Network traffic prediction algorithm research based on PSO-BP neural network

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Abstract. We Propose PSO-BP network traffic prediction algorithm which based on BP neural network and improved by the particle swarm optimization. Use PSO algorithm to optimize the initial weight and threshold values of BP network, and use history to train BP neural network and realize the simulation by MATLAB. The results show that, PSO-BP algorithm can improve network traffic prediction accuracy and speed up the convergence rate of BP network.

Introduction

Network traffic measurement of the Internet is a tool for people to research the Internet, also is the foundation of network performance analysis and network planning and design. Effective and accurate prediction of network traffic have very vital significances for network performance evaluation, congestion control, large scale network planning design and business service assurance.

BP neural network prediction algorithm is one of the most influential network traffic prediction algorithms. BP neural network time series prediction method based on neural network theory, and take full advantage of the numerical approximation of the network and memory function. According to the historical values of time series, the algorithm recognizes the inherent pattern of time series. BP neural network time series prediction method can be based on the historical data to predict the future value. Although the BP neural network algorithm has a strong information processing capability, it still has some defects. For example, the algorithm is easy to fall into local minimum point, has the problems of the network jitter and the selection of network initial weight values and threshold values. PSO algorithm is a community intelligent optimization algorithm which simulates the predation of birds. In this paper, we propose the PSO-BP algorithm based on the defects of BP neural network algorithm network's initial weights and threshold selection and falling into local minimum point. According to the actual data of campus network traffic, we use PSO-BP algorithm to predict network traffic.

BP neural network algorithm

BP neural network normally consists of an input layer, an output layer and a number of hidden layers. Each layer of neurons receives any inputs from previous layer, and outputs an output to the next layer. Many studies show that the neural network with only one hidden layer is enough to approximate any function, so we use the neural network model with one hidden layer in the experiment. The BP neural network algorithm is essentially an input / output problem into a nonlinear optimization problem, the problem is used to seek multiple minima, and Network connection weight matrix W is regarded as variables, the error function E (W) is regarded as the target [1]. BP algorithm determines the relevant parameters of the network through the learning and training by a certain capacity of samples.

The process of getting the values of weights and thresholds of BP neural network during the training is a process to determine the optimum parameters. Because the BP neural network algorithm uses the gradient descent method, so the different choices of initial weights cause different training results. At the same time, gradient descent method can causes some deficiencies of the BP

neural network algorithm such as slow convergence speed and easily falling into local minimum point.

PSO-BP algorithm

In this paper, aiming at the deficiency of BP algorithm which uses the gradient descent method, we use PSO algorithm which has the global search function to optimize the training process of BP neural network. As a global optimization algorithm, the PSO algorithm presents some advantages such as simple, easy realizing and fast convergence speed, it can combines with neural network to optimize the training process [2-3]. The PSO-BP algorithm is constituted by BP neural network and PSO algorithm, and it not only has the good local searching ability of BP algorithm, but also has the global optimization characteristics of PSO algorithm.

A. PSO-BP algorithm principle

In the PSO-BP algorithm training process, first, algorithm uses PSO algorithm to train the neural network learning. Because the neural network learning process mainly is the new weights and thresholds update process, it is possible to use the PSO algorithm to optimize weights and thresholds of BP neural network. And then the PSO-BP algorithm gets the weights and thresholds as the initial parameters of BP algorithm. Finally, BP neural network can be trained to get the optimal parameters. Due to the PSO algorithm replaces the initial optimization of neural network, BP neural network get the optimal solution based on the parameters which is close to the basic solution, so it can effectively improve the precision and speed of network.

B. PSO-BP algorithm training process

PSO-BP algorithm training process is described as the following:

a) Base on BP neural network structure to determine the particle number N, the maximum number of iterations T, the Particle dimension D, the inertia weight w, the learning factors c1 and c2 of PSO algorithm.

b) Initialize the speed V and position X of particles swarm at random.

c) Calculate the fitness function value of each particle in the population. In the calculation, individual particle restore to the network weights and thresholds, through the neural network compute the sample mean square error. The mean square error is the fitness function value.

d) Compare the fitness, and determine each particle individual extreme value Pi and the entire population extreme value Pg.

