Available online www.jocpr.com

Journal of Chemical and Pharmaceutical Research, 2014, 6(6):228-235

Research Article

ISSN : 0975-7384
CODEN(USA) : JCPRC5

Neural network-based athletics performance prediction optimization model applied research

Lei Song[1], Minggang Shen[1], Xuebo Chen[1] and Junsheng Wang[2]

[1]*School of Electronic and Information Engineering, Liaoning University of Science and Technology, Anshan, Liaoning, China*
[2]*Anshan Iron and Steel Corporation, Anshan, China*

ABSTRACT

There are many factors affect athletics competition, so it needs better prediction model to make prediction on athlete each event performance, the paper just based on such thought, it introduces BP neural network model, RBF neural network model and Elman neural network model, after comparing, it gets that BP neural network of the three has higher accuracy, in addition, by combining the three kinds of neural network models and then introduces it into specific examples, it gets that model after combining accuracy is higher than any one kind of single prediction model, so it proves such model's superiority, it will play important driving roles in neural network's sports performance prediction development.

Key words: neural network, prediction model, sports performance, nerve cell

---

INTRODUCTION

According to previous performance, it makes prediction on performance that to be generated, it is generally used to major sporting events, predict future sports competitive levels is particular more important for athlete being in best training level, so the sports performance prediction becomes more and more important, but there are many kinds of modern prediction methods, from which neural network is more popular in contemporary prediction and analysis aspect.

Regarding sports aspect each kind of events predicted research, formers have made efforts, such as: Wang Hao and others in order to improve sports performance prediction accuracy, it combines BP neural network with RBF to make prediction on Liu Xiang's performance, and finally got that model after combination was obvious higher than single prediction model before combination; Zhong Wu and others constructed shot special performance prediction in 2004, meanwhile they got that its accuracy is obvious higher than multiple linear regression model.

The paper based on previous research results, it analyzes sports performance influence factors, and by three kinds of neural network prediction model's mutual combination to predict sports performance, the result proves that combined prediction model is more accurate than single model, and shows established combinative neural network prediction model has important significance in sports aspect performance researching.

2 Three kinds of prediction models forming

2.1 BP neural network theoretical forming

In prediction field, neural network is one kind of higher applications, from which the most important belongs to forward neural network that is also BP neural network model, the model is composed of three kinds of forms that are output layer, input layer and hidden layer such three kinds, its structure is as Figure 1 show:

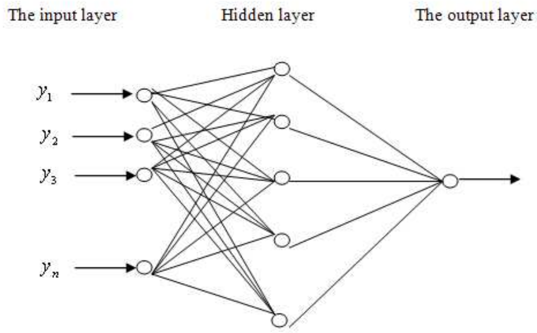

Figure 1: BP neural network structure

Though there are no any connections among them, their nerve cells are mutual correlated. The algorithm learning process is composed of two directions that are respectively forward direction process and reverse such two propagation processes, from which, forward propagation is:

$$net_{jk}^{l} = \sum_{j} \omega_{jk}^{l} o_{jk}^{l-1} \tag{1}$$

In above formula, $l-1$ represents number of layers, is expressed by o_{jk}^{l-1}, and when output j pieces of units nodes, the input is the k sample, then:

$$o_{jk}^{l} = f(net_{jk}^{l}) \tag{2}$$

Reverse propagation:

 If input unit node is j, then:

$$o_{jk}^{l} = \overline{y}_{jk} \tag{3}$$

Among them, use j as actual output unit which is expressed by $\overline{y}_{jk}$.

