

Sustainable assessment method for traditional sports in universities based on functional link fuzzy neural network

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Abstract. In order to improve the precision of sustainable evaluation algorithm for traditional sports in universities, it comes up with a type of sustainable assessment method for traditional sports in universities based on functional link fuzzy neural network. Firstly, it takes advantage of the influential factors, such as research equipment, condition, team, management ability and output of scientific research, etc. to construct sustainable evaluation of traditional sports, and has multiple characteristics and strong nonlinearity; secondly, according to suggested sustainable assessment model of traditional sports in universities, it uses the concept of functional link neural network to regard it as the fuzzy rule of output layer of fuzzy neural network, and design the network model of functional link fuzzy neural network; finally, it verifies the effectiveness of suggested method through simulation experiment.

Key words. Functional link, Fuzzy neural network, Traditional sports, Sustainable, Assessment.

1. Introduction

Education for Sustainable Development (ESD) is the educational idea appeared with the continuous development of educational theory, which was firstly and officially put forward by United Nations Educational Scientific and Cultural Organization in 1988. In April 2003, general assembly of the United Nations announced that from 2005 to 2014, it will implement sustainable development ten-year education for United Nations, which requests the government of each country to integrate sustainable development education into educational strategy and action plan in each relevant level. Sustainable development education is a type of educational idea related to educational development and educational essence, and within the quite long term from now to the future, sustainable development education will be the even-

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tual pursue of education. At present, the definition for sustainable development education includes narrow and broad sense. In narrow sense, it is to educate the educatees based on the concept of sustainable development, and its goal is to help it to form idea and ability of sustainable development, so it is a technical sustainable development education. In broad sense, all educations for the sake of sustainable development belong to sustainable development education, and its core is to promote the reform and development of education guided by sustainable development. Generally, narrow sustainable development education is the basis and important composition of broad sustainable development education and the latter is the effort direction of the former.

University sports teaching based on sustainable development education means that use the development view and value of sustainable development education, and sustainability, integrality, harmony, equality and other principle of the sustainable development to discuss college sports teaching process and teaching application. University sports teaching under the concept of sustainable development education should have the following main contents: the first is that as a subsystem of the university education, the universities sports teaching system can continue to keep vigor and vitality in the field of the whole education in universities; secondly, the university sports teaching and development should have the characteristics of sustainability, adapt to the change of the external environment, and make the active adjustment and improvement; the third is to help learners develop a teaching system of lifelong physical education. From application, according to the sustainable development education, sports teaching research in universities mainly concludes the following several aspects: first, it illustrates how to promote the sustainable development of school physical education teaching from teaching goal and function value; secondly, it studies the ways of improving the sustainable development of physical education teaching from physical education, teaching practice and reform; thirdly, the paper studies the presentation of sustainable development of physical education in universities.

In order to achieve the sustainable research of the physical teaching, this paper proposes a sustainable assessment method of traditional sports in universities based on functional link fuzzy neural network; it takes advantage of the influential factors, such as research equipment, condition, team, management ability and output of scientific research, etc. to construct sustainable evaluation of traditional sports in universities, and uses the concept of functional link neural network to regard it as the fuzzy rule of output layer of fuzzy neural network, and design the network model of functional link fuzzy neural network; its simulation experiment verifies the effectiveness of

2. Assessment and description for traditional sports science and technology in universities

According to the problems' connotation explained by existing achievement of literatures, it takes advantage of the influential factors, such as research equipment, condition, team, management ability and output of scientific research, etc. to con-

struct sustainable evaluation model of traditional sports in universities, as shown in figure one [10].

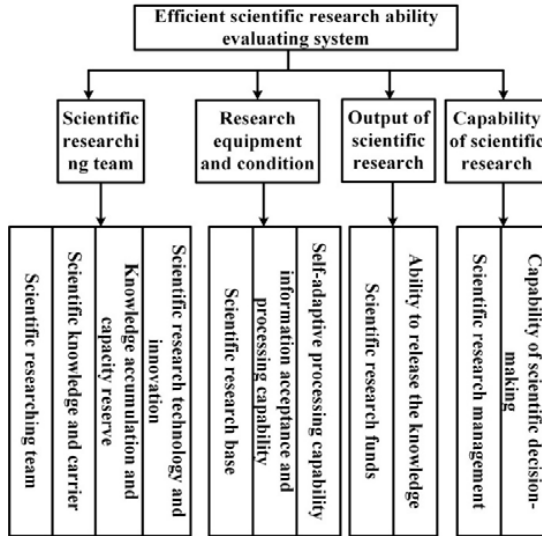


Fig. 1. Competence evaluation system for the traditional sports science and technology in universities