e) Update the speeds and positions of particles. The Speed and position update equations as in:

$$V_{id}^{t+1} = wV_{id}^t + c_1 r_1 (P_{id}^t - X_{id}^t) + c_2 r_2 (P_{gd}^t - X_{id}^t) \quad (1)$$

$$X_{id}^{t+1} = X_{id}^t + V_{id}^{t+1} \quad\quad\quad (2)$$

In the above equations, w is the inertia weight; d = 1,2, ..., D, i = 1,2, ..., N, t represents the iterations number of the current evolution, c1 and c2 are learning factors, r1 and r2 are random numbers within the [0,1], Pi is particle individual extreme value and Pg is the entire population extreme value.

f) Determine the end conditions, if do not meet, the iteration continues. If meet the requirements for the end, the population extreme value will be as the optimal solution.

g) Optimal solution reverts to the connection weights and thresholds of BP neural network and uses them to initialize the BP neural network.

h) Train BP neural network until the network performance to meet, and save weight and threshold values.

PSO-BP network traffic prediction algorithm simulation

After a long time operation, the university campus network has a large amount of historical data of network traffic. The experimental use per hour network traffic of campus network as data, the data is seven days, a total of 168 sets. We use MATLAB to realize the simulation of PSO-BP algorithm network traffic prediction.

A. The structure of BP neural network

Because for any continuous functions within any closed interval, you can use the BP network which has a hidden layer to approximate it [4]. So the experiment adopts three layer feed forward neural network to forecast the network traffic. The prediction algorithm is based on the neural network technology in the time series. We use 7 nodes in the input layer, and the 7 nodes is as the 7 time points network traffic which before the current forecast time point. The number of nodes in the output layer is 1, which is the current forecast time point of network traffic. There is an experience equation to get the suitable number of hidden layer nodes of BP network [5]. As in:

$$h = \begin{cases} n + 0.618(n - m) & n \geq m \\ m - 0.618(m - n) & n < m \end{cases} \quad (3)$$

n is the input nodes number, m is the output nodes number, h is the number of nodes in hidden layer. According to the equation, the number of hidden nodes is 10. Therefore, the structure of BP neural network is 7*10*1.

B. The activation functions of BP neural network

Activation function of the hidden layer is Tansig function.

$$f(x) = \frac{e^x - 1}{e^x + 1} \quad (4)$$

Activation function of the output layer is Sigmoid function

$$f(x) = \frac{1}{1 + e^{-x}} \quad (5)$$

C. Data preprocessing

Network traffic data must be normalized to eliminate the influence of network traffic absolute quantity in network operation and avoid the input of neurons too large.

D. Setting the parameters of particle swarm algorithm

1) Inertia weight w: The inertia weight w is introduced to optimize the development and detection ability of PSO algorithm [6]. The inertia weight w controls the affection that the former speeds of particles affect the right now speeds. When w is small, it can improve the convergence speed, which is very beneficial for local optimization. When w is large, it is possible to make algorithm optimize the parameters in the global scope, which is very beneficial to escape from local optima. In the simulation experiment, the value of w is adaptive in [0.3, 0.9].

2) *Learning factors c_1, c_2:* Learning factors c1, c2 determines the impact of individual extremes and population extreme for the current speeds of the particles in PSO algorithm. In the simulation experiment, the values of c1 c2 are 1.

3) The fitness function of PSO: In this paper, use PSO algorithm to optimize BP neural network initial weights and thresholds. So use the BP network training mean square error function E as the fitness evaluation function of particles.

E. Description and analysis of the experimental results

BP algorithm and PSO-BP algorithm use some historical data of campus network to train neural network, predictive and analysis the network traffic of a period of time. In the conventional BP neural network algorithm, the initial weights and thresholds values are (-0.05, 0.05), Algorithm uses

the adaptive learning rate and momentum. In the conventional BP algorithm, the initial weights and thresholds values are Random values in (-1, 1). Using PSO algorithm to optimize the values of weights and thresholds, and the weights and thresholds are used as the initial values to train the conventional BP neural network.

Figure 1 and Figure 2 are the results of network traffic prediction of conventional BP neural network algorithm and PSO-BP algorithm, the MSE of BP neural network algorithm is 0.0096, and MSE of PSO-BP algorithm is 0.0036. Comparative analysis, you can find that the accuracy of PSO-BP algorithm is higher than the accuracy of conventional BP neural network algorithm. PSO-BP algorithm has higher prediction accuracy, and shows a better performance of network traffic prediction.
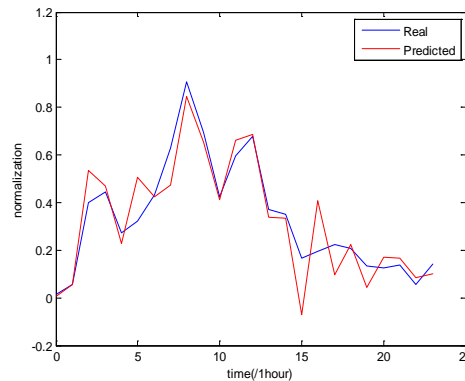

