal operating standards. Phase failure: One or two phases of the power system are disconnected and an asymmetry fault occurs. Complex failures: Causes of non-unitary failures, simultaneous failures in different parts of the power system (two locations and above).

2.2 Fault factors

Usually, the main parameters of power system fault diagnosis are inter-phase voltage, current, load, frequency, boiler temperature, mechanical vibration frequency, oil and gas information and so on. From an overall point of view, the internal information of the power system fault is mainly linear continuous data, while the external influence factors are mostly nonlinear discrete data. There is no direct correlation between internal and external data.

The traditional fault diagnosis is based on experience and a rational analysis of the causes and solutions of the faults. It is impossible to linearly model various faults, and it is difficult to implement computer control. However, the human approach is inevitably subjective to a certain extent, so there is also empiricism that leads to misjudgment. The artificial neural network has good learning characteristics and self-adaptability, so it can be predicted that it has a good application prospect in the function of fault analysis.

3. ANN prediction algorithm

The fault prediction technology of the ANN prediction algorithm is a more advanced maintenance mode than the simple fault diagnosis. From the perspective of the development of the power system, it is particularly necessary to develop fault prediction and diagnosis for power systems. Utilize the forecasting function that ANN has, predict the operation data of the electrical equipment, and carry on the fault diagnosis to the forecast data. In theory, potential hazards can be eliminated in a timely manner, reducing the difficulty of patrolling the power system and improving system stability.

3.1 Error back propagation algorithm (BP)

BP neural network consists of input layer, hidden layer, and output layer as shown in Figure 1. The number of output layers can be set as needed.

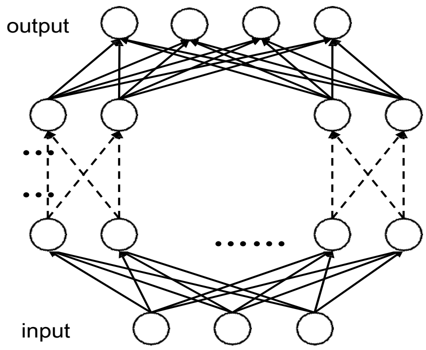

Figure 1. BP neural network structure

BP neural network is divided into two sub-processes: forward transfer and error reverse transfer. In the forward transfer process, the output of each layer is implemented using the activation algorithm S-function (or linear function) according to the output of the upper layer, the current node weight, and the threshold.

3.2 Elman neural network

J.L. Elman proposed that Elman neural network is a typical local regression network.It is similar to the BP neural network subject matter, but there is an additional correlation layer outside the hidden layer, in which the neuron nodes correspond to each hidden layer. The role of the association layer is to realize the memory function, and the previous feedback state of the hidden layer is treated as a new input together with the current state, so it is more relevant.

Elman neural network is also a kind of feedback neural network, but there is one more layer of inheritance than BP neural network. The role of the undertaker layer is to memorize the nodes of the hidden layer, and it can strengthen the relevance of speculation. Compared to the BP neural network, which only recurs the output error as feedback, the Elman neural network can use each hidden layer as a reference for feedback error. Therefore, it can be understood that during the prediction process of Elman neural network, the direct influence on the prediction result may be not only the previous group of data but the first four or five groups of data of the current data, which further strengthens the prediction result and historical data. Thus, Elman has a superior performance in the data prediction function of time series.

4. Simulation of ANN prediction algorithm

4.1 Using BP neural network to predict power data

This experiment simulation is difficult to find the actual parameters for prediction, so the simulation is performed using virtual data. First, the data is loaded and the experimental data scale is 9×3 as shown in Table 1.

Table 1. The reference data of neural network prediction algorithm

	Paramet1er1	Parameter2	Paramet3er3
Group 1	0.1291	0.4842	0.7976
Group 2	0.1084	0.4579	0.8187
Group 3	0.1828	0.7977	0.743
Group 4	0.122	0.5468	0.8048
Group 5	0.113	0.3636	0.814
Group 6	0.1719	0.6011	0.754
Group 7	0.1237	0.4425	0.8031
Group 8	0.1721	0.6152	0.7626
Group 9	0.1432	0.5845	0.7942

The training mode of BP neural network is to predict the next group of data by using the first set of data. This simulation uses parameter 2 and parameter 3 to predict parameter 1.First, use the first 8 groups of data for training, and enter and normalize the data from the first to the eighth groups. After the establishment of the BP neural network, this paper selects three hidden layers. The number of neurons in the hidden layer is 2, 3, and 1 respectively. The number of trainings is set to the upper limit of 1000, and the convergence error is 1×10^-6. After training the neural network, it is shown in Figure 2.

