Available online www.jocpr.com

Journal of Chemical and Pharmaceutical Research, 2014, 6(7):937-942

Research Article

ISSN : 0975-7384
CODEN(USA) : JCPRC5

BP neural network-based shot putters performance prediction research

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ABSTRACT

With sports rapidly development, especially for 2008 Olympic Games successfully hosted, it let each kinds of sports undertakings attracts much attention, from which shot becomes the focus issue, many scholars' researches on the event are even countless. The paper based on the thought, it utilizes neural network model to make prediction on shot putters, after stating BP neural network theory, and then combines it with practice, it gets prediction on future development trend, so it proves the model validness and rationality.

Key words: neural network, prediction model, sports performance, shot putter, physiological factor

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INTRODUCTION

According to previous athletes performance, it makes prediction that not only has impacts on small sports competitions, but also plays irresistible huge positive roles in Asian Games, National Games and even Olympic Games, in addition it also provides references for coaches, athletes' training, so the prediction model plays an essential role in previous sports competitions [1-5].

Regarding sports aspect each kind of events prediction correlation research, lots of scholars have made efforts, and provided impetus for its scientific prediction development. Such as, Zhang Yu and others, they made prediction on sports performance based on neural network, proposed that took men's 100m and others several items athletics performance, by applying BP algorithm and correlation software ,they handled with the data, and predicted sports performance in next two years, got the algorithm applicability and feasibility, and summarized BP neural network had strong ability in range of application and higher precise [6-9]; Wang Zong-Ping and others, they made prediction on men's swimming by neural network and got higher precise.

The paper just on the basis of previous research , it makes comparison by applying least square method, multiple regression and neural network, and finally gets scientific conclusion that neural network prediction efficiency is best.

NEURAL NETWORK THEORY CONSTITUTIONS

Regarding sports aspect performance, it can be divided into two kinds, in general , total performance is athlete's general quality performance and special performance, but the two often appear uneven status, now it needs BP neural network model to explore their mutual relations, so it forms into neural network model, after relative training, only input sports performance prediction into the neural network model then we can calculate total performance, and improve performance prediction accuracy in this way [10, 11].

Neural network includes single layer neural network and multi-layer neural network, the two is connected by nerve cell, and it is as following Figure 1 show:

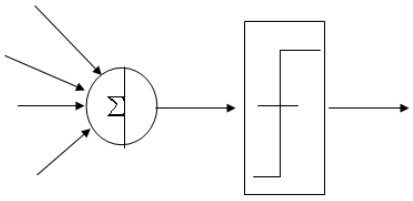

Figure 1: Neuron model

Establish output layer, input layer and hidden layer three kinds of patterns BP neural network model, its structure is as Figure 2 show:

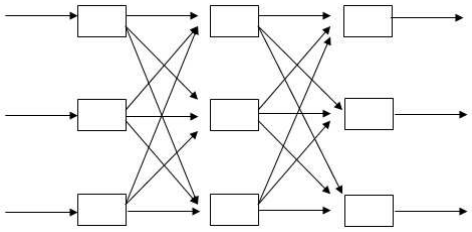

Figure 2: Process of neural network theory

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 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:

①If input unit node is j ,then

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

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

$$\delta_{jk}^{l} = -(y_k - \bar{y}_k) f'(net_{jk}^{l}) \tag{4}$$

②If input unit node is not j ,then:

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

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

Revise weight

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

Here

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

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:

$$u_k = \sum_{i=1}^{m} w_{ik} x_i \tag{8}$$

$$y_k = f(u_k + b_k) \tag{9}$$

In above formula ,nerve cell unit threshold value is b_k , in linear combination, input signal output is u_k , output signal is y_k , protruded weight is w_{ik} , input signal is x_k ,and meanwhile activated function is $F()$, corresponding function formula is as following:

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

Due to BP neural network nerve cell does not change; Corresponding model is as Figure 3:

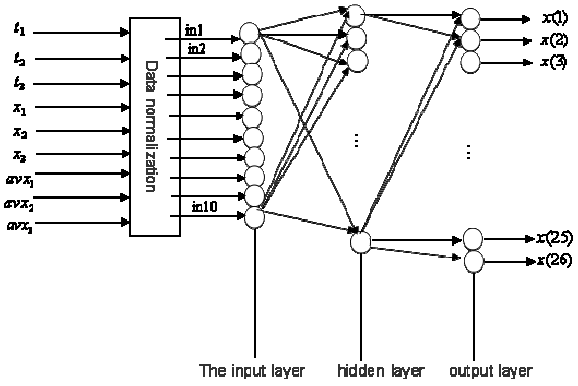

Figure 3: neural network operation process

For BP nerve cell, its input end is:

$$net = x_1 w_1 + x_2 w_2 + \cdots + x_n w_n \tag{11}$$

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.

BP NEURAL NETWORK LEARNING PROCESS

Neural network is mainly up to two aspects: model parameters, features, from which parameters include stopping , hidden layer, learning rate and other criterions, and the learning process is as Figure 4 show:

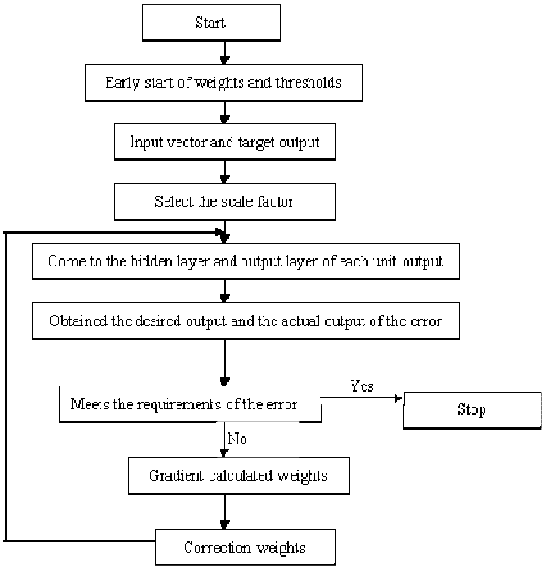

Figure 4: Learning neural network model

Neural network learning process starts implementing form initialized network, and then inputs the input layer into a training corresponding mode, after network transitive signal recognition, it defines output value size and automatically sets a matching minimum value, if error is out of the value , and then system will automatically circulate the function till error reduces to range.

Original data standardization process

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, therefore to avoid the fault status, we adopt standardization handling with these original data, adopt:

$$1 = \sqrt{m = n} + a \tag{12}$$

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

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

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 step by step.

Define error

Assume when outputs network, error value is:

$$E_K = \frac{1}{2}\sum_J (y_{jk} - o_{jk})^2 \tag{14}$$

We assume that $E = \sum E_K$ is the sum of the model whole process generated output errors, and in above formula, actual output value is o_{jlk} ,ideal output value is y_{jk} .

APPLY NEURAL NETWORK INTO SHOT PERFORMANCE PREDICTION THEORY RESEARCH MODEL

The paper selects world juvenile champion Mr. Lee as research object, the athlete physical quality and performance as following Table 1 show:

Table 1: Quality training level and special performance table

Years	2007	2008	2009	2010	2011	2012
Power clean/kg	56	60	77	90	95	99
Full squat/kg	82	100	130	140	145	155
Bench press/kg	52	60	80	87	89	105
Snatch/kg	42	52	55	61	65	70
4kg forward cast/m	14.50	13.78	14.80	16.40	17.10	17.80
4kg back cast/m	13.20	14.10	16.00	17.80	18.60	18.50
4kg in situ/m	12.50	12.80	14.10	15.40	16.00	16.40
3kg glide/m	15.60	16.80	18.50	19.20	19.80	20.90
30m/s	4.26	4.18	3.95	3.92	3.85	3.82
100m/s	14.17	13.77	12.91	12.70	12.60	12.40
Standing triple jump/m	7.30	7.20	7.50	7.85	8.20	8.30
Standing long jump/m	2.30	2.35	2.47	2.52	2.75	2.80
Special performance/m	13020	13.56	15.40	17.88	18.47	18.96