There are many factors to influence the quality of traditional sports science and technology in universities. As shown in figure one, the evaluation model totally selects eleven important influential points to qualify evaluation index: knowledge accumulation of scientific research, team, capacity reserve and carrier of knowledge and so on. In the model showed in figure 1, the influential factors are respectively correspond to $x_1 \sim x_{11}$ from the left the right side. It divided the quality of traditional sports science and technology in universities into five layers: very strong, stronger, common, bad and worse, which are respectively marked by the level I~V.

Due to many indicators involved in the quality of traditional sports science and research in universities and many characteristics and strong nonlinearities existed in it, the neural network is an effective tool to deal with this problem. At the same time, in order to improve the effect of neural network, the innovation and improvement are as follows: one is to consider front preprocessing based on rough set, preprocess the input data, and realize the data reduction of input sample; Second is to consider that use functional link neural network to effectively reduce the influence of the homogenization of characteristic training, and improve the scientific rationality of traditional sports science and research level in universities.

3. Functional link fuzzy neural network

In functional link neural network, the input data usually has higher order effect, and this effect is equivalent to artificially increase the dimension of input space,

and the relevant thing is that in the extended space, the input data has enhanced properties and separability. Functional link fuzzy neural network is used to algorithm of functional link neural network to perform complex nonlinear combination for input data, which can be used as the fuzzy rule of FNN model's output layer.

3.1. Functional link neural network (FLNN)

Functional link neural network is the single neural network without hidden layer; the linear link of neural network generates linear weighted function of input variables, and the function of functional link acts on input variable by producing a set of linear independent function, this is a set of orthogonal polynomials which is suitable for function extension, therefore, functional link neural network contains the trigonometric function relationship. For n dimensional input vector $X = [x_1, \dots, x_n]^T$, according to above description, it can obtain enhanced data [6] through regarding trigonometric function as functional spread function:

$$\Phi = \begin{bmatrix} 1, x_1, \sin(\pi x_1), \cos(\pi x_1), \dots, \\ x_n, \sin(\pi x_n), \cos(\pi x_n) \end{bmatrix}^T \tag{1}$$

The input variable can be separable in the enhancement space. Figure 2 shows the network structure of the functional link neural network. Φ is primary function set; W is weighting parameter set of fixed quantity. In the following contents, it will introduce the approximation theory of functional link neural network for the multi-dimensional nonlinear function.

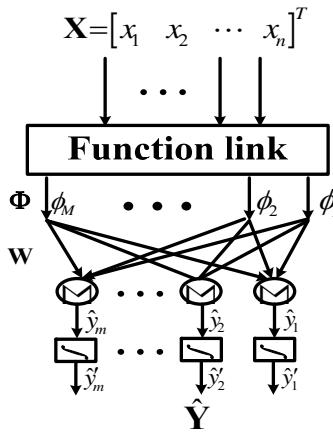


Fig. 2. Structure of functional link neural network

In view of a set of primary function $\mathbf{B} = \{\phi_k \in \Phi(A)\}_{k \in \mathbf{K}}$, and $\mathbf{K} = \{1, 2, \dots, n\}$, so this primary function has the following characteristics: 1) $\phi_1 = 1$; 2) subset of primary function $\mathbf{B}_j = \{\phi_k \in \mathbf{B}\}_{k=1}^M$ is a set of linearly independent set, namely, if $\sum_{k=1}^M \omega_k \phi_k = 0$, the all $k = 1, 2, \dots, M$, $\omega_k = 0$; 3) $\sup_j \left[\sum_{k=1}^j \|\phi_k\|_A^2 \right]^{1/2} < \infty$.

