Design of microcomputer anti-misoperation alarm system for substation based on intelligent Agent

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Abstract. The traditional substation microcomputer anti-misoperation alarm system has some problems, such as too long judgment time and low alarm accuracy. Therefore, this paper designs a kind of substation microcomputer anti-misoperation alarm system based on intelligent Agent. BP learning algorithm is used to judge the wrong operation of power station microcomputer and determine the error coefficient of substation. Through intelligent agent technology, the substation maloperation alarm and Substation Microcomputer anti maloperation alarm system are designed. In order to verify the effectiveness of the design system, a comparative experiment is designed. The results show that the designed system has high processing efficiency and high alarm accuracy.

1. Introduction
With the application of substation more and more widely, the intelligent automation level of its monitoring also needs to be improved. Therefore, there are many unmanned substations, many substations only through a comprehensive substation management and control center for comprehensive control, which can effectively improve the efficiency of processing substation. In daily work, when the substation can be controlled, microcomputer misoperation is easy to occur, which will affect the quality of substation work[1-3]. Therefore, the Substation Microcomputer anti misoperation alarm system appears. Relevant scholars have made some progress in this regard. Huang Qing et al. proposed a remote operation error prevention system for substation based on the analysis of busbar current. By analyzing the busbar current, the equivalent model of substation current is established, and the operation mode of substation under extreme circumstances is analyzed. The isolation switch current is calculated according to the variation of the zero sequence current of the bus coupling. The isolation switch closing is used to judge whether the substation has misoperation, and the criterion threshold is obtained to realize the design of the substation operation misoperation prevention system. This method can effectively improve the accuracy of substation operation error prevention system, but the calculation process is more complex, the time of the system is too long. Yang Bo et al. designed an uWideband based safety protection alarm system for substation personnel [4], and determined the positions of each personnel through UWB positioning tags. According to the ultra-wideband technology, the boundary of the substation's unsafe area is segmented, and according to the above results, the peripheral alarm design of the unsafe area is realized, which can effectively monitor the misoperation. However, this method can only protect the substation from the outside, but cannot control the internal causes.
Aiming at the above problems, this paper designs a microcomputer anti-misoperation alarm system of substation based on intelligent Agent, which can effectively solve the above problems. The specific ideas of this paper are as follows:

Firstly, BP learning algorithm is used to judge the misoperation of Microcomputer in power station;

Secondly, the error coefficient of substation is calculated;

Then, the intelligent agent technology is used to alarm the substation misoperation, and the design of the Substation Microcomputer anti-misoperation alarm system is realized.

Finally, The full text is summarized.

2. The substation misoperation alarm system of intelligent Agent

2.1. Anti misoperation diagnosis of substation computer based on BP learning algorithm

In order to realize the safe operation of substation, this paper uses BP learning algorithm to carry out Substation Microcomputer anti-misoperation diagnosis. The architecture of Substation Microcomputer anti-misoperation diagnosis system is based on the network of centralized control center and its related software. In this paper, the architecture of the system based on agent is shown in Figure 1[5].

![System architecture integrated into the Agent](image)

Figure 1. System architecture integrated into the Agent

The derivation process of BP learning algorithm is as follows: let the connection weight of neuron \( j \) in layer \( l \) to layer \( l-1 \) be \( w_{ji}^{(l)} \), \( p \) be the current learning sample, \( o_{pi}^{(l)} \) be the output of neuron \( j \) in layer \( l \) in sample \( p \), and the transfer function be Sigmoid function. For the \( p \) sample, the output error \( E_p \) of the network can be expressed as follows[6]:

\[
E_p = \frac{1}{2} \sum_{j} (t_{pj} - o_{pj}^{(2)})^2
\]  