$$\delta_{jk}^{t} = -(y_k - \overline{y}_k) f^{/}(net_{jk}^{t}) \tag{4}$$

 If input unit node is not j, then:

$$\delta_{jk}^{t} = \sum_{m} \delta_{mk}^{l+1} \omega_{mj}^{l+1} f^{/}(net_{jk}^{t}) \tag{5}$$

$$\frac{\partial E_k}{\partial \omega_{ij}} = \delta_{jk}^{l} o_{jk}^{l-1} \tag{6}$$

Revise weight:

$$\omega_{ij} = \omega_{IJ} - \mu \frac{\partial E}{\partial \omega_{ij}}, \mu \succ 0$$

Here:

$$\frac{\partial E}{\partial \omega_{ij}} = \sum_{K=1}^{N} \frac{\partial E}{\partial \omega_{ij}} \tag{7}$$

Among them, the process from input layer to hidden layer and then transfer to output layer is information forward direction propagation, but once end cannot get corresponding output result, it will automatically turn to reverse propagation; one nerve cell k is expressed by following formula.

$$u_k = \sum_{t=1}^{m} w_{ik} x_t \tag{8}$$

$$y_k = f(u_k + b_k) \quad (9)$$

Among them, in linear combination, input signal's output, nerve cell threshold value are respectively using u_k and b_k to express, input signal and output signal are respectively using x_k and y_k to express, w_{ik} represents protruded weight, and meanwhile activated function is $F()$, corresponding function formula is:

$$f(v) = \frac{1}{1+e^{-v}} \quad (10)$$

Due to BP neural network nerve cell does not change, input end is :

$$net = x_1 w_1 + x_2 w_2 + \cdots + x_n w_n \quad (11)$$

In above formula, connection weight value: $w_1, w_2, \cdots, w_n$, Input value: $x_1, x_2, \cdots, x_n$ 。

These nerve cells all activated functions use S type function, the function not only is continuous but also can derive.

Define that between 0 and 1 is BP neural network node value, if input information hasn't arrived at hidden layer, then the node is 0, so as to avoid the fault status, we adopt standardization handling with these original data, adopt:

$$1 = \sqrt{m = n} + a \quad (12)$$

Hidden point initial number value can be defined by formula (2), that is:

$$1 = \sqrt{0.43nm + 0.12n^2 + 2.54m + 0.77n + 0.35 + 0.51} \quad (13)$$

Among them, in above two formulas, a is a constant, and is a number between 1and 10, n, m are the number of output and input nodes. We work out an initial value by formula (1), and then solve it gradually, after that, adopt:

$$x_i^{'} = \frac{x_i - x_{\min}}{x_{\max} - x_{\min}} \quad (14)$$

Only need to do normalization processing.

For the model, take one sports school triple jump relative data as examples references, and let x_1 to be final 5m running-up instant speed, x_2 to be horizontal speed before taking off, x_3 is maximum running-up speed, x_4 is distance between starting point and position at this time when running-up arrives at maximum value, y represents triple jump final results, as following Table 1show:

Table 1: Triple jump performance indicator

No	$x_1/(m\cdot s^{-1})$	$x_2/(m\cdot s^{-1})$	$x_3/(m\cdot s^{-1})$	$x_4/(m\cdot s^{-1})$	y/m
1	9.69	9.71	9.61	1.00	16.02
2	9.65	9.84	9.84	3.90	16.03
3	10.05	10.02	9.83	0.00	16.04
4	10.04	9.74	9.94	4.90	16.05
5	9.90	9.91	9.89	2.00	16.11
6	10.44	10.21	10.35	1.00	16.12
7	10.06	10.06	10.01	1.00	16.15
8	9.74	9.74	9.58	0.00	16.18
9	10.98	9.75	9.94	4.00	16.19
10	9.90	9.76	9.79	4.90	16.21
11	10.10	9.94	9.95	2.00	16.22
12	10.26	10.02	10.11	2.00	16.27
13	9.78	9.60	9.66	1.90	16.30
14	9.97	9.98	9.94	0.00	16.40
15	9.39	9.25	9.33	1.90	16.40
16	10.00	9.66	9.92	1.90	16.40
17	9.65	9.65	9.49	0.00	16.41
18	10.13	10.12	9.96	2.10	16.44
19	10.11	10.06	9.94	1.00	16.46
20	10.12	9.99	9.97	3.00	16.50
21	9.76	9.50	9.59	1.90	16.56
22	9.87	9.66	9.73	4.90	16.60
23	10.08	10.02	9.98	1.00	16.60
24	9.80	9.80	9.80	0.00	16.60
25	9.92	9.89	9.89	4.00	16.68

