

# 17 Research on the technique diagnosis model based on artificial neural network in table tennis

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## 1 Introduction

Since the 1980s, the theory of the artificial neural network has become mature gradually and has made the plenteous achievement in many fields. In recent years, the application of the artificial neural network has gone deep into many fields. Compared with the traditional methods such as estimation, forecast and decision-making etc., mathematics models dose not need to be designed. We can establish a model only according to input and output of data. The interior information of the network is saved in a mass of power matrices. Possessing the unique power of self-adaptation, self-organization and self - training, the network has a bright future in complexly nonlinear field and undefined physical athletical system.

## 2 The theory of artificial neural network

The artificial neural network is a system of information process, the purpose of which is imitating structure and function of human brain. The network is a great deal of artificial nerve cell combined extensively with each other. Artificial nerve cell is a mathematical model of imitating the living creature nerve cell. And each artificial nerve cell will accept information from all the others which offer the power data and connect with it. A total power value added up the entire power datum is compared with the artificial nerve cell one by one, if it is more than cell's bias number being the inherent number in the cell, the cell is activated and its signal is delivered to the next-layer nerve cell connected with it.

Currently, the artificial neural network has lots of varieties used for the different purposes. Among them BP network, short for back-propagation, is one of the most noticeable and the most extensive neural network used at present. It is capable of self-adaptation, self-organization, self-training, simulation and prediction. The construction diagram of BP network is shown below:

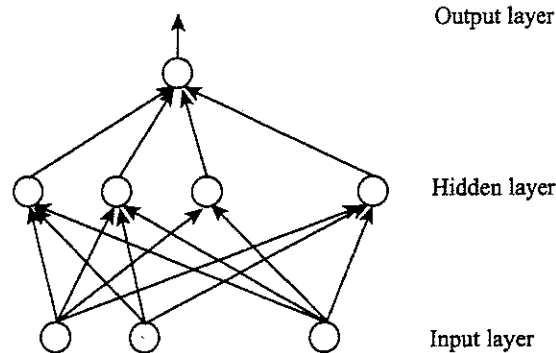


Figure 1. construction of BP network

To each nerve cell, its input and output's data relation is as follows:

$$\text{net}_{i,k} = \sum W_{i,j,k} O_{i,j,k-1} - \theta_{i,k}$$

$$O_{i,k} = f(\text{net}_{i,k})$$

Among them,  $j$  ( $j = 1, 2, \dots, n$ ) is a number about nerve cell in each layer;  $O_{i,k}$  is the output data about No.  $i$  cell in the  $k$  layer;  $\text{net}_{i,k}$  is the input data about No.  $i$  cell in the  $k$  layer;  $W_{i,j,k}$  is the power data between No.  $j$  in the  $k-1$  layer and No.  $i$  in the  $k$  layer;  $f(\cdot)$  is the delivering function which generally adopts the linear function or the function of sigmoid.

BP's training procedure is composed of propagation and back-propagation. In course of propagation, importation from the input layer spreads one by one to the hidden layer by means of the delivering function. And then if one cell is activated, its power value spreads to output layer also by the delivering function. State of every layer nerve cell only affects the next layer nerve cell. If we can not get the expected exportation at the output layer, the process turns into back-propagation. The errors between the actual data and simulating output data will return along the original conjunction path. During this course, each power datum of each layer nerve cell is amended by means of the training function in order to make the error smaller. This training process does not stop cycling again and again until the error is smaller than the one that was given beforehand. Thus we acquire BP neural network and the covered power matrix.

It is important to choose the structure of network model. If it is done well, we can reduce the cycled times of network training and improve the accuracy; whereas, it may cause the failure in the network train. The BP structure is related to how many the nerve cells of the input layer, the output layer and the hidden layer are offered, which delivering function is fit and training function of the network BP can be used.

### 3 Methods

#### 3.1 Participants

The Subject was the excellent ping-pong player Wang Liqing, who was the

first at men's doubles in 2000 Sydney Olympic Games, the champion of men's singles in the 46th Table Tennis World championships in 2001, and the third place in men's singles of 2004 Athens Olympic Games.

### 3.2 Procedure

(1) Wang Liqing's 23 matches, which have been played at domestic and international games from 2003 to 2004, were selected at random. They were divided into two groups. 20 matches were used for establishing the diagnosis network model; the others were for examining the model.

(2) The BP neural network was adopted and the model was built. A special tool of Matlab7.0 software was used to complete all calculations.

## 4 Results

### 4.1 Building of the table tennis technique diagnosis model

The diagnosis network model adopted three layers of BP network. Data of input layer which had 6 nerve cells were six indexes which were selected according to the traditional skill analysis method of the ping-pong match. These are scoring rate of the phase of attack - after - service (AAS), scoring rate of the phase of reception, scoring rate of the phase of rally, using rate of the phase of AAS, using rate of the phase of reception, and using rate of the phase of rally. Data of output layer which had only 1 nerve cell were winning probability of Wang Liqing and hidden layer which had 18 nerve cells. The delivering function of every nerve cell was Purelin(*n*) function. The training function of network was Levenberg - Marquardt.