In the above formula, \( t_{pj} \) is the ideal output of the \( j \)-th neuron when the \( p \)-th sample is output, and \( o_{pj}^{(2)} \) is its actual output. In this paper, we consider the \( l \)-layer of multilayer neural network, assuming that the \( l \)-layer has \( j \) neurons and the \( l-1 \)-layer has \( I \) neurons[7-8]. For the non input layer, the neuron has the following operation characteristics

\[
net_{pj}^{(l)} = \sum_{i=0}^{l-1} w_{ji}^{(l)} o_{pi}^{(l-1)} - \theta_{pj}^{(l)}
\]

\[
\theta_{pj}^{(l)} = f(net_{pj}^{(l)})
\]
In the above equation (2), if \( \theta_j^{(i)} \) is regarded as the output of a virtual neuron in the \( l-1 \) layer, then
\[
\theta_j^{(i)} = 1, \quad \omega_j^{(i)} = -\theta_j^{(i)}
\]  
(4)

Then formula (2) can be rewritten as follows[9]:
\[
net_j^{(i)} = \sum_{t=0}^{l} \omega_j^{(t)} O_p^{(t)}
\]  
(5)

also
\[
\Delta \omega_j^{(i)} = -\eta \frac{\partial E_p}{\partial net_j^{(i)}} = -\eta \frac{\partial E_p}{\partial net_j^{(i)}} \frac{\partial net_j^{(i)}}{\partial \omega_j^{(i)}}
\]  
(6)

From (5), we can get that:
\[
\frac{\partial net_j^{(i)}}{\partial \omega_j^{(i)}} = \frac{\partial net_j^{(i)}}{\partial \omega_j^{(i)}} \sum_{k=0}^{l} \omega_j^{(k)} O_{pk}^{(i)} = O_{pi}^{(i-1)}
\]  
(7)

The definition \( \delta_j^{(i)} = -\frac{\partial E_p}{\partial net_j^{(i)}} \) is obtained by synthesizing the above formula:
\[
\Delta \omega_j^{(i)} = \eta \delta_j^{(i)} O_{pi}^{(i-1)}
\]  
(8)

It can be seen that in order to calculate the adjustment value, \( \delta_j^{(i)} \) must be calculated first.
\[
\delta_j^{(i)} = -\frac{\partial E_p}{\partial net_j^{(i)}} = \frac{\partial E_p}{\partial net_j^{(i)}} \frac{\partial net_j^{(i)}}{\partial \delta_j^{(i)}}
\]  
(9)

From (3), we can get the following results
\[
\frac{\partial \delta_j^{(i)}}{\partial net_j^{(i)}} = f'_j(net_j^{(i)})
\]  
(10)

The following two situations are discussed:
1. If the neuron in question is an output unit, then
\[
\frac{\partial E_p}{\partial net_j^{(i)}} = -(t_j - \delta_j^{(2)})
\]  
(11)

Substitute (9) to get
\[
\delta_j^{(i)} = -(t_j - \delta_j^{(2)}) f'_j(net_j^{(i)})
\]  
(12)

2. If it is a neuron, then it is a neuron
\[
\frac{\partial E_p}{\partial \delta_j^{(i)}} = \sum_k \frac{\partial E_p}{\partial net_{pk}^{(i)}} \cdot \frac{\partial net_{pk}^{(i)}}{\partial \delta_j^{(i)}} = \sum_k \delta_{pk}^{(i+1)} W_{kj}^{(i+1)}
\]  
(13)

Substituting this result into (9) to get the result
\[
\delta_j^{(i)} = f'_j(net_j^{(i)}) \sum_k \delta_{pk}^{(i+1)} \cdot W_{kj}^{(i+1)}
\]  
(14)

According to (14), \( \delta_j^{(2)} \) is a necessary parameter to obtain the output error coefficient \( \delta_j^{(i)} \) of the substation.

3. Experiment

3.1. Experimental index

(1) Time consumption of microcomputer anti-misoperation alarm in Substation
The shorter the alarm time is, the higher the alarm efficiency is; the longer the alarm time is, the worse the alarm efficiency is.

(2) Accuracy rate of anti misoperation alarm of Microcomputer in Substation
On the contrary, the lower the alarm accuracy, the worse the performance of the system.

(3) False alarm rate of microcomputer operation in Substation
The higher the false alarm rate of microcomputer operation in substation, the worse the system performance. On the contrary, the lower the false alarm rate of microcomputer operation in substation, the better the system performance.

