Research on Distribution Network "Low Voltage" Prediction Based on BP Neural Network

Wenbin Wang¹, Yongyue Wang², Ruixiang Fan¹, Qiong Li¹, Bei Cao¹, Wenbin Wang*¹

¹Distribution Network Technology Center ,State Grid Jiangxi Electric Power Co., Ltd. Electric Power Research Institute,Nanchang,Jiangxi Province,330096,China
² School of Information Engineering,Nanchang University,Nanchang,Jiangxi Province,330096,China
*Corresponding author’s e-mail: 277056512@qq.com

Abstract. In order to solve the problem that the power consumption data of low-voltage users in the distribution network is difficult to obtain, under the premise of using the existing monitoring system to allocate limited data such as outlet voltage and power, the voltage prediction model of low-voltage distribution network is established, and a BP neural network based on BP neural network is proposed. The "low voltage" prediction method of distribution network realizes the "low voltage" prediction of low voltage users in distribution network, and provides an effective and accurate prediction method for "low voltage" management of distribution network.

1. Introduction
The foundation of China's rural power grid is weak, the investment is insufficient, and there are some problems in some areas. The voltage quality of rural power grids is relatively poor. With the increase of rural household appliances in recent years, the rural residents' requirements for voltage quality are also higher and higher [1]. This paper takes Jiangxi Power Grid as the research object., at present, the construction of distributed power supply in Jiangxi Power Grid has begun to take shape, as most of the distributed power sources are connected to remote rural power grids, between weak grid structures and distributed power access requirements. The contradiction has become more prominent. When the distributed power supply has a large output, the access point exhibits a high voltage state, and when the distributed power supply has a low output or even no force, the access point has a low voltage problem; At the time scale, high voltage phenomenon and low voltage problem exist at the same time. How to combine the access of distributed power supply, effectively predict and judge the low voltage station area, and put forward the comprehensive treatment scheme of low voltage in rural power grid is the hot spot of current research [2-3]. In view of the fact that the use of traditional optimization techniques needs to be based on the mathematical basis of the specification, there are certain limitations in the solution process. This makes a lot of real problems unsolvable. To further solve the above problems, the heuristic algorithm that emerged in the early 1980s has made a new attempt on the above phenomenon [4]. This paper mainly discusses an algorithm for the cause of short-term low voltage: BP(Back Propagation) neural network algorithm. On the basis of summarizing the available parameters of low-voltage distribution network, the influencing factors of low-voltage distribution network voltage are analyzed, and the low-voltage distribution network voltage prediction model is
established [5]. Combined with the neural network based on data modeling, the self-learning ability of input and output characteristics is based on voltage historical data. The sample is used to predict the voltage of the distribution network in a certain period of time in the future. In order to prevent the neural network from falling into a flat area during the training process, the learning rate and momentum factor of the neural network are dynamically adjusted in the algorithm to improve the learning efficiency [6-8].

2. BP neural network model

The BP neural network is an error back propagation neural network. It is a feed forward network with an implicit layer. If the number of input nodes of the network is M, the number of output nodes is L. Then this neural network can be regarded as a mapping from M-dimensional Eulerean space to L-dimensional Eulerean space[9]. The error back propagation algorithm is adopted. The BP neural network usually consists of an input layer, an output layer and an implicit layer. The neurons between the layers are connected by a full interconnection, and each layer is connected by a corresponding network weight coefficient w. The neurons inside are not connected, as shown in Figure 1.

![Figure 1.BP network neural map](image)

3. Low voltage short-term prediction—BP neural network algorithm

For the low-voltage distribution area, the operating parameters are difficult to obtain, and the problem of voltage full coverage monitoring or voltage accurate calculation cannot be realized. Based on the available outlet voltage and power of the station, the voltage prediction based on BP neural network with less data is proposed. In a large number of repeated experiments, the main factors affecting short-term power forecasting are: sample load data, maximum temperature, minimum temperature, weather conditions, and date type. Moreover, some influencing factors must also consider their cumulative effects, so it is not possible to simply consider the data of the day and combine it with the data of the previous days or even the previous weeks. However, if the factors affecting the forecast are too much, it will inevitably make the network structure too large, which greatly increases the training time and training difficulty. It is necessary to consider the influence degree of different influencing factors. Under the premise of comprehensively considering various important influencing factors, reducing unnecessary or less influential factors and streamlining the network structure can shorten the network training time and increase the prediction accuracy, so that the prediction results are more accurate[11-12].