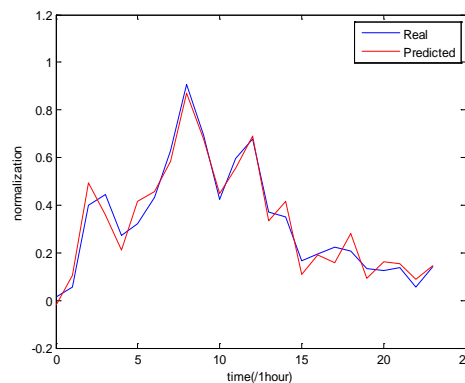Figure 1. Conventional BP neural network algorithm prediction results

Figure 2. PSO-BP algorithm prediction results

When the training goal is 0.008 in the simulation, Figure 3 is the BP neural network algorithm training error curve, the figure shows that training times is 174 times to reach the goal. Figure 4 is PSO-BP algorithm training error curve, the figure shows that training times is 47 times to reach the goal. Comparative analysis, we can find that PSO-BP algorithm learning times is less than the conventional BP neural network. This shows that PSO-BP algorithm does improve the convergence speed of neural networks.
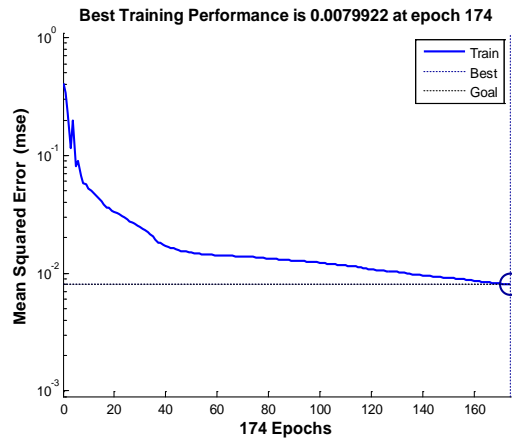
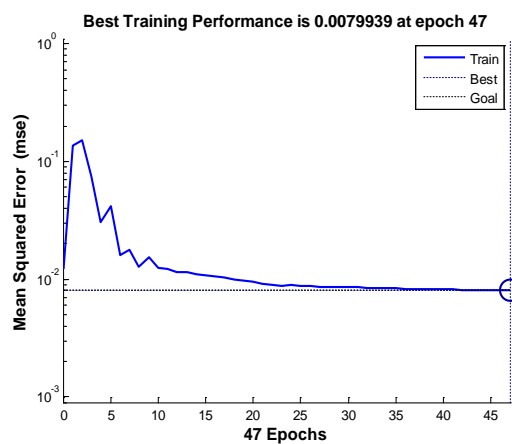Figure 3. Conventional BP neural network algorithm training error curve

Figure 4. PSO-BP algorithm training error curve

Summary

PSO-BP algorithm overcomes the defects of the BP neural network such as slow convergence speed and easily falling into local minimum point. It improves the prediction accuracy and accelerates the convergence speed of the network. PSO-PB algorithm is feasible in network traffic prediction, it provides a more excellent way for network traffic prediction.

References

[1] Zhao Zhenjiang. Prediction and rearch on network traffic based on PSP-BP neural Network.Computer Applications and Software[J], 2009(01).

[2] Berghf V D, Engelbrecht A P. Cooperative learning in neural using particle swarm optimizers. South African Computer Journal, 2000, 26(11): 84-90..

[3] Zhang J R, Zhang J, Lok T M, et al. A hybrid particle swarm optimization-back-propagation algorithm for feedforward neural network training.Applied Mathematics and Computation, 2007,1026-1037.

[4] Hecht Nielsen R. Neurocomputing[M]. Addison Wesley, 1990.

[5] Qi Dehu Kang, Jichang. On Design of the BP Neural Network.Computer Engineering and Design[J]. 1998(02).

[6] Shi Y, Eberhart R C. A modified particle swarm optimizer. Proceedings of the IEEE Conference on Evolutionary Computation, 1998:69-73.

[7] lu guohao. research and realization of Network Flow prediction System[D]. Soochow University. 2007.