

Application of Artificial Neural Network in Slope Stability Analysis

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ABSTRACT

This paper mainly expounds the natural factors that affect the slope stability and the application principle of artificial neural network in the slope stability analysis. The advantages and disadvantages of general neural network and BP network are analyzed, and the corresponding countermeasures are put forward.

Keywords: Artificial Neural Network; BP Neural Network Problems Countermeasures

1. Application of artificial neural network in slope stability analysis

1.1 Introduction of artificial neural network

Artificial neural network is a research hot topic in the field of artificial intelligence in the 21st century. It can build a simple model similar to artificial neural network from the perspective of information processing, and build different neural networks according to different connection modes. It is set up by human and carries out information processing through the continuous or intermittent external input to make state response. With the development of science and technology, people pay increasing attention to artificial intelligence researches, and artificial neural network researches are deeper. In recent years, great progress has been made. It can solve the practical problems that are difficult to solve by modern computers in the fields of information, medicine, intelligent robots, biology, transportation, economy and so on. The artificial neural network can adjust, change the behavior of the system and adapt to the environment through supervised learning and unsupervised learning.

1.2 Main factors affecting slope stability

There are many factors that affect the stability of the slope, among which the main natural factors are the mechanical properties, the structure and the development of the structural surface of the rock and soil, the role of water, weathering, topography and so on. The

composition, structure, cement and cementation type of rock determine the material basis of rock slope stability. The structure of rock mass and the development of structural plane are the key factors to control the failure of slope. The role of water is to make the soluble minerals in the rock and soil be taken away by water, which leads to the increase of the pores of the rock mass and the fragility of the rock mass. Moreover, it will increase the mass of rock and soil mass, and water will generate dynamic and hydrostatic pressure on rock mass, which will eventually lead to the increase of sliding force generated by rock and soil mass on the sliding surface. When the sliding force reaches a certain degree, it will cause slope deformation or even damage. Weathering includes physical weathering and chemical weathering. The most common physical weathering is thermal expansion and cold contraction. Weathering will increase the internal pores of rock mass, increase the permeability of rock mass, and reduce the ability of rock mass to resist shear failure. Due to the large temperature difference between day and night in some areas, the weathering causes the increase of rock pores, and the rain water brought by precipitation penetrates into the rock mass. Under the effect of the alternation of day and night temperature, the water droplets penetrating into the rock mass continuously expand and contract, and finally the rock mass collapses. The topography will affect the stress distribution inside the slope, thus affecting the

stability of the slope.

1.3 Application principle of artificial neural network in slope stability analysis

Artificial neural networks can be roughly divided into two categories according to their different connection modes (i.e. different topological structures): feedbacks neural networks and non feedbacks neural networks. This paper takes BP network as an example, which is the most important one of the more mature and widely used non feedback neural networks.

BP multi-layer neural network back propagation learning algorithm, which neuron activation function is differentiable function. It introduces a number of learning samples, and inputs teacher value through network training. BP network will compare the actual output value with the given teacher value, use the error generated between them, and then modify the connection weight between the input layer and the hidden layer of each layer of neural network by gradient descent method to minimize the total error of the final learning.

Firstly, the input layer is constructed, and the number of neurons in the specific input layer is constructed by considering the natural factors that affect the slope stability. The output layer can be designed as a neuron of safety factor in slope stability analysis. Finally, we take the design of neurons in the middle hidden layer into consideration. The number of neurons in the hidden layer is very important. If the number of neurons is too small, the neural network will not have enough information processing ability and learning ability. If there are too many neurons in the hidden layer, the network structure will be complex and the learning speed will be affected. The number of hidden layer nodes given by Kolmogorov's theorem is $s = 2n + 1$ (n is the number of input layer nodes), which can be adjusted as necessary. Then we need to normalize the input learning samples and teachers' values, and then train the network. After the corresponding requirements are met, the safety factor of the actual slope stability can be calculated.

2. Advantages of neural network compared with traditional analysis methods

Different types of neural networks have different advantages. Generally speaking, neural networks have the following advantages.

(1) At present, neural network is the hotspot of artificial intelligence research in the world, and it involves a wide range of fields. It has a close relationship with modern science and technology. The development of artificial neural network will promote the development of modern science and technology, and the two will promote each other and make common progress. For example, in the field of mathematics, as the artificial neural network is a non-linear system, it is impossible to accurately analyze each index and get an absolutely correct value because of its high complexity. The indexes analyzes will have certain fuzziness, which makes mathematics become an important tool to verify its correctness. The uncertainty of neural network brings a new research direction to mathematics and promotes the development of modern mathematics.

