Study on the Blasting Safety Evaluation Method Based on BP Neural Network

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Abstract: For the complexity of safety system of blasting engineering, and the advantage of Artificial Neural Network (ANN) in solving such uncertain problem, ANN is introduced in this paper.Assessment model based on BP Neural Network is established, which can achieve variable weights and dynamic assessment which cannot be achieved by traditional methods. The model achieves perfect combine of knowledge and experience, reconstructed the experts' knowledge and experience. The research on safety assessment model of blasting engineering in this paper is not only significant to actual using but also to the establishment of expert system of safety assessment of blasting.

Keywords: blasting engineering; safety assessment; BP neural network

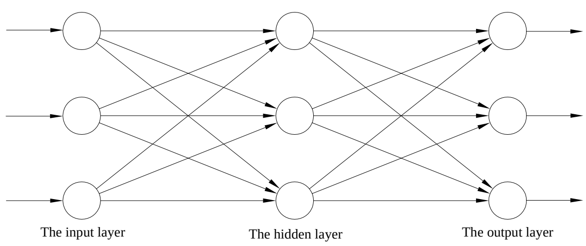
1. Introduction

The blasting safety assessment is a comprehensive system engineering, which factors involved are very complex. These factors have presented themselves as random factors and the role between factors is to vary with the specific circumstances, which betrays the dynamic nature, and the relationship of these factors with the security situation shows ambiguity, and the factors are interrelated mutually effect. On the one hand, some factors can not accurately describe the numbers, but only a vague concept; the other hand, there is not an one-to-one correspondence function between the change s of various factors and the security situation, and it is impossible to establish a precise mathematical model to solve it.The traditional methods of evaluation have its own characteristics, although we can effectively evaluate the system in specific areas, it is basically a fixed linear relationship to set the safety factor and security situation in mapping. This does not clearly reflect the actual relationship of the blasting safety assessment system dynamics, stochastic and fuzzy characteristics. It can be seen that there are some limitations in the existing evaluation methods more or less, which can not fully meet the requirements of blasting safety evaluation[1-10].

Neural network security assessment model can fully solve the problem which these traditional methods can not, neural network has a strong nonlinear function approximation capability and can be trained to draw functional relationship between the input and output variables based on the sample data, namely, via learning from the network, it can determine the weights between neurons to make the network have a similar function as a whole, which also has high accuracy. In addition, the application of the neural network to security assessment can create a much closer human thought integrated evaluation model of combining the qualitative analysis with quantitative analysis. By learning from the given sample models, neural network model can get the knowledge, experience, subjective judgments and the importance of orientation on the target of evaluation experts. Using the model to evaluate blasting safety, it can reproduce the experience, knowledge and intuitive thinking of evaluation expert, and can better ensure the accuracy of the results[11-13].

2. The BP Neural Network Model

Artificial neural network is the simulation of biological nervous system, which information processing capabilities are determined by the input and output characteristics (active properties) of the network elements(neurons), the network topology (neuron connections), the connection of the right size (Strength of synaptic connections) and the neuron threshold (considered as a special connection weight), etc.



The multi-layer neural network model using BP algorithm, commonly called the BP network is one of important models of neural networks. In BP neural network model, the hierarchical arrangement of neurons form an input layer, a hidden layer and an output layer respectively. Neurons in each layer only receive the input from the front. The later layer has no signal feedback to the front. The final output in the output layer can be got from the input model through various levels of the order transmission.

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3 The Basic Algorithm and Steps of BP Neural Network

3.1 The Basic Algorithm of BP Neural Network

It uses a certain threshold excitation function in BP network, which is continuously differentiable. The commonly used S-(Sigmoid) function is as follows:

$$f\left(Net_{kj}\right)=\frac{1}{1+e^{-Net_{kj}}} \tag{1}$$

Where Net_{kj} is the state of network unit u_j:

$$Net_{kj}=\sum_i w_{ji}o_{ki}+\theta_i \tag{2}$$

Then the unit output is:

$$o_{kj}=\frac{1}{1+\exp\left(-\sum_i w_{ji}o_{ki}-\theta_j\right)}=\frac{1}{1+e^{-Net_{kj}}} \tag{3}$$

Where θ_j is the threshold of unit u_j. In this excitation function, there are:

$$f_j'\left(Net_{kj}\right)=\frac{\partial o_{kj}}{\partial Net_{kj}}=o_{kj}\left(1-o_{kj}\right) \tag{4}$$

Therefore the error of the output layer unit is as follows:

$$\delta_{kj}=\left(t_{kj}-o_{kj}\right)o_{kj}\left(1-o_{kj}\right) \tag{5}$$

The error of hidden layer units is as follows:

$$\delta_{kj}=o_{kj}\left(1-o_{kj}\right)\sum_m \delta_{km}w_{mj} \tag{6}$$

The weight can be adjusted as follows:

$$\Delta w_{ji}\left(t+1\right)=\eta\delta_{kj}o_{ki} \tag{7}$$

3.2 The Basic Algorithm of BP Neural Network

1) Set each of weights and initial values of threshold: $w_{ji}(0)$, $\theta_j(0)$ are small random values.

