Application Research of BP Neural Network Algorithm in Power Line Loss Calculation

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Abstract. In recent years, it is still a difficult problem to calculate the line loss of distribution system. The main reason is that China's power system data is not perfect, the components are huge, the management function does not exist, the network structure is directly connected. Therefore, reducing the loss rate of power system has become an urgent problem for energy companies to solve. Developing effective methods for line loss reduction evidence and line loss assessment requires careful calculation and analysis of line loss, which ultimately contributes to and guides line loss management.

Keywords: BP Nerve, Network Algorithm, Power Line Loss

1. Introduction
Artificial neural network (ANN) is a theoretical mathematical model based on the knowledge and understanding of human brain and nervous system, which can simulate some brain functions. Generally, ANN is an information processing system that can process information with complex relationships, unclear boundaries and unclear rules. Artificial neural network has many advantages: distributed information storage, the combination of information processing and storage operations, self-planning of information processing and self-learning operations, fault tolerance and strength, etc. Based on these advantages, artificial neural networks have been widely used in various fields, such as automatic control, composition optimization, pattern analysis, graphics processing, robot control and medical fields [1].

2. Application of BP neural network algorithm in power line loss calculation

2.1. Interpretation and design of BP neural network algorithm
BP neural network is a multi-algorithm system, in which ANN has a good generalization. A trained ANN network can identify input samples that are not part of the training sample set. This makes ANN unique in dealing with complex nonlinear problems such as classification, recognition and troubleshooting. Introducing neural networks into line loss calculation can effectively solve many difficult problems in calculation, as shown in Figure 1 below:
Figure 1. Grid structure of BP neural algorithm

The BP network model has many advantages. Now more and more scholars begin to study its application in line loss calculation of distribution system, and have made some achievements. This is also a new development strategy of artificial neural network model and opens up a new theoretical method for calculating the line loss of distribution system. But in general, the current level is still in the exploratory stage, because neural networks lack general network design methods, they rely on experimental methods used in practice, so they are limited by practical use [2-4].

In recent years, line calculation and management software has been widely used and evaluated. From previous versions of DOS in the current window: release procedure, from simple line loss calculation to line loss management system, from the line loss management system to the senior DMS and EMS software part, from the application of independence to the network exchange, from network connection from the calculation to network computing, from interactive-to-interactive visual data and graphic integrated management, and is a leap compared to a few years ago. This is mainly due to the development of computer technology, network and distribution system automation, although some of them have not been well explained, but this is the future trend of development [5].

2.2. Analyse the composition of line loss

Line loss is the power loss of the grid, which refers to the power loss caused by the current flowing through each component of the grid in a period of time. It has two aspects: one is in the process of electric energy transmission in transmission, distribution and substation equipment performance loss. The other is the loss of electricity from the plant to the utility meters that cannot be accounted for in the marketing process. The proportion of line loss in a power supply is called line loss rate, or simply line loss rate, as shown in Figure 2 below
The difference of theoretical line loss includes loss of management clue, loss of statistical clue and loss of theoretical clue. The loss of the management line is due to management's mistakes and negligence in operation and management. It mainly includes: omissions, incorrect readings, asynchronous readings and numerous errors caused by multiple readings by operators, such as statistics, power outages due to damage to insulation of various electrical components and power theft due to management failures in the energy sector [6-9].

3. Optimization design of BP neural algorithm in power line loss calculation

A power system is a unified system that converts primary energy into electricity, including equipment and technologies such as energy generation, conversion, transmission, power supply, distribution and electricity consumption. The power grid includes energy supply, transmission, conversion, distribution, electrical equipment and corresponding additional systems. In particular, it consists of power lines (transmission lines and distribution lines), electrical connection equipment (oil switches, fuses, switches, etc.), transformers (power users' substations and the main transformers and converters in the substations), monitoring electrical equipment (including electrical equipment). Used for power supplies (e.g., switching capacitors, etc.), protection equipment or automatic control equipment and other primitive components. The main function of an electrical system is to convert voltage (convert), transmit and distribute electricity, and is an important basis for coordinating the production, distribution, transmission and consumption of electricity. We usually use the following formula to calculate:

\[
 f(\alpha) = a_0 + \sum_{n=1}^{\infty} \left( a_n \cos \frac{n\pi\alpha}{L} + b_n \sin \frac{n\pi\alpha}{L} \right) \tag{1}
\]