(2) Because the artificial neural network is composed of a large number of neurons connected widely, each neuron has a very small impact on the whole system, which makes even if a small number of neurons are wrong or even damaged. It will not affect the normal operation of the whole neural network, and the neural network has a certain degree of fault tolerance.

(3) Neural network has a huge scale of parallel interconnected neuron model, and it can use its unique network structure form to store the processed data information in the weights of neurons, which is equivalent to associative memory. It divides the memory into different parts and assigns it to the weights of other neurons, so that its information cannot be seen from a single weight content. These characteristics make the neural network have the ability of high-speed operation, increase the possibility of carrying out a large number of calculations quickly, also make the artificial neural network have the work of recovering damaged patterns, extracting features, etc. It can also complete the functions of pattern association, image recognition, etc.

(4) Artificial neural network has a strong learning ability. It can adapt to the external environment by using training to change the weight and structure, which reflects a strong ability to adapt to the environment and learn.

(5) The storage of knowledge in artificial neural network system is not in a specific neuron, but in the whole neural network system.

3. Problems in application of neural network

(1) Neural network is a highly nonlinear system, which is not only its advantages, but also its disadvantages. Because of its high nonlinearity, it is difficult to realize the accurate analysis of each index, which limits the scope of its application. For some problems that must get correct answers, neural network is not applicable. It can't guarantee the "absolute correctness" of answers. In the face of such problems, we can only rely on high-precision computers and precision design algorithms to solve them.

(2) At present, the application of neural network is still in the research stage. Because of the complexity of its network structure, how to arrange it to improve the efficiency of neural network and the correctness of the results of data analysis of neural network is a problem. Taking BP neural network as an example, how to determine its network structure and the number of nodes in the hidden layer is a very important problem. If the network structure design is too large, the complexity of the structure will be improved, and the phenomenon of over fitting may appear, which will eventually lead to the low efficiency of network operation. If the network structure design is too small, it may cause network non convergence and affect the correct analysis of data. Currently, there is no complete theoretical guidance for the design of neural network structure. The design of network structure is mostly based on people's experience.

(3) Compared with digital computer, neural network can't solve the problem that digital computer solves very well. For example, the best solution to a problem is to design a best algorithm by people, that is, to write a program to solve the problem through a digital computer and get the best answer. Only in the face of big data and complex conditions, when people can not find the best solution rules reasonably, can the artificial neural network find the best solution rules, and the artificial neural network can give full play to its advantages. Therefore, the artificial neural network for data analysis

and problem-solving is only a supplement to the digital computer. It can not replace the status of the digital computer, the two are complementary status. The combination of artificial neural network and digital computer can help people to solve the complex practical problems in reality more perfectly.

(4) The generality of artificial neural network is poor, and is not omnipotent. For several kinds of network structure types proposed at present, they have their own advantages and disadvantages. However, any of these structures can only solve one or even several kinds of problems. There is not a very general neural network structure, and its general performance is poor.

4. Countermeasures and suggestions for the problems in the application of neural network

4.1 Change algorithm

Taking BP network as an example, the algorithm of BP neural network is a mature algorithm now, and it is also a classical algorithm in artificial neural network. The error return algorithm used in BP network is essentially gradient descent method. The minimization objective function of this method is very complex, which makes the learning process of BP network very long and makes the efficiency very low. So we can change the convergence speed and improve the efficiency of BP algorithm by adding momentum term, using conjugate gradient method, recursive least square method, neuron space search method and so on.

4.2 Determining the number of nodes in hidden space

The number of hidden nodes in BP network is a very important parameter, which directly affects the generation of "over fitting phenomenon". Too many hidden layer nodes will increase the learning time of the network, and increase the possibility of "over fitting phenomenon" of the network. Too few hidden layer nodes will make the network unable to learn. So how to choose the best number of hidden layer nodes has become a crucial step. At present, there is no complete theoretical guidance to determine, most of which are based on experience. Firstly, we can determine the range of the target hidden layer nodes by experience,

then we can use the "three-point method" to screen two-thirds of the nodes, and then we can determine them by experience. The essence of the "three part method" is to divide the given target interval into three parts, and then study its changing trend respectively to predict which interval the best number of hidden layer nodes lies in. In this way, the time to determine the number of hidden layer nodes is greatly reduced, and the error of BP network in the application process is also reduced.

5. Conclusion

To sum up, artificial neural network in slope stability analysis has brought a lot of convenience for people analyzing whether the slope is stable or not. Artificial neural network has its unique advantages. However, at present, it still has many shortcomings. With the deepening research on artificial neural network, its ability to solve engineering problems such as slope stability will be greatly enhanced, and the application scope in the field of construction engineering and even in the whole human society will be more extensive.

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