### 4.2 Calculation of model

The calculation of the process of the neural network was very big. Here we made use of the Matlab7.0 software to build the diagnostic model. Its procedure was as follows:

$p =$

Columns 1 through 11

0.6000	0.6875	0.6667	0.5652	0.5294	0.7500	0.7273
0.6250	0.8000	0.7778	0.7000			
0.3333	0.6316	0.5278	0.5385	0.4333	0.5000	0.6000
0.4688	0.4444	0.5263	0.3750			
0.4565	0.4583	0.5000	0.4483	0.5909	0.6316	0.7037
0.5000	0.5200	0.6842	0.5526			
0.1765	0.2712	0.2903	0.2949	0.1868	0.2909	0.2292
0.2500	0.2586	0.1915	0.2439			
0.2824	0.3220	0.3871	0.3333	0.3297	0.3636	0.2083

```
0.3333 0.3103 0.4043 0.2927
0.5412 0.4068 0.3226 0.3718 0.4835 0.3455 0.5625
0.4167 0.4310 0.4043 0.4634
```

Columns 12 through 20

```
0.6190 0.7368 0.6471 0.5556 0.6757 0.6774 0.5714
0.5789 0.6087
0.6364 0.4444 0.3548 0.3200 0.4375 0.3243 0.5135
0.5926 0.4667
0.5769 0.4545 0.5806 0.5778 0.3696 0.4595 0.6333
0.5217 0.4667
0.3043 0.3333 0.2152 0.2748 0.2824 0.2981 0.2947
0.2754 0.3382
0.3188 0.4737 0.3924 0.3817 0.3664 0.3558 0.3895
0.3913 0.4412
0.3768 0.1930 0.3924 0.3435 0.3511 0.3558 0.3158
0.3333 0.2206 % to train the imported data of the sample
```

t =

Columns 1 through 11

```
0.4607 0.5738 0.5567 0.4819 0.5161 0.6071 0.6600
0.5204 0.5763 0.6471 0.5357
```

Columns 12 through 20

```
0.6081 0.4809 0.5556 0.5122 0.4769 0.4808 0.5889
0.5652 0.5147 % to train the exported data of the sample
```

Net = newff (minmax (p), [18,1], {'purelin', 'purelin', 'trainlm'}); % to establish the nerve network construction

Net.trainParam.show = 5;

Net.trainParam.epoch = 5;

Net.trainParam.goal = 1e-4; % to establish training parameter

Net the = train (net,p,t) % to train the neural network

### 4.3 Relation between times and error in the model

Acquiring the relationship between the errors of training and the times of training were shown in figure 2.

In the figure, these coordinates showed that x - axis was training times (epochs) and y - axis was training error. Here we supposed that the expectation of the error accuracy was  $10^{-4}$ . While the training was merely the third time, the error had arrived at steady state. Its value was about 0.00063 and closed to the accuracy expected. It revealed that the model established was nearly ideal and had good stability.

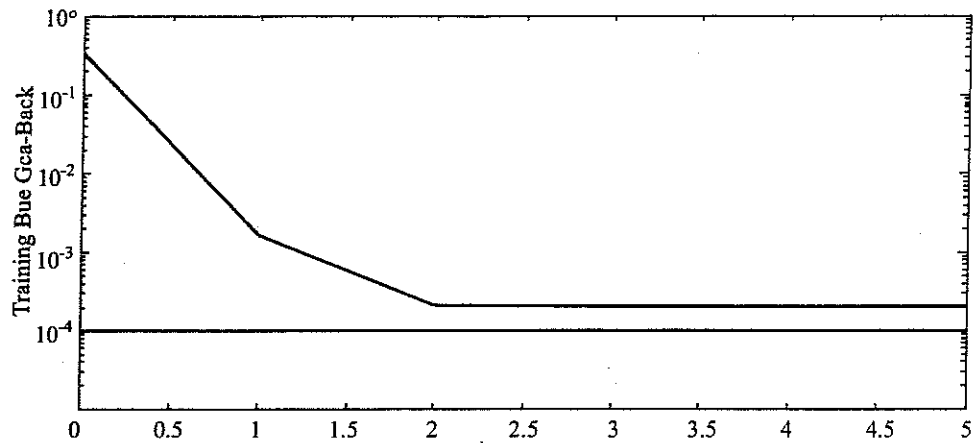


Figure 2. Relation about the errors and the times

#### 4.4 Accuracy of the model

The rest data about Wang Liqing's 3 matches were put into the neural network model.

q =

0.6897 0.6667 0.7037

0.4848 0.5476 0.3438

0.4483 0.4074 0.6308

0.3187 0.2195 0.2177

0.3626 0.3415 0.2581

0.3187 0.4390 0.5242 % Used for the imported data of the exami-

nation model

r =

0.5376 0.5122 0.5351 % Used for the exported data of the examina-

tion model

Acquiring the difference between actual data and simulating data were shown in table3.

Table 1 expresses the error was very small between actual data and simulating data on the winning probability of Wang Liqing. Its maximum was 0.02996 and minimum was 0.00417. Above technique diagnosis model established according to the method was successful and could be used for forecasting the achievements that had certain accuracy.

Table1. Comparing actual data with simulation data

	Match 1	Match 2	Match 3
Actual data	0.53763	0.51219	0.53509
Simulation data	0.51732	0.51261	0.56504
Error	0.02032	-0.00417	-0.02996

## **5 Discussion**

Above research made clear that we could gain a good technique diagnosis model based on artificial neural network in table tennis. After establishing the technique diagnosis model, according to the technique level of that player we could pertinently increase or reduce a certain index data of a match, and then the data were put into existent network model. The simulating data will appear. Consequently we could find out the most important factor influencing achievements of that player. These would provide the basis of the theory on the player's creating achievements.

Another feature of the artificial neural network was to enable network to reserve the internal information of existent network model in a mass of power matrices. When skill of the athlete changed, recent data came into being. Only when we required to input new data and to train the artificial neural network again, could we still establish the new model based on the existent model. The model appeared to the latest technique and achievements of the player. Meanwhile, the past achievements were still saved.