Suppose $\mathbf{B} = \{\phi_k\}_{k=1}^M$ is the function set in the following contents, and functional link neural network includes M primary function; $\{\phi_1, \dots, \phi_M\} \in \mathbf{B}$, so the linear combination of j nodes can be expressed as [7~8]:

$$\hat{y}_j = \sum_{k=1}^M \omega_{k,j} \phi_k(\mathbf{X}) \quad (2)$$

In the formula, $\mathbf{X} \in \mathbf{A} \subset \text{Re}^N$, $\mathbf{X} = [x_1, \dots, x_N]^T$ is input vector, $\mathbf{W}_j = [\omega_{1,j}, \dots, \omega_{M,j}]$ is the j output node's weight coefficient of functional link neural network. \hat{y}_j indicates that the local output of functional link neural network, so the above formula can be expressed [9] as: $\hat{y}_j = \mathbf{W}_j \Phi$, this formula is the output of function extension, and $\Phi = [\phi_1(x), \dots, \phi_M(x)]^T$ is the vector quantity of input primary function; for m dimensional linear output $\hat{y} = \mathbf{W} \Phi$, in $\hat{y} = [\hat{y}_1, \dots, \hat{y}_m]^T$, m indicates number of functional link, and it equals to the fuzzy rule in the functional link fuzzy neural network model; \mathbf{W} is functional link neural network, and $(m \times M)$ is weight matrix which can be expressed as $\mathbf{W} = [\omega_1, \dots, \omega_m]^T$; in this network, the j output can be expressed as $\hat{y}_j = \rho(\hat{y}_j)$, and $\rho(\cdot) = \tanh(\cdot)$ is the nonlinear function, therefore, m dimensional output vector can be expressed as:

$$\hat{\mathbf{Y}} = \rho(\hat{y}) = f_W(x) . \quad (3)$$

In the formula, $\hat{\mathbf{Y}}$ is the output of functional link fuzzy neural network.

3.2. Network structure of functional link fuzzy neural network

This section mainly introduces network structure of functional link fuzzy neural network which uses the nonlinear combination of input variable, and each fuzzy rule corresponds with one sub-function [10] of a functional link. Figure 4 provides structure chart of functional link fuzzy neural network, and FLNFN model realizes the fuzzy rule [11] of if-then through the following forms:

Rule_j : IF $x_1 = A_{1,j}, \dots, x_n = A_{n,j}$, THEN

$$\hat{y}_j = \sum_{k=1}^M \omega_{k,j} \phi_k = \omega_{1,j} \phi_1 + \dots + \omega_{M,j} \phi_M . \quad (4)$$

In the formula, x_i and \hat{y}_j respectively are the input of model and internal output variable; $A_{i,j}$ is the language description of the prerequisite Gaussian subordinating degree function; N is the quantity of input variable; $\omega_{i,j}$ is hyperlink weight of local output; ϕ_k is triangle basis function of input variable; M is the quantity of primary function; *Rule_j* refers to the j fuzzy rule.

In the following text, it shall emphatically introduce the operation of nodes in each level of functional link fuzzy neural network; in the following description, $u^{(l)}$ indicates the output of the nodes at the l level.

The first level: the first level of functional link fuzzy neural network has no

computing operation, and its main function is to directly transfer the input variable value to the next level:

$$u^{(1)} = x_i . \quad (5)$$

The second level: every fuzzy rule set $A_{i,j}$ is defined by Gaussian subordinating degree function, and the form is as follows:

$$u_{ij}^{(2)} = \exp \left(- \frac{[u_i^{(1)} - m_{ij}]^2}{\sigma_{ij}^2} \right) . \quad (6)$$

In the formula, m_{ij} and σ_{ij} respectively are mean value and variance of functional link fuzzy neural network, network fuzzy set and Gaussian subordinating degree function.

The third level: the nodes in this level accept the relevant rules of one-dimensional membership from the nodes of second level, and the nodes' operational results will be the prerequisite of fuzzy rule described before; the inference output rule of nodes in this level can be expressed as:

$$u_j^{(3)} = \prod_i u_{ij}^{(2)} . \quad (7)$$

In the formula, $\prod_i u_{ij}^{(2)}$ presents the linking strength of nodes' relevant rule.

The fourth level: the input of nodes in this level comes from the output of nodes in the third level and the input of the other part is generated from the above functional link neural network, as shown in figure 2, which can be expressed as:

$$u_j^{(4)} = u_j^{(3)} \times \sum_{k=1}^M \omega_{kj} \phi_k . \quad (8)$$

In the formula, ω_{kj} is the relevant hyperlink weight of functional link neural network and ϕ_k indicates the function of input variable; function extension part adopts trigonometric polynomial primary function, and its form is shown in formula (1), so the quality of primary function is $M = 3 \times N$, N is the number of input variable, in addition, the quantity of output node of functional link neural network relies on the fuzzy rule numbers of functional link fuzzy neural network model.