According to above Table 1 data, it makes relational degree analysis and correlation analysis on the athlete performance and quality training indicators, its corresponding result is as following Table 2 show:

Table 2: Quality training indicator and special performance correlation coefficient and relational degree

Quality training indicator	Correlation coefficient	Relational degree
Power clean/kg	0.9730	0.8711
Full squat/kg	0.9356	0.8302
Bench press/kg	0.9732	0.8206
Snatch/kg	0.9704	0.9125
4kg forward cast/m	0.9200	0.8521
4kg back cast/m	0.9028	0.8590
4kg in situ/m	0.9880	0.9702
3kg glide/m	0.9650	0.7633
30m running/s	-0.8960	0.8805
100m running/s	-0.8965	0.7412
Standing triple jump/m	0.9854	0.8695
Standing long jump/m	0.8863	0.9096

Establish neural network structure model

Firstly select 12 items physical quality training as input nerve cell amount, then use 1 to represent performance as output nerve cell amount, and nerve cell hidden layer is 20 that takes one layer, they are using linear function to transfer.

Take athlete previous performance as BP algorithm samples, utilize BP algorithm to carry out corresponding correlation learning, its essence is a process that optimizes neural network weights, so we design program for shot putters' neural network prediction model, input above previous data into the model, it gets the athlete special item performance, and then by utilizing least square method ,it makes fitting between previous special performance and physical quality training, and get corresponding function relations :

$$\begin{aligned} y &= 0.07x_1 - 0.29x_2 + 9.84x_3 - 3.57x_4 - 0.03x_5 - 0.06x_6 + 0.04x_7 + 0.21x_8 + 3.27x_9 - \\ &\quad 0.01x_{10} - 0.94x_{11} - 1.48x_{12} \\ &= 17.55 \end{aligned}$$

Input Table 1 performance into above model, it gets prediction model fitting precise table , as following Table 3 show:

Table 3: Prediction model fitting precise

Year	Actual value/m	Neural network model		Multiple regression model	
		Predicted value/m	Error/m	Predicted value/m	Error/m
2010	13.40	13.363	0.037	13.567	-0.167
2011	14.90	14.903	-0.003	15.208	-0.308
2012	15.65	15.641	0.009	16.095	-0.544
2013	17.80	17.805	-0.005	17.416	-0.384

For athlete corresponding sports performance in 2014 and 2015 such two years, apply multiple regression way to handle with predicted performance, meanwhile input the two years data into neural network above model, it can get the two years corresponding prediction performance and then get prediction precise as following Table 4 show:

Table 4: Prediction model predicted precise

Actual value/m		Neural network model		Multiple regression model	
		Predicted value/m	Error/m	Predicted value/m	Error/m
Year 2014	18.42	18.358	0.062	18.716	-0.296
Year 2015	18.63	18.790	0.160	18.98	-0.350

By above Table 4, we can see that multiple regression model is worse than BP neural network, so by comparison, it can see neural network model prediction precise is high that highlights neural network superiority.

CONCLUSION

(1) Regarding shot putters performance analysis, it suffers many factors impacts, we utilize BP neural network method to predict and analysis that overcomes disadvantages and drawbacks relative to least square method and multiple regression model, which shows obvious superiority.

(2) Due to neural network has self storing, organizing and learning abilities, it will bring great convenience for shot performance prediction that helpfully improves prediction model computing efficiency.

(3) The paper uses neural network to predict, the method provides beneficial evidence for coaches and athletes reasonable mastering its performance development, so provide important references for arranging scientific and reasonable athletes' training plans.

(4) The paper not only introduces shot putters' performance prediction BP neural network algorithm, but also it also applies practical examples to verify, its result shows the model structure rationality and precise.

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