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110m Hurdler competitive ability and performance prediction research based on fuzzy neural network

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ABSTRACT

Take Liu Xiang specific performance prediction as research object, on the basis of fuzzy neural network method, it collects 70 times' Liu Xiang 110m hurdle performance in 2000 to 2010 composing data set, establish fuzzy neural network prediction model after normalization processing of the previous 60 times' performance, and make prediction on final 10 times' performance. Result shows that the fuzzy neural network prediction method is effective, Liu Xiang 110m hurdle performance prediction is basic correct, it can provide theoretical reference for its training and even other excellent hurdlers' training.

KEYWORDS

Normalization process;
MATLAB;
Fuzzy neural network;
Prediction model.

INTRODUCTION

In competition readiness training, according to athlete concrete competitive ability indicators, it makes scientific prediction, and ensures realize training objectives with making clear, targeted, planned training to a great level that has very important practical significance. There are varieties of factors influence on competitive performance, for example, it can include athlete own training level, competitive state during competition, corresponding opponents' performance status, even court weather conditions and other all can affect athlete final performance, while to these factors, they don't have a clear link and present a kind of fuzzy and unclear state, therefore it is relative difficult to establish correct prediction model by adopting traditional prediction method. Fuzzy neural network model as a powerful learning system, it has already gone through all kinds of testing, as non linear prediction tool, it has already widely used in many aspects' problems prediction. It can realize high nonlinear mapping from input to output, meanwhile it provides clear link between the two. Considering combination model prediction can integrate dispersive single prediction special uncertainty, meanwhile it can also reduce entirety uncertainty, so that it achieves improving prediction precise[3]. Therefore, on the basis of Liu Xiang personal official network[4] data, at first adopt BP network model, and establish fuzzy neural network model on that basis to predict Liu Xiang hurdle performance.

MODEL ESTABLISHMENT

BP network model

In prediction field, the most widely used artificial neural network model is forward network model that is BP network model; it is composed of input layer, hidden layer and output layer. BP network has ability

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of drawing near any non linear function in theory, it maps input mode into output mode, only needs to use known mode training network and by learning, and the network will have such mapping ability. The research establishes a 3 layers' BP neural network prediction model, BP network structural design as Figure 1 shows.

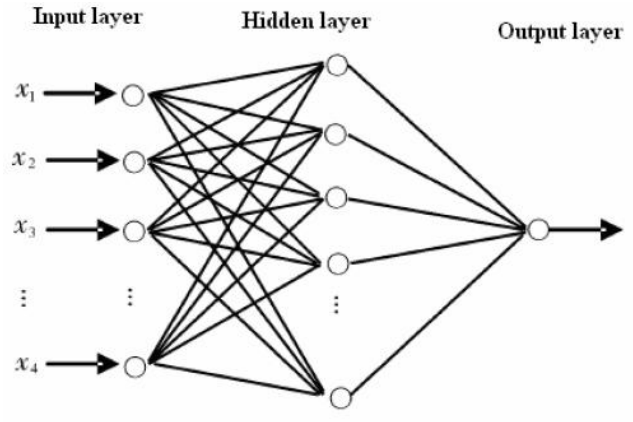

Figure 1 : Common BP neural network structure

Three layers BP network, input node x_i, hidden node y_i, output node z_i. Input node and hidden node network weight is w_{ji}, hidden node and output node network weight is v_{1j}. When output expectation value is t_1, model is as following Figure 2:

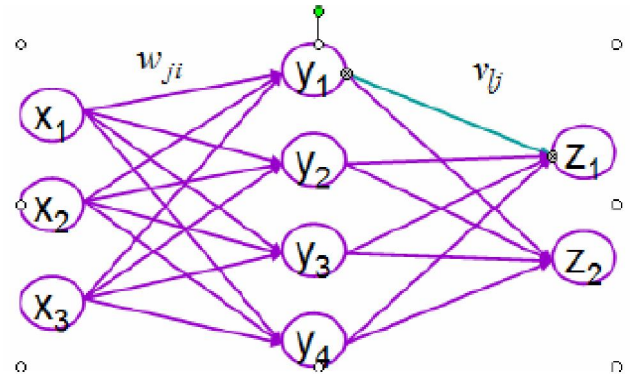

Figure 2 : Model when output node expectation value is t_1

Hidden node output:

$$y_j = f\left(\sum_i w_{ji}x_i - \theta_j\right) = f\left(net_j\right)$$

$$y_1 = f\left(w_{11}x_1 + w_{21}x_2 + w_{31}x_3 - \theta_1\right)$$

Output node output:

$$z_l = f\left(\sum_j v_{lj}y_j - \theta_l\right) = f\left(net_l\right)$$

$$z_1 = f\left(v_{11}y_1 + v_{21}y_2 + v_{31}y_3 + v_{41}y_4 - \theta_1\right)$$

Define network weight w and threshold value $\theta[2,3]$, threshold value θ can be regarded as another one nerve cell weight with -1 input, Such threshold value defining converts into weight defining. It realized through making Matlab program, set network error precise as 0.001, preinstall learning cycle index into 200 times, transfer function adopts tangent S type function. From Figure 3, it can see that network arrives at error requirements after 140 times cycling.

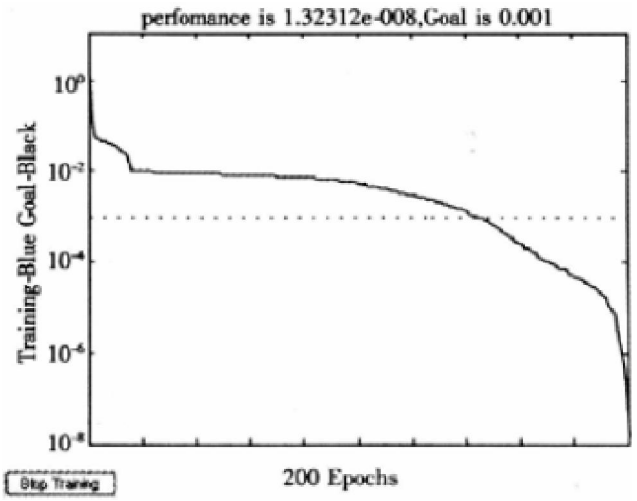

Figure 3 : Error analysis chart

Data normalization process

In order to easier Fuzzy neural network handle with collected data, it makes normalization process on collected Liu Xiang 70 times'110m hurdle performance data on December in 2000 to 2010, refer to TABLE 1. Normalization formula is:

$$x_i' = \frac{x_i - x_{\min}}{x_{\max} - x_{\min}}$$

Establish fuzzy neural network prediction model

T—S fuzzy neural network model is as Figure 4 show. The network is composed of antecedent network and subsequent network two parts, which are

TABLE 1 : Liu xiang performance statistical table

No.	Actual performance	Normalization Process	No.	Actual performance	Normalization Process
1	13.87	1.0000	36	13.05	0.1458
2	13.32	0.4271	37	13.24	0.3438
3	13.42	0.5313	38	13.08	0.1771
4	13.33	0.4375	39	13.12	0.2187
5	13.36	0.4688	40	13.30	0.4063
6	13.76	0.8854	41	13.05	0.1458
7	13.12	0.2187	42	13.08	0.1771
8	13.56	0.6771	43	13.10	0.1979
9	13.27	0.3750	44	13.21	0.3125
10	13.50	0.6146	45	13.22	0.3229
11	13.27	0.3750	46	13.21	0.3125
12	13.51	0.6250	47	13.19	0.2917
13	13.45	0.5625	48	13.20	0.3021
14	13.22	0.3229	49	13.30	0.4063
15	13.20	0.3021	50	12.93	0.0208
16	13.75	0.8750	51	13.03	0.1250
17	13.23	0.3333	52	13.07	0.1667
18	13.19	0.2917	53	13.14	0.2396
19	13.27	0.3750	54	13.15	0.2500
20	13.31	0.4167	55	13.14	0.2396
21	13.20	0.3021	56	12.92	0.0104
22	13.06	0.1563	57	13.23	0.3333
23	13.40	0.5104	58	13.15	0.2500
24	13.33	0.4375	59	13.01	0.1042
25	13.25	0.3542	60	13.23	0.3333
26	13.11	0.2083	61	12.95	0.0417
27	13.06	0.1563	62	13.21	0.3125
28	12.91	0.0000	63	13.20	0.3021
29	13.59	0.7083	64	13.19	0.2917
30	13.23	0.3333	65	13.18	0.2813
31	13.12	0.2187	66	13.15	0.2500
32	13.06	0.1563	67	13.34	0.4479
33	13.11	0.2083	68	13.50	0.6146
34	13.21	0.3125	69	13.66	0.7813
35	13.06	0.1563	70	13.09	0.1875