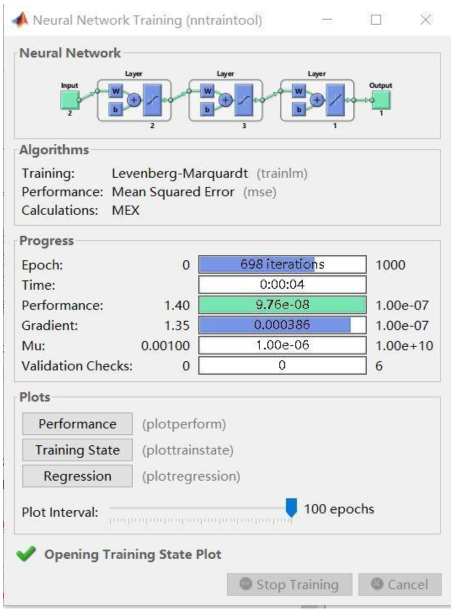

Figure 2. BP neural network training process

As can be seen from Figure 3, when the training step is 698 steps, training will achieve the desired effect.

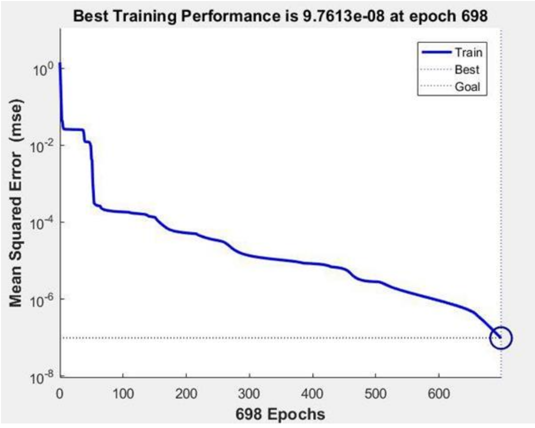

Figure 3 Error variance map

So far, the training part of the BP neural network is over. Then use the ninth group of data to make predictions. Select parameter 2 and parameter 3 in group 9 as input, and parameter 1 is actual result.

4.2 Using Elman Neural Network to predict Power Data

This experiment focuses on Elman's training and predictive implementation. This data is the same as the simulation data used by the BP algorithm.

First, the data is loaded and the experimental data scale is 9×3 as shown in table 2.

Table 2. The training parameters of Elman neural network

	Paramet1er1	Parameter2	Paramet3er3
Group 1	0.1291	0.4842	0.7976
Group 2	0.1084	0.4579	0.8187
Group 3	0.1828	0.7977	0.743
Group 4	0.122	0.5468	0.8048
Group 5	0.113	0.3636	0.814
Group 6	0.1719	0.6011	0.754
Group 7	0.1237	0.4425	0.8031
Group 8	0.1721	0.6152	0.7626
Group 9	0.1432	0.5845	0.7942

Select training data and test data after entering. Training begins with the fourth set of data. The reference parameters for each training are the first three sets of data. Therefore, this experiment selects the training input data as the first to the fifth group of data, and the 4 to 8 groups of data correspond to the training output. Finally, the sixth row is used as the test input to perform the prediction and compare with the group 9 data. After the establishment of Elman neural network, the number of neurons in the hidden layer will largely affect the data prediction effect. This article selected 7, 11, 14, 18 neurons for training. Each neural network is trained 1000 times. The training process is shown in Figure 4.

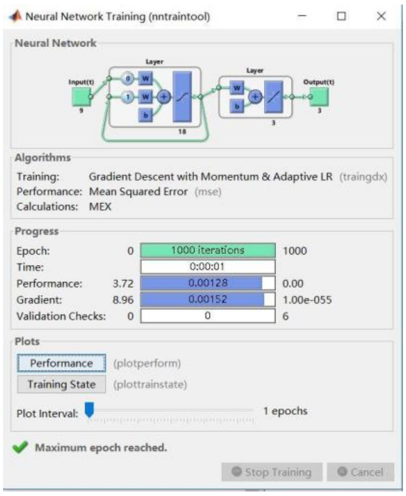

Figure 4 Elman training process

It can be seen from the training process that the mean square error gradually approaches the actual value as the number of training increases. As shown in Figure 5.

