Road safety Evaluation based on artificial neural network

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Abstract. BP neural network algorithm is easy to get a local optimum and fall into local loop in calculation, which makes slow training speed and unstable calculation, so the development and application of the algorithm are restricted. The road safety evaluation is an important Part of the traffic safety research. The existing traffic safety evaluation most based on traffic accident data but not the road environment; otherwise, the traffic safety evaluation is usually in the large area but not the road: the methods used most are traffic accident rate and step analysis. For this situation, this paper advanced a new evaluation that uses the factors that influence the road safety. This paper uses ordinary BP algorithm to overcome the above problems. After analyzing the root causes of the defects of BP algorithm, specific calculation steps of genetic algorithm is improved when used to improve BP algorithm first. Then the calculation flows of new algorithm are redesigned.

Introduction

As the important sub-field and the quintessence of artificial neural network, BP neural network accelerates the development in this field. In 1985, Rumelhart and some other scholars advanced the Error Back Propagation theory that was improved as BP Neural Network theory today. BP neural network has integrated system, explicit algorithmic process, data identification and simulation function.

BP algorithm also owns the excellent ability to solve nonlinear problem, therefore, the value of practical application is outstanding. Along with researching deeply, the defects of BP neural network have been found.

Such as low convergence speed, long training time, falling into local minimum easily, bad generalization ability and few principle to build network structure. These defects can depress the accuracy of BP neural network and damage the practical effect. So, improving BP neural network step by step is significant not only for theory, but also for practical application

Defect Analysis of BP Algorithm

There are some shortages of BP neural network. It is small in the calculation of change of error gradient.

Though the weight is large in adjustment amount, the error is descending slowly. So only with correct adjustment direction and long adjustment time can quit the flat site and enter some valley point, which causes a big increase in calculation training times, thus influencing rate of convergence. There are many minimum points. BP algorithm is a non-linear optimal method based on gradient descending method, inevitably having the problem of local minimum. And the solution space of actual problems is often extremely complicated multidimensional curved surface, having lots of local minimum points, leading to an increasing possibility of falling into local minimum point. Generally, while randomly set initial weight in BP algorithm, training of network is generally difficult to reach global optimum, which will make the algorithm training fall into local minimum, thus causing the training fail to converge to assigned error.

BP neural network layers

From the picture we can see that BP neural network is mainly comprised of input layer, hidden layer and output layer. Adjustable weight ω connects the layers. There can be several hidden layers, forming multi-layer BP neural network. The input of BP neural network is recorded as $x_i(k)$, the actual output of network is recorded as $y_j(k)$, the ideal output of network is recorded as $Y_i(k)$, the subscripts i, j indicate the nodes of input layer of network respectively, and k is the running iterations of BP neural network. Its approximation error is defined as formula (1) in which L is the quantity of output layer nodes; in this way, the function characteristic of BP neural network can be described as Formula (2).

$$E = \frac{1}{2}\sum_{j=1}^{L}(Y_j(k) - \gamma_j(k))^2 \tag{1}$$

$$\gamma_j(k) = f(x_i(k), \omega) \tag{2}$$

In formula 2, function f is obtained through the composition of weights of each network layer and node function, generally being very complicated non-linear function BP neural network training is to dynamically adjust the connecting weight ω to make Formula 3 workable. The learning of weight ω adopts the fastest grads descent principle, i.e. the variable quantity of weights is in proportion to the negative gradient direction of approximation error E. See reference 2 for specific calculation.

$$\lim_{k\to\infty} E = \lim_{k\to\infty}\frac{1}{2}\sum_{j=1}^{L}(Y_j(k) - \gamma_j(k))^2 = 0 \tag{3}$$

Specific Improvement Steps of Genetic Algorithm

An Ann (Artificial Neural Networks, ANN) model can be described by the connecting method of finite parameters such as neuron, network layers, neuron number of each layer and neuron, weight of each connection and transfer function.

So we can encode an ANN model and realize the learning process of neural network with genetic algorithm.

Parameter setting. Input population size P, network layers (not including input layer) and neuron number of each layer.

Genetic algorithm has excellent robustness towards the setting of these parameters; changing these parameters won't exert great impact on obtained results.

Initialization and evaluation. Randomly generate initial population $P = (x_1, x_2, ..., x_n)$, any $x_i \in P$ being a neural network weight, which is comprised of a weight vector and a threshold vector, weight vector being n-dimensional real vector, n being the number of all the connection weights, threshold vector also being n-dimensional real vector (not including neuron of input layer). Each network weight x_i is equal to a chromosome; there are N such chromosomes, i.e. population size. The neurons are numbered from the bottom to the top, from the left to the right (including input neuron).

According to corresponding neural network of randomly generated weight vector and threshold vector, as for the given input set and output set, calculate the global error of each neural network, as genetic algorithm can only evolve towards the direction of increasing fitness.

So the fitness function can be formed according to formula (4) and formula (5), among which f_i is the adaptive value of the i th individual, $i = 1,2,...,N$ being the number of chromosome, $k = 1,2,...,n$ being the number of nodes of output layer, $p = 1,2,...,m$ being the number of learning samples, v_{pk} being the output value of the k th node while inputting the p th training sample, T_{pk} being the anticipated output value [2,3].

$$f_i = 1/E_i \tag{4}$$

$$E_i = \sum_{p=1}^{m}\sum_{k=1}^{n}(v_{pk} - T_{pk}) \tag{5}$$

Evaluation Indicator and Experimental Results and Analysis for Road safety Evaluation

The paper takes regional road safety evaluation for examples and, on the basis of referring to references, experts consultation and practice survey, designs a set of evaluation indicator system which includes 5 second-class indicators and 34 third-class indicators. 5 second-class indicators are road safety culture, administrative system, resource allocation, operation mechanism, benefit performance respectively.

And second-class indicators road safety culture includes ideology and culture, method culture, artifact culture, administrative system includes organization system, and security system, the specific contents of rest three second-class indicators are omitted here.

As for the performance of the presented algorithm, this paper also realizes the application of the ordinary BP neural network and ordinary fuzzy comprehensive evaluation algorithm, evaluation results of training effects of different regions are selected and compared with artificial evaluation to calculate the evaluation accuracy.

And the calculation platform as follows: hardware is Dell Power edge R710, in which processor is E5506, memory 2G, hard disk 160G; software platform is Windows XP operating system, C programming language environment.

Experimental data come from the database of some typical regions, Beijing, Shanghai, Liaoning, Shangxi, and Yunnan.

Limited to paper space, the evaluation of intermediate results is omitted here, only providing evaluation results of second grade indicators and final comprehensive performances, see table 1.

Table 1 Evaluation results of second grade indicators and final performance

	Road safety culture	Administrative system	Resource allocation	Operation mechanism	Benefit performance	Final results
Beijing	4.662	4.091	4.031	4.232	4.571	4.389
Shanghai	4.669	3.988	3.989	4.001	4.386	4.223
Liaoning	4.221	3.785	3.861	3.889	4.109	3.981
Shanxi	3.624	3.189	3.287	3.229	3.573	3.376
Yunnan	3.118	2.899	2.901	2.866	3.102	2.941

Conclusion

The road traffic safety evaluation that based on ANN also can used in forecast the traffic accidents: checkup the traffic accident black Point and so on. It has a very important significance in traffic safety research.

Reference

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