3.2. Substation microcomputer anti-misoperation alarm time
In order to verify the performance of the design system, the reference [3] system, the reference [4] method and the design system were used to carry out statistics on the time of microcomputer anti-misoperation alarm in substation, and the results were shown in Table 1.

| Number of iterations/times | Substation microcomputer anti-misoperation alarm time/s | Literature [3] system | Literature [4] system | Design system |
|---------------------------|--------------------------------------------------------|-----------------------|-----------------------|--------------|
| 100                       | 12.8                                                   | 28.4                  | 0.4                   |
| 200                       | 21.0                                                   | 26.7                  | 0.8                   |
| 300                       | 18.2                                                   | 22.9                  | 0.5                   |
| 400                       | 16.5                                                   | 20.8                  | 0.2                   |
| 500                       | 17.9                                                   | 19.7                  | 0.6                   |
| 600                       | 20.8                                                   | 27.8                  | 0.1                   |
| 700                       | 25.2                                                   | 29.6                  | 0.6                   |
| 800                       | 32.3                                                   | 26.6                  | 0.7                   |
| Mean value                | 20.59                                                  | 25.31                 | 0.49                  |

It can be seen from Table 1 that different systems of substation microcomputer anti-misoperation alarm time is different. When the number of iterations is 200, the time of microcomputer anti-misoperation alarm in the substation of reference [3] system is 21.0s, the time of microcomputer anti-misoperation alarm in reference [4] system is 26.7s, and the time of microcomputer anti-misoperation alarm in the designed system is 0.8s. When the number of iterations is 700, the time for microcomputer anti-misoperation alarm of substation in reference [3] system is 25.2s; the time for microcomputer anti-misoperation alarm of substation in reference [4] system is 29.6s; and the time for microcomputer anti-misoperation alarm of substation in design system is 0.6s. The time of reference [3] system, reference [4] system and design system for substation microcomputer mis-operation alarm is 20.59s, 25.31s and 0.49s respectively. The design system always has a short time when the substation microcomputer anti-misoperation alarm, it can quickly monitor and alarm the substation microcomputer wrong operation, has a certain application value.

3.3. Substation microcomputer anti-error operation alarm accuracy rate
In order to verify the performance of the design system, the system [3], the method [4] and the design system were used to detect the accuracy of the microcomputer anti-misoperation alarm. The results are shown in Table 2.

| Number of iterations/times | Substation microcomputer anti-error operation alarm accuracy rate |
|---------------------------|---------------------------------------------------------------|
|                           | Literature [3] system | Literature [4] system | Design system |
|---------------------------|-----------------------|-----------------------|--------------|
| 100                       | 56%                   | 66%                   | 93%          |
| 200                       | 58%                   | 68%                   | 97%          |
It can be seen from Table 2 that the accuracy of microcomputer anti-misoperation alarm in different substations is different. When the number of iterations is 300, the accuracy rate of microcomputer anti-error operation alarm in the substation of reference [3] system is 67%, that of reference [4] system is 72%, and that of the substation of design system is 98%. When the number of iterations is 500, the accuracy of microcomputer anti-error operation alarm in the substation of literature [3] system is 62%, that of the substation of literature [4] system is 68%, and that of the substation of design system is 94%. The accuracy rates of reference [3] system, reference [4] system and design system for substation microcomputer mis-operation alarm are 65.38%, 70% and 95.13%, respectively. The design system always has a high accuracy of substation microcomputer anti-misoperation alarm, can accurately monitor and alarm the substation microcomputer wrong operation, has a certain application value.

### 3.4. Substation microcomputer operation false alarm rate

In order to verify the performance of the design system, the literature [3] system, literature [4] method and the design system are used to detect the false alarm rate of microcomputer error operation in substation. The results are shown in Table 3.

| Number of iterations/times | Substation microcomputer anti-misoperation alarm false alarm rate |
|---------------------------|---------------------------------------------------------------|
|                           | Literature [3] system | Literature [4] system | Design system |
| 100                       | 22%                  | 36%                  | 0.20%        |
| 200                       | 28%                  | 32%                  | 0.09%        |
| 300                       | 31%                  | 27%                  | 0.12%        |
| 400                       | 17%                  | 29%                  | 0.31%        |
| 500                       | 18%                  | 31%                  | 0.12%        |
| 600                       | 21%                  | 26%                  | 0.23%        |
| 700                       | 25%                  | 23%                  | 0.35%        |
| 800                       | 26%                  | 16%                  | 0.28%        |
| Mean value                | 23.5%                | 27.5%                | 0.21%        |