3.1 Quantitative processing of data

In the algorithm, the factors affecting short-term power forecasting must be quantified before they can be used. We have obfuscated weather conditions, temperature, holidays, and time periods.

(1) Fuzzification of weather conditions
Table 1. Fuzzification of weather conditions

| Weather conditions | sunny day | cloudy day | Rain and snow |
|--------------------|----------|------------|---------------|
| Fuzzy value        | 0        | 1          | 2             |

(2) To improve the accuracy of voltage prediction, we must also consider the date type. The voltage values of different date types are different, and each has its own rules. For example, the voltages on Friday and Saturday are not the same, whether it is the voltage value at the same time or the voltage value, even the law of change is slightly different. In this article, the national legal holidays and weekend rest days are assigned a value of 1, and the normal working day is assigned a value of zero.

(3) Fuzzy processing of time period

For different time periods of the day, the power consumption period is blurred:

Table 2. Time segment fuzzification

| Period             | 23:00-7:00 | 7:00-11:00/13:00-17:00 | 19:00-23:00 | 11:00-13:00/17:00-19:00 |
|--------------------|------------|------------------------|-------------|-------------------------|
| Fuzzy value        | 0          | 1                      | 2           | 3                       |

(4) Fuzzy processing of temperature

Table 3. Fuzzy processing of temperature

| Temperature (Celsius) | <0 | 0-10 | 11-20 | 21-30 | 30-35 | >36 |
|-----------------------|----|------|-------|-------|-------|-----|
| Fuzzy value           | 0  | 1    | 2     | 3     | 4     | 5   |

3.2 Actual case simulation and result analysis

The training was carried out at 11:00 am phase-out voltage data of Huangsanli District, Jiangxi Province in October 2017. The simulation predicted the phase-phase voltage of 11:00 on November 2, 2017. Table 4-2-1 shows the sample station area data. Only the voltage data of the first week of October is listed as a reference:

Table 4. B-phase outlet voltage data of huangsanli district

| Time           | one day ago | two days ago | three days ago | four days ago | five days ago | six days ago | seven days ago | Weather | temperature | period | Holiday | Result voltage |
|----------------|-------------|--------------|----------------|---------------|---------------|--------------|---------------|---------|-------------|--------|---------|----------------|
| 2017-10-01     | 209.4       | 217.3        | 200.7          | 209.1         | 201.6         | 201.8        | 200.8         | 1       | 4           | 1      | 1       | 201.2           |
| 2017-10-02     | 201.2       | 209.4        | 217.3          | 200.7         | 209.1         | 201.6        | 201.8         | 2       | 3           | 1      | 0       | 207.5           |
| 2017-10-03     | 207.5       | 201.2        | 209.4          | 217.3         | 200.7         | 209.1        | 201.6         | 2       | 3           | 1      | 0       | 204.1           |
| 2017-10-04     | 204.1       | 207.5        | 201.2          | 209.4         | 217.3         | 200.7        | 209.1         | 2       | 3           | 1      | 0       | 216.6           |
| 2017-10-05     | 216.6       | 204.1        | 207.5          | 201.2         | 209.4         | 217.3        | 200.7         | 2       | 2           | 1      | 0       | 208.5           |
| 2017-10-06     | 208.5       | 216.6        | 204.1          | 207.5         | 201.2         | 209.4        | 217.3         | 1       | 3           | 1      | 0       | 211.2           |
| 2017-10-07     | 211.2       | 208.5        | 216.6          | 204.1         | 207.5         | 201.2        | 209.4         | 1       | 3           | 1      | 1       | 224.2           |

The simulation program is programmed in the MATLAB R2014b software environment, and the BP neural network in the MATLAB toolbox is used to construct the model [13-15]. The procedures and steps of BP neural network short-term low voltage prediction are as follows:

The first step: training data.