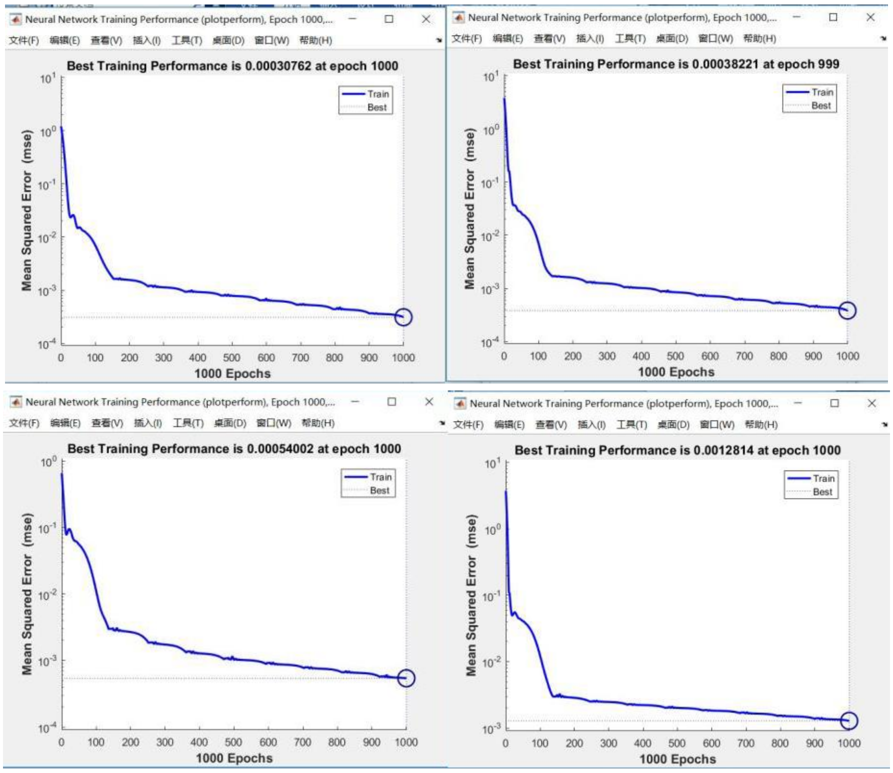

Figure 5 Elman error curve

Make predictions separately. The forecast data is as follows:

When the number of neurons in the hidden layer is 7, the corresponding parameters: 0.1294; 0.4987; 0.7926

When the number of hidden layer neurons is 11, the corresponding parameters: 0.1618; 0.5246; 0.7984

When the number of hidden layer neurons is 14, the corresponding parameters: 0.1380; 0.6181; 0.7897

When the number of neurons in the hidden layer is 18, the corresponding parameters are: 0.1551; 0.5766; 0.7839

The 9th group of data is actual parameter: 0.1432; 0.5845; 0.7942

It can be seen that in the case of the number of neurons in different hidden layers in the Elman neural network, there is a gap in the corresponding prediction effect.

4.3 Comparison of predictive effects of BP neural network and Elman neural network

This paper uses BP algorithm and Elman algorithm to predict faults. There are a lot of difficulties in these two algorithms, that is, the training parameters are set during the training process. Training an excellent neural network will obtain better prediction results in actual prediction, but there are generally more difficulties in finding the correct parameters, and multiple attempts and comparisons are needed.

The BP neural network prediction algorithm requires more training parameters in the early training process, and can achieve a more accurate degree when a large amount of data is trained. In the prediction, the current part of the data is also needed as a support, and the algorithm is used in practical applications. There are major flaws that need to rely on other algorithmic theories to cooperate.

In contrast, Elman's neural network algorithm relies on the temporary storage function of the receiving layer to increase the reference factors in the training process and make the prediction result more accurate and effective. Compared with the BP algorithm, the Elman neural network prediction process refers to more than one set of data, but rather multiple sets of previous data. This also requires that the training data must satisfy a certain number before the network can be trained.

5. Summary

The inevitable trend in the future development of the power industry is to intelligently diagnose faults in power systems, reduce maintenance costs, and increase operating efficiency. Using the learning characteristics of the artificial neural network can predict the operation of the equipment, which is the basis for reasonable fault diagnosis, which greatly reduces the equipment failure rate and economic losses caused by equipment maintenance. In this paper, we studied and compared several different types of neural network classification algorithms and prediction algorithms, and selected two more appropriate algorithms for different characteristics. In addition, the advantages and disadvantages of neural network in power system fault diagnosis are summarized.

References

[1] Mori H, State－of－ art overview on data mining in power systems[C], IEEE Power Engineering Society General Meeting, Canada, 2016, 764－767.

[2] COURY D V, JORGE D C． Artificial neural network approach to distance protection of transmission lines[J]． IEEE Transactions on Power Delivery,2012,13(1):102－108．

[3] Yu Gang. Turbine Generator Set Fault Diagnosis System Based on Neural Network and Expert System [J]. Power System Automation, 2014, 28(4): 67-70.

[4] Wu Ning, Chen Hao. The application of the human neural network in the power system [J]. Jiangxi Electric Vocational Technology Academy School Report, 2015, 18(2): 44-45.