Due to inadequate market management, imperfect rating system and other reasons, there will be errors in electricity meters, insufficient reading of electricity meters, illegal use of electricity by users, and theft of electricity due to power failure; Poor insulation level of living equipment will lead to electricity leakage; Inadequate measurement composition, calibration and update not in time, resulting in measurement errors; Power grid accidents caused by abnormal maintenance, power outages and energy loss. For management reasons, such losses cannot be accurately calculated and their value cannot be detected or predicted early. It can only be determined from statistical data and is therefore called an undetermined loss. Also called management loss (or operating loss). Determination of management line loss:

\[
 \text{Management line loss} = \text{operating loss} = \text{unknown loss} = \text{power supply} - \text{electricity sold} - \text{theoretical line loss} \tag{2}
\]
In the formula, the quantity of electricity supplied and sold can be measured by the meter, and the theoretical line loss can be obtained by calculation method [10].

According to efficiency and voltage levels, electrical systems are divided into distribution systems and transmission networks. The energy distribution system can be divided into 380/2200(or 0.4kV). The energy distribution system is also called the low voltage power distribution system, and the 10/6kV energy distribution system is also called the high voltage power distribution system. Transmission network is divided into 35(66)kV, 110kV, 220kV high voltage distribution system, 500K V, 750kV ultra high voltage transmission network, 1000kV ultra high voltage transmission network and AC transmission network (line) or DC transmission network (line).

4. Line loss of power network and application of BP neural network

The energy loss of the power system (called line loss) refers to the energy loss caused by the power transmitted to the energy customer through a series of transmission processes in the various links of power supply, as shown in Figure 3 below:

![Figure 3. Line loss calculation and application analysis of power network cable](image)

Calculating the theoretical losses of each line helps to understand the active and reactive power losses of each device and component in a distribution system, and to estimate the power losses in a given time. This helps to identify the exact composition and current operational problems of the network so that targeted measures can be taken to reduce line losses to normal and manageable levels; Help reduce loss and save energy, promote more in-depth, more detailed and scientific line loss management, and constantly improve the power system to strengthen construction and technical transformation, improve the operation level and management level, strengthen the economic operation of the power system, develop a reasonable line loss assessment standard line loss. Therefore, the calculation of line loss theory is very important, and its functions are as follows:

1. The theoretical ratio of line loss calculated according to the corresponding circuit diagram can be compared with the actual line contraction frequency, and through this comparison, the rationality of unknown loss in the power supply and the actual ratio of line loss can be determined.

2. The theoretical ratio of line loss can be compared with the calculated optimal line shrinkage rate, so as to determine the efficiency of network operation, the rationality of network layout and the structure and technical level of power grid. The quality and effect of the original composition is very good.

3. The calculation ratio of all kinds of electrical line loss can successfully analyze the line loss, according to these data, can diagnose the symptoms and change the rule of power line loss, so as to conveniently find the weak link in the management, explain the specific reason of power line loss, and take effective measures to reduce the loss.
(4) All kinds of data released by theoretical calculation of line loss are the main basis for rational formulation of line loss estimation and scientific release of line loss index.

(5) The analysis of various data obtained from the theoretical calculation of line loss and the analysis of the rule of line loss change can become a valuable reference map for the construction and planning of new power grid, and also an important basis for the reconstruction and transformation of old power grid.

(6) Theoretical calculation of line loss is an important part of power supply company to strengthen technical loss and loss management.

5. Conclusion
The theoretical calculation of line loss of distribution system refers to the calculation of line loss of each branch of power system, copper loss, iron loss and line loss rate of distribution variable according to the normal function and actual power or load of distribution system. Theoretical line losses specify annual, quarterly and monthly indications of line losses. According to the theoretical line loss, the rationality of network structure and network structure can be determined, and the change of line loss and the economy of equipment operation can be controlled. Determine the mitigation capacity of the power system and specify the corresponding mitigation methods.

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