respectively used to math T-S type fuzzy rule antecedent and subsequent.

T—S Fuzzy neural network model

The network each layer nerve cell functions are as following[2]:

(1) Antecedent network

The first layer: In the layer, each node and input vector each component $x_i (i = 1, 2, ...n)$ are direct correlated, it can directly transfer input vector to the next layer.

The second layer: The layer can be called membership function layer, is the key step to make each input vector justification, each node represents a linguistic variable value, make use of the layer membership function, it can work out each input component affiliated each linguistic variable value degree μ_i^k, that is:

$$\mu_i^k = \mu_{A_i^k}(x_i), k = 1, 2, ..., m_i$$

This paper adopts Gaussian function expressed membership function, that is:

$$\mu_i^k = \exp(-(x_i - c_{ik})^2 / 2\sigma_{ik}^2)$$

In formula, c_{ik} and σ_{ik} respectively represent membership function center and width.

The third layer: In the layer, each node is required to match one T-S type fuzzy rule antecedent, make use of the antecedent; it can work out every rule corresponding fitness value, that is:

$$a_j = \min\left\{\mu_1^{i_1}, \mu_2^{i_2}, ...\mu_n^{i_n}\right\},$$

$$, i_1 \in \{1, 2, ..., m_n\}, ..., i_n \in \{1, 2, ...m_n\}$$

$$j = 1, 2, ...m$$

The fourth layer: normalized calculation layer, that is:

$$\bar{a}_j = a_j / \sum_{j-1}^{m} a_j$$

(2) Subsequent network

The first layer: In the layer, regulate that the 0 node input value $x_0 = 1$, other every note is required to direct linked with input value x_i.

The second layer: The layer every node is required to match to one T-S type fuzzy rule subsequent, formula as following:

$$y_j^l = \sum_{l=1}^{n} p_{ij}^l x_i, (l = 1, 2, ...R)$$

The third layer: Calculate system output, that is:

$$y_l = \sum_{j=1}^{m} \bar{a}_j y_j^l$$

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MODEL SOLUTION

Adopt learning, feedback, improving, learning again rolling learning mode, by algorithm many times simulations, finally it defines results as following, when the number of input nerve cell is 6, the number of hidden layer node is 13, the model learning and training convergence is the best, prediction precise is higher. Corresponding solution curve is as following figure shows, from which Figure 5 expresses BP network learning curve, Figure 6 expresses output prediction curve. Intuitively, the model better solves Liu Xiang performance problems, with better convergence; the prediction result basically conforms to the actual.