By utilizing principal component analysis method, it handles with above table and gets corresponding indicators' feature values that are respectively:

λ_1=3.2047 、λ_2=0.1867 、λ_3=0.0735, by above table, it can get that space curve is:

$$\begin{pmatrix} x_1 \\ x_2 \\ x_3 \end{pmatrix} = \begin{pmatrix} 9.94 \\ 9.84 \\ 9.84 \end{pmatrix} + \begin{pmatrix} 0.592 \\ 0.573 \\ 0.567 \end{pmatrix} \quad (15)$$

floating around, so above three kinds of indicators have great connections, therefore we can use x_1, x_4 as input function, then y is output, according to BP algorithms to train, its training samples select 20 indicators to make research, as following Table 2 and Table 3 show:

Table 2: Test sample

P	x_1	x_2	y	P	x_1	x_2	y
1	9.72	1.00	16.01	11	9.65	0.00	16.30
2	9.63	3.90	16.01	12	10.00	1.90	16.40
3	10.03	0.00	16.03	13	10.13	2.10	16.41
4	9.91	4.90	16.11	14	10.11	1.00	16.44
5	10.06	2.00	16.12	15	10.11	3.00	16.46
6	10.10	1.00	16.18	16	9.78	1.90	16.50
7	9.91	2.00	16.27	17	9.87	4.90	16.56
8	9.48	0.00	16.30	18	9.80	0.00	16.60
9	10.26	1.90	16.30	19	10.08	1.00	16.60
10	10.28	2.00	16.30	20	9.93	4.00	16.68

Table 3: Test sample actual result

p	21	22	23	24	25
$x_1^p/(m\cdot s^{-1})$	9.75	10.46	10.10	10.08	9.92
x_4/m	0.00	1.00	1.90	4.00	4.90

Before training, it should firstly make transformation, make standard deviation as 1 and mean as 0 transformation on variables in above table, and then make training, after training for 29452 times, its weight threshold value, weight can be solved as following show :

$$W_1 = \begin{pmatrix} -15.6451 & -0.4756 \\ -0.1846 & 1.2356 \\ 2.0999 & 0.0473 \\ 3.7347 & -0.1751 \\ -1.3145 & 3.6582 \\ -3.6762 & -0.4139 \\ -40.2941 & -3.1100 \\ -15.0159 & -0.3060 \\ -0.4765 & 0.1815 \\ 3.4593 & -0.1150 \\ 7.4356 & -0.4526 \\ 3.2966 & -0.1193 \\ -11.0789 & -0.9087 \\ -6.2950 & 0.0598 \\ 3.6456 & 0.4064 \\ -10.9287 & 1.9648 \\ -4.1478 & -0.3478 \\ -4.1371 & -0.4456 \\ -17.6541 & -0.5216 \\ -1.1597 & 0.4789 \end{pmatrix}, \quad b_1 = \begin{pmatrix} 154.2235 \\ -2.5589 \\ -35.1447 \\ -20.5241 \\ 5.2589 \\ 40.1236 \\ 412.7895 \\ 123.4789 \\ 325.1121 \\ 4.1124 \\ -36.1665 \\ -80.5896 \\ -40.4587 \\ 124.1189 \\ 68.5588 \\ -35.6969 \\ 110.2256 \\ 42.0987 \\ 180.2258 \\ 24.1456 \end{pmatrix} \quad W_2 = \begin{pmatrix} 0.6010 \\ 0.3320 \\ 0.0852 \\ 0.2015 \\ 0.7994 \\ 0.2465 \\ 1.3965 \\ -0.3726 \\ 1.1258 \\ 0.0426 \\ -1.1256 \\ 0.2100 \\ 0.3621 \\ 0.4546 \\ 0.1980 \\ -0.2427 \\ -0.6889 \\ -0.2654 \\ -0.3098 \\ 0.5521 \end{pmatrix}$$

$$b_2 = (16.6528)$$

After solving threshold value and weight, input above Table 3 sample into neural network model, and then get result as following Table 4 show:

Table 4: Output result

Network input		Network output $y\,/\,m$	Expected output $y^p\,/\,m$	Error $/cm$
$x_1\,/\,(m\cdot s^{-1})$	$x_4\,/\,m$			
9.74	0.00	16.245	16.17	3.4
10.43	1.00	16.08	16.14	-5.8
9.38	1.90	16.362	16.38	-1.7
10.08	4.00	16.223	16.21	1.6
9.94	4.90	16.250	16.25	0.0

By above Table 4, we can see that the first and second test result have big differences, and final kind error is zero, so it proves that lots of data is needed to more accurately deduce prediction result and then being more accurate, meanwhile it also proves that the model has certain superiorities.

2.2 RBF neural network model

The model similarly is composed of above three forms, its structure is as following Figure 2 show:

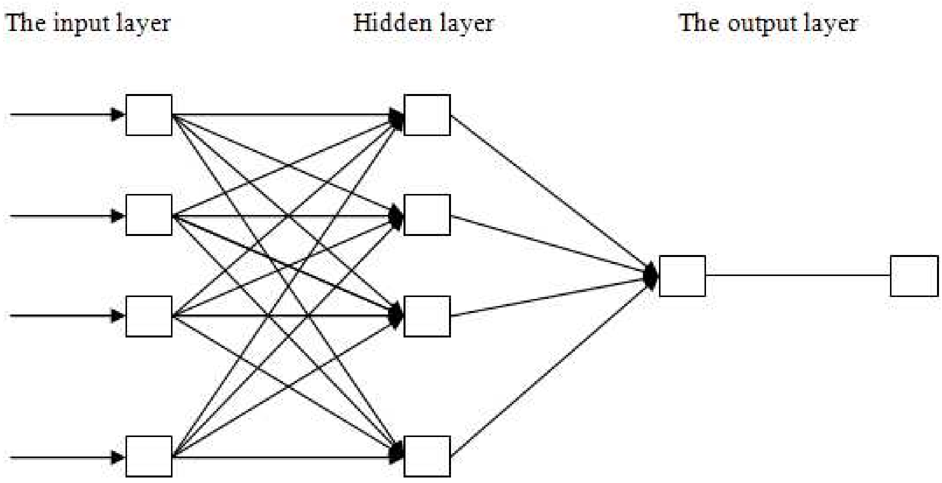

Figure 2:RBF neural network structure

The model can create a very high precise model, and its hidden function is self selected, so that its error is 0, and then previous k times of performance is $x_1, x_2, \cdots x_k$, output is performance at this time.

2.3 Elman neural network model

The model is relative special, its structure is composed of four elements that are output layer, undertake layer, hidden layer, input layer, and its output layer includes one nerve cell, input layer includes six nerve cells, hidden layer is defined as seventeen nerve cells, its structure is as following Figure 3 show:

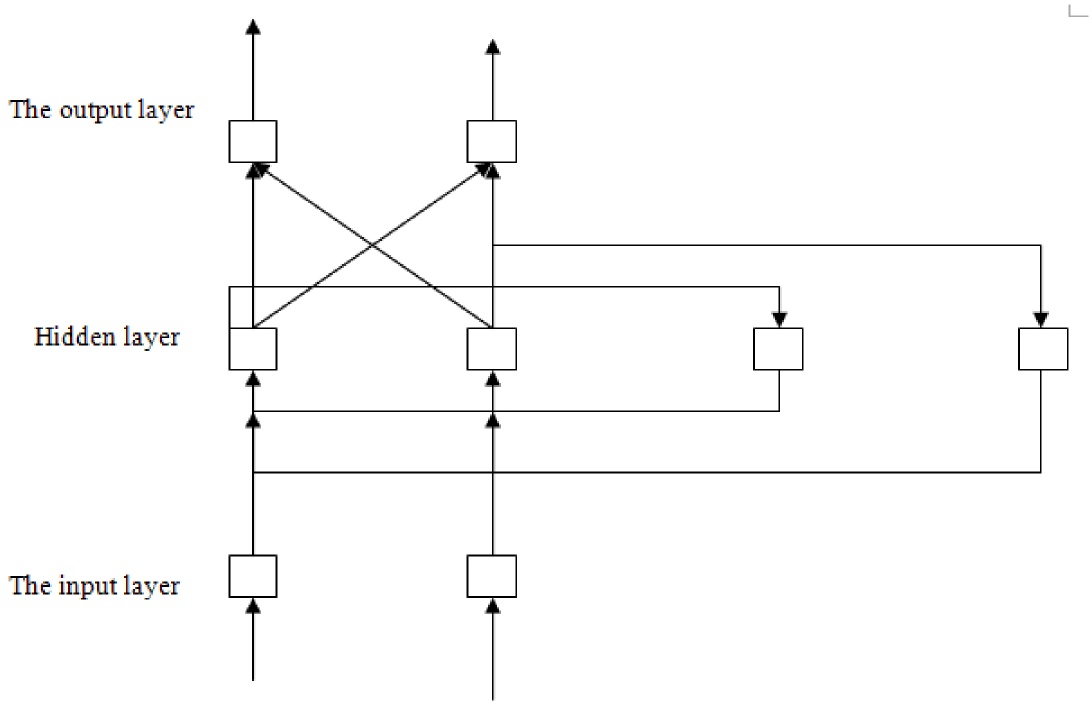

Figure 3:Elman neural network model

3 Model combinations

We let f_1 f_2 f_3 respectively represent above three kinds of neural network prediction model, and establish the three mutual relations' equation :

$$f = \alpha f_1 + \beta f_2 + \gamma f_3 \tag{16}$$

In above formula, coefficients respectively represents three kinds of prediction models weights, it can solve such value by establishing following formula that:

$$\min f = \sum_{i=1}^{h} \left(y_i - \alpha f_1 - \beta f_2 - \gamma f_3 \right)^2 \quad (17)$$

Among them, in above formula:

$$s,t \begin{cases} \alpha + \beta + \gamma = 1 \\ 0 \le \alpha, \beta, \gamma \le 1 \end{cases} \quad (18)$$

So, combining above formula with one school athletes' competition performances, it can solve their weights, their competition performances as following Table 5show:

Table 5: Athletes' competition performances table

No.	Actual performance	No.	Actual performance	No.	Actual performance	No.	Actual performance
1	13.45	18	13.12	35	13.21	52	12.93
2	13.32	19	13.19	36	13.08	53	13.03
3	13.45	20	13.20	37	13.05	54	13.04
4	13.33	21	13.24	38	13.11	55	12.91
5	13.36	22	13.18	39	12.86	56	12.89
6	13.12	23	13.17	40	12.84	57	13.11
7	13.75	24	13.19	41	13.19	58	13.04
8	13.27	25	12.24	42	13.17	59	12.82
9	13.87	26	13.21	43	13.21	60	13.23
10	13.22	27	13.31	44	12.96	61	12.79
11	13.20	28	13.26	45	13.02	62	13.18
12	13.15	29	12.97	46	13.08	63	13.19
13	13.24	30	12.89	47	12.65	64	13.20
14	13.26	31	13.45	48	12.84	65	12.95
15	13.23	32	13.29	49	13.34	66	13.23
16	13.21	33	12.78	50	13.28	67	13.01
17	13.33	34	13.14	51	12.87		