P=[209.4 201.2 207.5 204.1 216.6 208.5 211.2 224.2 219.3 215.8 213.7 209.4 208.5 203 196.9 196.7 205.3 198.9 203 200.2 198.3 204.3 203.5 198.1 208.9 208.7 215.1;217.3 209.4 201.2 207.5 204.1 208.5 216.6 204.1 207.5 201.2 209.4 217.3 200.8 1 4 1 1 201.2 207.5 204.1 207.5 201.2 209.4 217.3 200.7 2 3 1 0 204.1 216.6 204.1 207.5 201.2 209.4 217.3 200.7 2 2 1 0 208.5 211.2 208.5 216.6 204.1 207.5 201.2 209.4 217.3 1 3 1 0 224.2]
216.6  208.5  211.2  224.2  219.3  215.8  213.7  209.4  208.5  203  196.9
196.7  205.3  198.9  203  200.2  198.3  204.3  203.5  198.1  208.9  208.7;
200.7  217.3  209.4  201.2  207.5  204.1  216.6  208.5  211.2  224.2
219.3  215.8  213.7  209.4  208.5  203  196.9  196.7  205.3  198.9  203
200.2  198.3  204.3  203.5  198.1  208.9;
209.1  200.7  217.3  209.4  201.2  207.5  204.1  216.6  208.5  211.2
224.2  219.3  215.8  213.7  209.4  208.5  203  196.9  196.7  205.3  198.9
203  200.2  198.3  204.3  203.5  198.1;
201.6  209.1  200.7  217.3  209.4  201.2  207.5  204.1  216.6  208.5
211.2  224.2  219.3  215.8  213.7  209.4  208.5  203  196.9  196.7  205.3
198.9  203  200.2  198.3  204.3  203.5;
201.8  201.6  209.1  200.7  217.3  209.4  201.2  207.5  204.1  216.6
208.5  211.2  224.2  219.3  215.8  213.7  209.4  208.5  203  196.9  196.7
205.3  198.9  203  200.2  198.3  204.3;
200.8  201.8  201.6  209.1  200.7  217.3  209.4  201.2  207.5  204.1
216.6  208.5  211.2  224.2  219.3  215.8  213.7  209.4  208.5  203  196.9
196.7  205.3  198.9  203  200.2  198.3;
1  2  2  2  2  2  1  1  0  0  2  2  2  1  2  2  2  2  1  1  1  0
0  1  0  1  0  0;
4  3  3  3  2  3  3  4  4  4  4  3  2  2  3  2  2  2  2  3  3
3  3  2  3  3  3;
1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1
1  1  1  1  1  1;
1  0  0  0  0  0  1  1  0  0  0  0  0  0  1  1  0  0  0  0  0  1
1  0  0  0  0  0;
];
Output Data:
T=[201.2  2207.5  204.1  216.6  208.5  211.2  224.2  219.3  215.8  213.7
209.4  208.5  203  196.9  196.7  205.3  198.9  203  200.2  198.3  204.3
203.5  198.1  208.9  208.7  215.1  208];
[p1,minp,maxp,t1,mint,maxt]=premnmx(P,T);
The second step : create a network.
net=newff(minmax(P),[11,15,1],{'tansig','tansig','purelin'},'trainlm');
The third step : set the number of training sessions.
The third step is to set the convergence error.

```matlab
net.trainParam.epochs = 5000;
```

The fourth step: training data.

```matlab
net.trainParam.goal = 0.1;
```

The fifth step: data verification.

```matlab
[net, tr] = train(net, p1, t1);
```

The sixth step: Input data normalization

```matlab
a = premnmx(a);
```

The seventh step: Put in the network and output data

```matlab
b = sim(net, a);
```

The eighth step: Denormalize the obtained data to obtain prediction data

```matlab
c = postmnmx(b, mint, maxt);
c = 208.8
```

The "c" value predicted by the above procedure predicts the 11:00 voltage result on November 2, 2017, compared with the known simultaneous measurement data of 208.7, the error is within the accuracy range, and the result is valid.

Based on the factors such as the amount of data that can be collected, from the perspective of the power supply department, only the low voltage is estimated by the outlet voltage of the station. For the low voltage on the user side, the user side voltage is calculated according to the voltage drop level. That is to say, as long as it is lower than a certain value (here set to 210V), it is considered that there is a risk of low voltage on the user side. This can achieve the purpose of low-voltage short-term prediction, and the results can be further verified in actual use.

4. Conclusion

This paper starts with the basic model of BP neural network algorithm, and combines the low-voltage cause analysis to establish a low-voltage prediction model of BP neural network considering the influence of various factors such as weather, and proposes a low-voltage prediction method based on BP neural network. And carry out case verification. As a result, the method can shorten the network training time, increase the prediction accuracy, and improve the accuracy of the prediction results. This method is being applied to the advanced functional application of the power supply service command system in Jiangxi Province.

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