The fifth level: the output value of nodes in this layer is like the solving ambiguity for the fuzzy rule of nodes in the third layer and fourth layer, and its output form can be expressed as [7]:

$$\begin{aligned} y = u_j^{(5)} &= \sum_{j=1}^R u_j^{(4)} \Big/ \sum_{j=1}^R u_j^{(3)} = \sum_{j=1}^R u_j^{(3)} \hat{y}_j \Big/ \sum_{j=1}^R u_j^{(3)} \\ &= \sum_{j=1}^R u_j^{(3)} \left(\sum_{k=1}^M \omega_{kj} \phi_k \right) \Big/ \sum_{j=1}^R u_j^{(3)} . \end{aligned} \quad (9)$$

In the formula, R is the quantity of fuzzy rule, and y is the final output result of functional link fuzzy neural network.

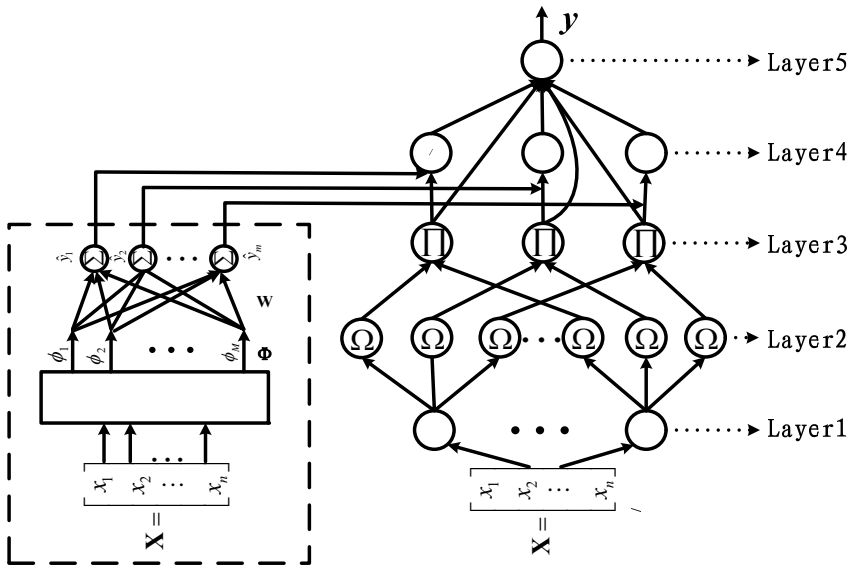


Fig. 3. Model structure of functional link fuzzy neural network

4. Experimental analysis

It uses the following five levels to evaluate the quality of traditional sports science and technology in universities: very strong [I], stronger [II], common [III], bad [IV], worse [V]. The test data for the quality of traditional sports science and technology in universities comes from proficiency assessment of 20 universities random selected by management and science college in 2013, as shown in table 1 [14].

Contrast algorithm selects neural network, intelligent water drop (IWD) neural network and Hopfield neural network. The experimental data in table 2 selects 1~15 sets of data to train the above selected contrast comparative network algorithm; the selection of test data can be divided into two conditions: (1) select test data from the above selected 15 sets of training data, for example, select the third, fifth, eighth, ninth and eleventh set of data to make test; (2) select test data the data except for the 15 sets to make network testing, for example, in the contrast experiment, the text selects the last five sets of data as test data. The assessment result sees figure 4 and table 2.

Table 1. Research data for the quality of traditional sports science and technology in universities

x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}	Degree
86	92	91	96	96	94	97	96	96	94	94	I
97	87	92	88	92	96	96	94	92	93	93	I
85	72	81	66	80	82	87	77	82	81	74	II
74	94	87	82	84	85	74	76	89	88	87	II
93	95	96	87	89	98	87	93	93	93	87	I
67	63	64	68	72	60	64	65	75	72	67	III
62	61	73	64	64	67	68	56	63	60	61	III
52	48	38	57	46	35	57	61	52	54	47	IV
45	56	45	45	58	53	44	57	55	61	44	IV
93	92	97	95	97	92	93	95	86	91	95	I
32	34	36	25	28	45	42	21	30	25	22	V
74	81	75	82	87	73	82	64	94	83	82	II
37	52	54	47	43	56	51	44	49	47	53	IV
15	33	21	36	44	34	32	37	34	25	39	V
25	44	32	12	37	28	37	26	22	17	31	V
66	67	64	71	67	57	63	60	64	66	65	III
57	64	63	63	65	68	73	66	70	68	64	III
77	75	72	79	71	87	75	92	63	72	83	II
36	17	28	27	23	23	23	30	38	37	27	V
91	93	87	93	96	92	91	87	93	86	98	I