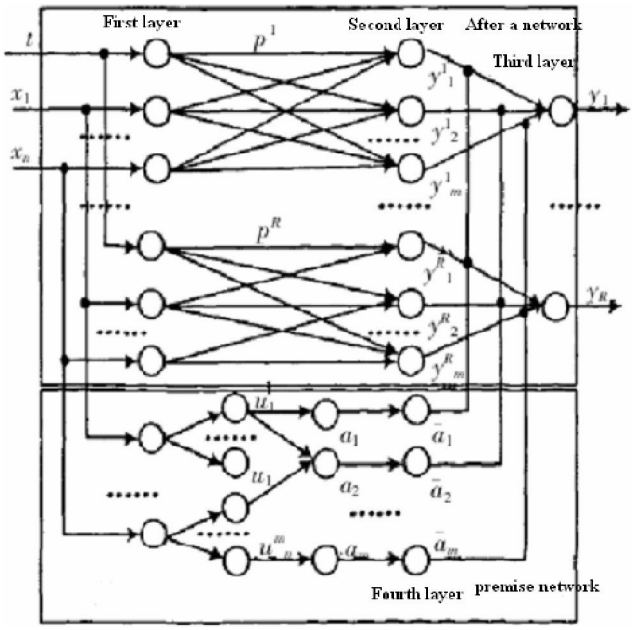

Figure 4 : Fuzzy neural network structural charts

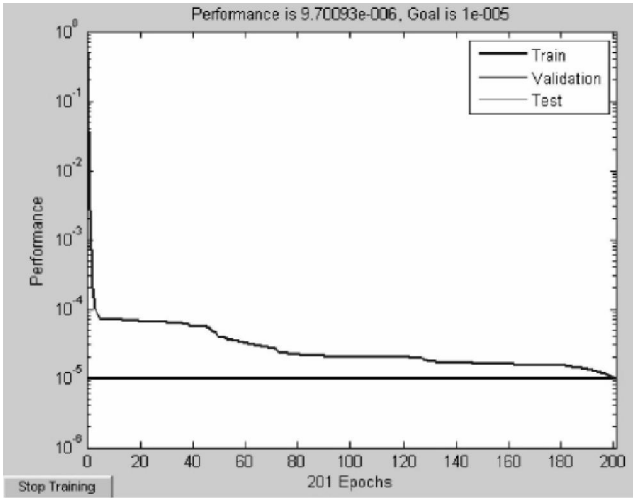

Figure 5 : BP network learning curve

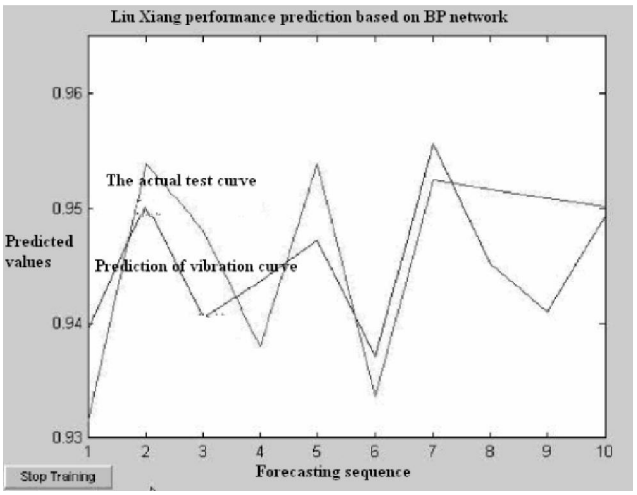

Figure 6 : BP output prediction curve

TABLE 2 : BP neural network prediction and fuzzy neural network prediction comparison

BP neural network prediction performance	Absolute error	Relative error%	MSE
13.193144	-0.243144	-1.877560	
13.115472	0.094528	0.715579	
13.244463	-0.044463	-0.336841	
13.147373	0.042627	0.323177	
13.222271	-0.042271	-0.320721	0.048691
13.212562	-0.062562	-0.475757	
13.198692	0.141308	1.059280	
13.243076	0.256924	1.903141	
13.230593	0.429407	3.143536	
13.253144	-0.163144	-1.246325	
Fuzzy neural network prediction	**Absolute error**	**Relative error%**	**MSE**
13.100215	-0.150215	-1.159961	
13.204240	0.005760	0.043603	
13.091893	0.108107	0.818992	
13.096054	0.093946	0.712252	
13.157082	0.022918	0.173885	0.010667
13.148760	0.001240	0.009430	
13.137664	0.202336	1.516762	
13.492736	0.007264	0.053807	
13.685529	-0.025529	-0.186889	
13.105623	-0.015623	-0.119351	

Establish fuzzy neural network by selecting TABLE 1 data after normalization, the previous three times Liu Xiang performance is fuzzy neural network input, the fourth performance is fuzzy neural network output, use the previous 60 times normalized Liu Xiang performance data composing training set to establish fuzzy neural

network prediction model, use 61 to 70 times normalized Liu Xiang performance data composing test set to make prediction on Liu Xiang performance.