So we input above data into combined model, it can solve three kinds of models weights, that: α=0.463、β=0.243、γ=0.294, thereupon we can get combination model is:

$$f = 0.463 f_1 + 0.243 f_2 + 0.294 f_3 \quad (19)$$

3.1 Establish optimal combination prediction model

We let sample actual value use y_i to express, predicted value use y_{it} $t = 1, 2, \cdots n$ to express, its equation is :

$$y_i = a + \sum_{i=1}^{n} b_i y_{it} \quad (20)$$

After that, use linear regression method, it can respectively solve above coefficients, and then solve their predicted value, its formula is:

$$y_{i+1} = a + \sum_{i=1}^{n} b_i y_{it+1} \quad (21)$$

3.2 Prediction model result and analysis

We let y to represent actual performance, and x_i to represent predicted performance, from which $i = 1, 2, \cdots 10$, and establish mean absolute percentage error(MAPE), that:

$$MAPE = \frac{1}{n} \left| \frac{x_i - y_i}{y_i} \right| \times 100\% \quad (22)$$

By above formula, input data and then it can get combination model's prediction fitting value, as following Table 6 show:

Table 6: Prediction result comparison

No.	Actual performance	First kind of network prediction		Second kind of network prediction		Third kind of network prediction		Optimal weighting combination		Optimal linear combination	
		Predicted value	MAPE	Predicted value	MAPE	Predicted value	MAPE	Predicted value	MAPE	Predicted value	MAPE
1	13.12	13.0522	0.547	13.1256	0.743	13.0522	0.7896	13.1106	0.565	13.0698	0.562
2	12.98	13.0845		13.0626		13.0546		13.1018		13.1104	
3	13.25	13.0911		13.1212		13.1304		13.1245		13.0754	
4	13.01	13.1232		13.1826		13.0908		13.0948		13.1199	
5	13.28	13.1947		13.0988		132.0711		13.1298		12.9858	
6	13.18	12.0517		13.0836		13.0739		13.0659		13.0748	
7	13.19	13.0294		13.2144		12.9877		12.9598		13.1374	
8	13.21	13.1366		13.0683		13.2632		13.0877		13.1320	
9	13.23	13.1474		13.1362		13.0867		13.1078		13.0676	
10	13.15	13.0433		13.1244		13.0546		13.1047		13.0777	

By above Table 6, we can get three kinds of neural network prediction methods' maximum error values that are differences between actual results and predicted results, so that it can get that in three kinds of neural network prediction methods, BP neural network predicted value and actual value difference is minimum, therefore it proves BP neural network is a kind of relative accurate prediction method, and combination model after handling has better efficiency in prediction than single model.

CONCLUSION

The paper predicts athletes' performances, their performances prediction is affected by lots of factors, we utilize three kinds of network prediction methods to evaluate individual prediction that shows BP neural network has obvious superiorities and good prediction efficiency, in addition, we combine the three prediction ways, and get optimal combination pattern after handling, and after optimal weighting, it can let the combination model has much higher accuracy than single model, so the combined prediction model has feasibilities.

REFERENCES

[1] ZHU Hong-bing, LIU Jian-tong, WANG Gang, etc, . *Journal of Capital College of Physical Education*, **2003**, 15(1):118-121.
[2] WANG Wei. *Journal of Nanjing Institute of Physical Education*, **2004**, 18(6):85-87.
[3] ZHAO Yun hong, ZHOU Yao. *China Sport Science and Technology*, **2002**, 38(2):39-40.
[4] CHEN Liang, SAI Qing-bin. *Journal of Capital College of Physical Education*, **2006**, 18(5):85-88.
[5] SONG Ai-Ling, CHEN Kai. *Journal of Capital College of Physical Education*, **2003**, 15(4):68-69, 116.
[6] CHEN Liang, TIAN De-bao. *Journal of Capital College of Physical Education*, **2006**, 18(6):127-128.
[7] Tong Liping, Yuan Jianguo.GM(1, 1).*Journal of Shanghai Physical Education Institute*, **2001**, 25(2):44-47.
[8] LIU Jia-jin. *Journal of Guangzhou Physical Education Institute*, **2006**, 26(2):54-56.
[9] LIU Jia-jin et al. *Zhejiang Sport Science*, **1999**, 21(1):60-64.