It can be seen from Table 3 that the false alarm rate of microcomputer anti-misoperation in different substations is different. When the number of iterations is 100, the false alarm rate of microcomputer error operation in substation of reference [3] system is 22%, the false alarm rate of microcomputer error operation in substation of reference [4] system is 36%, and the false alarm rate of substation of design system is 0.20%. When the number of iterations is 600, the false alarm rate of microcomputer error operation in substation of reference [3] system is 21%, that of microcomputer error operation in substation of reference [4] system is 26%, and that of microcomputer error operation in substation of design system is 0.23%. In reference [3] system, reference [4] system and design system, the false alarm rate of microcomputer error operation in substation is respectively 23.5%, 27.5% and 0.21%. The design system always has a low false alarm rate of substation microcomputer error operation, which can effectively monitor the accuracy of substation microcomputer error operation alarm.
4. Conclusion
This paper designs a substation microcomputer anti-misoperation alarm system based on intelligent Agent, uses BP learning algorithm to judge the power station microcomputer wrong operation, and determines the error coefficient of substation. Through intelligent agent technology, the substation maloperation alarm and Substation Microcomputer anti maloperation alarm system are designed. According to the experiment, the following conclusions can be drawn:

(1) The design system always has a short time for microcomputer anti-misoperation alarm of substation. When the number of iterations is 700, the time for microcomputer anti-misoperation alarm of substation of the design system is 0.6s.

(2) The design system always has a high accuracy of substation microcomputer anti-misoperation alarm, can accurately monitor and alarm the substation microcomputer wrong operation, has a certain application value. When the number of iterations is 500, the microcomputer alarm accuracy of the designed system is 94%.

(3) The design system always has a low false alarm rate of substation microcomputer error operation, which can effectively monitor the substation microcomputer error operation. When the number of iterations is 600, the false alarm rate of microcomputer error operation in the substation designed system is 0.23%.

Reference
[1] CHEN H J, WANG W B, Polytechnic G R. (2019) Application and Fault Effect of Photocoupler in High Speed Railway Substation[J]. Electric Switchgear, 66(26):78-82.
[2] CHE B, XU J Y, XU X C, et al. (2018) Research of secondary maintenance safety measures error proofing technology in smart substation[J]. Power System Protection and Control, 25(18):56-62.
[3] HUANG Q, DENG J Q, HUANG Z C, YANG Y, ZHANG S Y. (2019) Remote Anti-maloperation Technology for Substation Based on Bus Coupler Current Analysis[J]. Automation of Electric Power Systems, 43(24):194-200.
[4] Yang B, PENG Z H, LIU D K, Chen Z P, WANG C D. (2019) The safety protection and alarm system of substation personnel based on UWB[J]. Experimental Technology and Management, 36(11):141-145,149.
[5] Yu Z. (2018) Research on Sensor Array Optimization Based on Reducing False Alarm Technology[J]. Mathematics in Practice and Theory, 12(06):22-28.
[6] XU G, HUANG F P, XU Q F, et al. (2018) Analysis and Processing of a Three-Phase Inconsistent Signal False Alarm of Circuit Breaker[J]. Electric Engineering, 21(16):21-35.
[7] Goncalves C F, Menasché, Daniel S, Avritzer A, et al. (2020) A Model-Based Approach to Anomaly Detection Trading Detection Time and False Alarm Rate[J]. 32(16):36-41.
[8] Wang C, Lu W, Redmond S J, et al. (2018) A Low-Power Fall Detector Balancing Sensitivity and False Alarm Rate[J]. IEEE Journal of Biomedical and Health Informatics, 22(6):1929-1937.
[9] SU J F, LIU J, ZHAO S, et al. (2019) Design of anti-jamming system for substation weak current equipment based on point cloud data[J]. Electronic Design Engineering, 27(22):166-169.