2) Provide training samples: input vector $X_k, k=1,2,\cdots,P$, expect to output $d_k, k=1,2,\cdots,P$; carry out the iteration of each outward-inward samples from 3) to 5) bellow.

3) Calculate the actual output and hidden layer unit status of network:

$$o_{kj}=f_j\left(\sum_i w_{ji}o_{ki}+\theta_j\right) \tag{8}$$

4) Calculate the training error:

$$\delta_{kj}=\left(t_{kj}-o_{kj}\right)o_{kj}\left(1-o_{kj}\right) \tag{9}$$

$$\delta_{kj}=o_{kj}\left(1-o_{kj}\right)\sum_m \delta_{km}w_{mj} \tag{10}$$

5) Modify the weight and threshold:

$$w_{jt}\left(t+1\right)=w_{ji}\left(t\right)+\eta\delta_j o_{ki}+\alpha\left[w_{ji}\left(t\right)-w_{ji}\left(t-1\right)\right] \tag{11}$$

$$\theta_j\left(t+1\right)=\theta_j\left(t\right)+\eta\delta_j+\alpha\left[\theta_j\left(t\right)-\theta_j\left(t-1\right)\right] \tag{12}$$

6) When k after 1 to P, judge the index whether meets accuracy requirements,

$E\le\varepsilon$; ε: accuracy

7) The end.

4 The Steps of Building the Blasting Safety Evaluation Model Based on BP Neural Network

The system comprehensive safety assessment is a safety evaluation of a whole or a system, which evaluation process can be divided into the following five steps:

1) Make a definition of the safety evaluation object.

2) Establish the safety evaluation index system. The security situation in the system can be evaluated through a series of evaluation indexes, each of which portrays the system security situation from different sides to determine the input layer, hidden layer and output layer of nodes of BP neural network and build the basic framework of the BP neural network.

3) Identify with the initial weight factor corresponding to each of safety evaluation index. In relation to the safety evaluation purpose, the relative importance between the evaluation indexes is different and the extent of relative importance is embodied by the size of the weight coefficients between the safety evaluation indexes. In the course of evaluation by neural network, the size of weight determines all of the information in the neural network, in the training period, the weight of neural network can be updated constantly until satisfy some previously given conditions, therefore, the definition of the initial weight coefficient can directly affect the efficiency of neural network learning and evaluation of results.

4) Choose a comprehensive safety evaluation index of learning samples for neural network training and learning.

5) Carry out a comprehensive safety evaluation to the system by BP neural network.

5 Engineering Practice

5.1 The Establishment of BP Neural Network Model

The most commonly used 3-layer BP neural network structure is adopted, namely an input layer, an output layer and a hidden layer.

According to the established index system, the node number of input layer which depends on the number of evaluation index is 31. According to the domain of established evaluation theory, the node number of output layer which is the fuzzy membership of different evaluation grade is 3.The number of hidden layer neurons is 35. Transfer function is based on the Type S (sigmoid).

5.2 Training Samples

Using the method of fuzzy comprehensive evaluation for security evaluation on the different Project,12 sets of samples are obtained. Using the first 11 groups as the training samples and the last group as the validation sample, the precision of the established BP neural network evaluation model is tested. Training samples of the fuzzy comprehensive evaluation are listed in Table 1.