Table 2. Comparison of performance period and convergence precision

Test data selection	Index	Neural network	IWD neural network	Hopfield neural network	Algorithm in this text
Condition 1	Convergence precision	2.68	0.35	5.35	2.32E-3
	Computing time	4.57	9.45	4.42	3.21
Condition 2	Convergence precision	3.42	1.18	6.09	3.57E-2
	Computing time	4.96	9.91	4.73	3.53

Figure 4 displays the evaluation comparison for the two conditions, and the assessment results in figure 7 respectively are I~V level from top to bottom; it selects the testing samples (five samples) in two conditions from left to right side. According to the test results in figure 4, we can know that the compared to the selection mode in condition 2; the selection mode of test data, training data and the algorithmic evaluation precision in condition 1 are all higher; the Hopfield neural network and neural network both have one set of error evaluation items; neural network optimized by IWD parameters and improved algorithm both have correct evaluation. For condition 2, Hopfield neural network in test data selection has low evaluation precision, namely, about 20%, and the assessment accuracy of neural network is about 60%; neural network optimized by IWD parameter of evaluation accuracy is about 60%; evaluation accuracy of improved algorithm is about 100%.

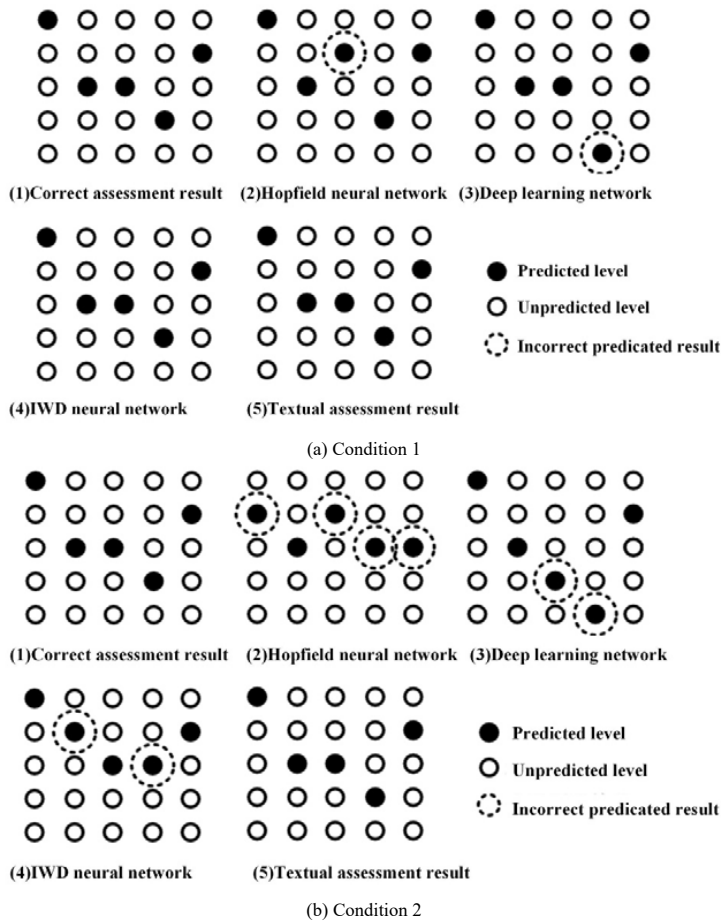


Fig. 4. comparison of evaluation

The above correlation data confirm the effectiveness of the improved method. Table 3 shows that the convergence time and precision index of selected concentration algorithms. The improved algorithm is optimal in the two indexes. The convergence accuracy of the neural network optimized by IWD parameters is better, but due to the addition of the IWD parameter optimization process, the calculation time of the IWD parameter increases correspondingly, which is not convenient for practical application.

5. Conclusion

Sustainable development education is an educational idea and educational thought with era significant, which will be widely noticed in quite long period from present to the future. Under the context of the education reform and increasingly deep quality-

oriented education, and university sports teaching will play the more prominent role in education. It will bring the concept of sustainable development of education into university sports teaching, and go deep into the sports teaching goal, curriculum content, implementation of teaching, teaching evaluation, and other applications, which is conducive to provide the further improvement of university sports teaching with new thought, and has the positive significance for the continuous, stable development of university sports.

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