Apply MATLAB software fuzzy logic toolbox function (anfis) to train samples[4-6]. Analyze from consistency perspective, it is clear that the model's number of input variables defines as consistent that indicates it should define 5 pieces of Gaussian functions as membership functions, and corresponding number of fuzzy rules is required to define 125 pieces. Therefore, after 200 times' uninterrupted training, it gets required self-adaption fuzzy neural network model as following.

Use estimated error variance (MSE) to evaluate Liu Xiang performance prediction model property. MSE are expressed as:

$$MSE = \frac{1}{l-1}\sum_{t=1}^{l}\left|a_t - r_t\right|^2$$

In formula:

x_t —Actual performance;

r_t - —Prediction performance;

l —Numbers of performance3;

In order to make comparison with fuzzy neural network model prediction results[7] this paper meanwhile makes use of BP neural network model making simulation on Liu Xiang final 9 times' performance by utilizing BP neural network model, two models' simulation results can refer to TABLE 2, data change tendency can refer to Figure 7.

From TABLE 2, it is clear that fuzzy neural network prediction error and BP neural network prediction model prediction absolute error get smaller, in test data, fuzzy neural network MSE is 0.010667, maximum relative error is 1.516762%, BP neural network MSE is 0.048691, maximum relative error is 3.143536%, that is to say, fuzzy neural network prediction error is smaller than BP neural network model, meanwhile from Figure 7, it can find out that fuzzy neural network prediction model prediction value and actual value fitting effects are obvious better than that of BP neural network prediction model, which indicates fuzzy neural network prediction model has higher prediction precise and better prediction effects.

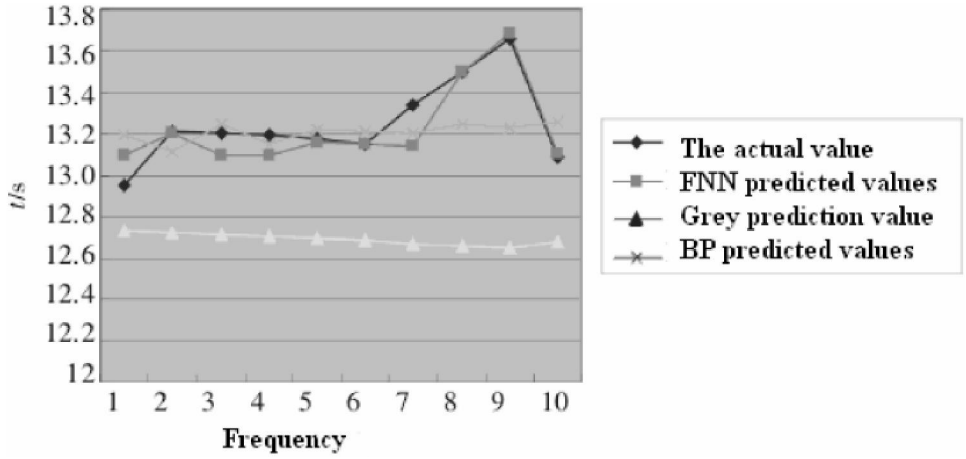

Figure 7 : BP neural network prediction and fuzzy neural network prediction comparison

CONCLUSIONS

Through research, it put forward a kind of fuzzy neural network-based Liu Xiang performance prediction method, the method combined fuzzy mathematics correlation theory and neural network learning method, overcome traditional neural network prone to get involved in local minimum problems, meanwhile it avoided traditional grey prediction system required prediction essence is a kind of index growth shortcoming. From the perspective of prediction result, fuzzy neural network prediction method has higher prediction precise and calculation efficiency by comparing to traditional BP neural network method, its result had certain reliability and reference value. The model is not only fit for Liu Xiang, but also fit for other world excellent hurdlers' training, which could be regarded as reference basis for adjust training.

In addition, the paper used data was fewer, if it had efficient more correlation data, fuzzy neural network

prediction precise would be further improved. In future 110m hurdle time prediction, it thoroughly could collect more historical data, meanwhile combined with other quantities related to competitive ability indicator, and established more completely and scientific sports competition prediction model.

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