Table 1. Training Samples of the Fuzzy Comprehensive Evaluation

samples	1	2	3	4	5	6	7	8	9	10	11	12
Index 1	0.89	0.87	0.83	0.85	0.92	0.96	0.94	0.97	0.90	0.89	0.87	0.93
Index 2	0.85	0.88	0.87	0.90	0.70	0.67	0.70	0.65	0.95	0.97	0.98	1.00
Index 3	0.83	0.82	0.85	0.80	0.83	0.82	0.85	0.80	0.83	0.82	0.85	0.80
Index 4	0.80	0.82	0.83	0.85	0.85	0.87	0.84	0.85	0.90	0.92	0.87	0.85
Index 5	0.85	0.84	0.79	0.80	0.88	0.90	0.91	0.86	0.80	0.76	0.69	0.73
Index 6	0.85	0.90	0.88	0.87	0.83	0.82	0.79	0.84	0.90	0.85	0.87	0.85
Index 7	0.80	0.84	0.85	0.83	0.80	0.84	0.85	0.83	0.80	0.84	0.85	0.83
Index 8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Index 9	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Index 10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Index 11	0.95	0.95	0.97	0.95	0.94	0.98	0.98	0.96	0.95	0.97	0.93	0.98
Index 12	0.85	0.88	0.86	0.85	0.90	0.91	0.89	0.90	0.85	0.86	0.85	0.90
Index 13	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Index 14	0.81	0.82	0.85	0.82	0.80	0.82	0.81	0.79	0.90	0.89	0.86	0.91
Index 15	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Index 16	0.90	0.88	0.93	0.91	0.83	0.81	0.80	0.79	0.91	0.87	0.90	0.85
Index 17	0.90	0.93	0.94	0.92	0.80	0.79	0.75	0.70	0.93	0.92	0.95	0.92
Index 18	0.87	0.90	0.83	0.88	0.80	0.75	0.76	0.79	0.95	0.94	0.94	0.93
Index 19	0.90	0.85	0.90	0.90	0.86	0.88	0.87	0.87	0.90	0.95	0.94	0.93
Index 20	0.81	0.82	0.82	0.85	0.90	0.95	0.92	0.95	0.82	0.83	0.85	0.85
Index 21	0.90	0.85	0.88	0.90	0.95	0.95	1.00	0.95	0.85	0.85	0.86	0.84
Index 22	0.85	0.84	0.87	0.90	0.90	0.92	0.93	0.89	0.80	0.75	0.70	0.69
Index 23	0.90	0.85	0.87	0.88	0.85	0.84	0.80	0.79	0.90	0.92	0.93	0.89
Index 24	0.85	0.87	0.90	0.85	0.85	0.83	0.90	0.85	0.85	0.87	0.90	0.85
Index 25	0.80	0.79	0.75	0.77	0.80	0.79	0.75	0.77	0.80	0.79	0.75	0.77
Index 26	0.77	0.69	0.73	0.75	0.80	0.81	0.83	0.80	0.79	0.80	0.81	0.76
Index 27	0.80	0.85	0.77	0.75	0.83	0.72	0.80	0.77	0.79	0.82	0.85	0.85
Index 28	0.77	0.76	0.69	0.70	0.77	0.76	0.69	0.70	0.77	0.76	0.69	0.70
Index 29	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

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Index 30	0.86	0.88	0.87	0.90	0.86	0.88	0.87	0.90	0.90	0.90	0.92	0.90
Index 31	0.90	0.93	0.95	0.96	0.90	0.93	0.95	0.96	0.80	0.77	0.75	0.78
membership degree 1	0.7690	0.7711	0.7810	0.8210	0.8374	0.8503	0.8432	0.8048	0.7913	0.7570	0.7318	0.7288
membership degree 2	0.4690	0.4450	0.4235	0.3916	0.3734	0.3571	0.3449	0.3694	0.4441	0.4307	0.4101	0.4351
membership degree 3	0.0001	0.0013	0.0018	0.0012	0.0025	0.0065	0.0063	0.0132	0.0001	0.0084	0.0428	0.0339

5.3 Training and Test Results

After 24 trainings, neural network reaches convergence. Figure 1 shows the training result of neural network.

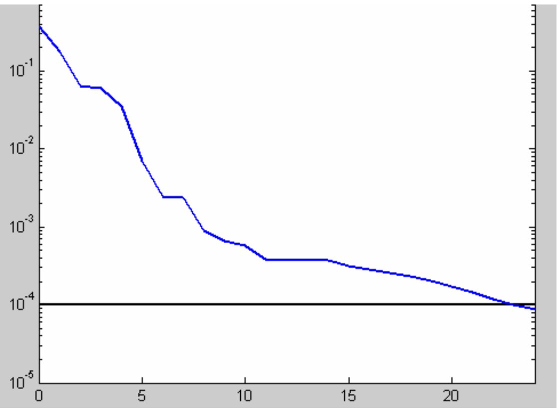

Figure 1. The training result of neural network

The last group data are used as the test samples to test the trained neural network. Table 2 shows the test results of the output of the neural network.

Table 2. The test results table of neural network

Membership degree	Membership degree 1	Membership degree 2	Membership degree 3
Calculated values	0.7288	0.4351	0.0339
Simulation values	0.6847	0.4343	0.0344
Errors	6.05%	0.18%	1.47%

6. Conclusions

1) The established BP neural network evaluation model can be comprehensive evaluation of the system's security situation and the security status which are under the action of multiple factors. It is a good solution to the determining of the variable weight which is the traditional evaluation methods that can not be solved .It also can realize the historical experience combination with the new knowledge perfectly, reconstruction of the experience of evaluation expert, knowledge and intuitive thinking. And in the process of development, dynamically evaluate the security status of blasting. It is proved that BP neural network applied to the safety assessment of blasting is feasible.

2) The sample, to a great extent, affects the accuracy of the neural network evaluation model. And when the condition of the sample data completeness and orthogonality are bad, it will reduce the accuracy of evaluation results.

3) Compared with the result of actual evaluation, the result of system safety assessment using the trained neural network model has a high accuracy.

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