Building Project-Based Teaching Model Based on BP Neural Network Associative Learning

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Abstract. The project-based teaching has become an effective model for training practical talents. BP neural networks learn to continuously adjust the network linkage weights and thresholds by propagating formulas to achieve minimum error control. Introducing BP neural network associative learning algorithm into Project-based teaching process design, through repeated training, the corresponding index weights are continuously adjusted to build a more ideal Project-based teaching model, then achieve the purpose of optimizing all aspects of the Project-based teaching process and ensuring the effective implementation of Project-based teaching.

Keywords: Project-Based Teaching · Associative Learning · BP Neural Network · Teaching Model

1 Introduction

From a neuropsychological perspective, learning refers to the process of altering the nervous system and behavior through experience [1]. The BP network learning is a process that adjusting the network linkage weights and thresholds along the direction of error reduction for a given training pattern by using the propagation formula [2].

The project-based approach originated from the European idea of labor education and has become an important learning theory [3]. The Project-based teaching has become a form of modern education in the information society, providing a useful training model especially in the cultivation of practical talents [4].

The BP neural network associative learning algorithm is introduced into the Project-based teaching process in order to be able to adjust different index weights through several iterations to obtain a more ideal Project-based teaching model, then optimizing the project the teaching process, include the selection, student participation, project operation and result evaluation etc., and ensuring the effective implementation of Project-based teaching [5].

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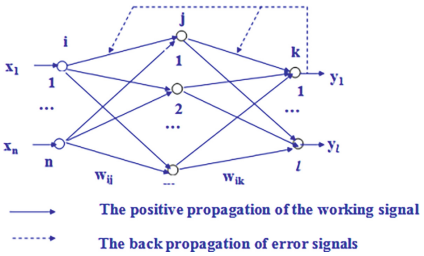

Fig. 1. The three-layer BP network structure

2 Knowledge Preparation

2.1 Associative Learning

The basic idea of associative learning is that the information obtained from learning in the human brain is distributed over the synaptic connections between neurons, and the learning and memory process is actually the correction and stabilization of synaptic connection weights completed during network training. The learning is expressed as a modification of synaptic association weights, and the memory is expressed as a stabilization of synaptic association weights [6]. The association learning rules can be considered as the rules for adjusting the association weights between neurons and the thresholds of neurons themselves during learning process.

2.2 BP Neural Network Learning Model

The neural network basis of BP network learning is a BP network with a multi-layer feed-forward structure. The three-layer BP network structure is shown in Fig. 1.

2.3 Project-Based Teaching Method

The project-based teaching method is based on projects. According to the learning objectives, Designing the learning content as a project and split the project into sub-projects. Under the guidance of the teacher, the sub-projects of information collection, project design, project implementation and final evaluation are given to the students to handle. Finally, all sub-projects are integrated after completion and the overall completion of the project is examined [7].

The process of implementing project-based teaching method is:

1) Collect user information and communicate with users in depth to perform contract analysis.
2) Develop contract plan and complete quotation.
3) Implement the contract, including making process sketches, physical drawings, control circuit diagrams, and forming the product.
4) Teachers guide students to complete the project check.
5) Evaluate the project and prepare for the next project.

3 Applying BP Neural Network Associative Learning Algorithm to Build Project-Based Teaching Model

3.1 Building Model

Based on the error correction learning rules, the deviation between the desired output and the actual output of the artificial neural network is used to adjust the linkage weighting under the guidance of the tutor, and improve and optimize the Project-based teaching program.

Assume that i is the input layer, j is the implicit layer, and k is the output layer. Apply the three-layer BP neural network learning algorithm to create a Project-based teaching model as following:

1) For different roles, including teaching objectives, participants, instructors, and administrators, are set as first-level indicators, and then multiple second-level indicators are divided for each one, and then normalized to eliminate the influence of the scale: $X = (x_{11}, x_{12}..., x_{1n}, x_{21}....x_{2m}, x_{31}....x_{3p}, x_{41}....x_{4s})$.
2) Set BP network learning parameters: w_{ij} is the linkage weight of the input layer to the hidden layer, w_{jk} is the linkage weight of the hidden layer to the output layer, R is the number of samples and its counter is r, T is the maximum number of iterations of the training process and its counter is t.
3) Initializing the network and learning parameters. W_{ij}, w_{jk}, θ_j, θ_k are taken to be smaller random numbers, *wij, wjk, θj, θk* $\in [0, 1]$, $\eta \in [0, 1]$, $r = 0$, $E = 0$ and the error threshold ε is set a very small value.
4) Inputting a random training sample, $r = r + 1$, $t = 0$.
5) Computing the input state of the implicit layer neurons I_j:

$$I_j = \sum_{i=1}^{n} w_{ij} O_i = \sum_{i=1}^{n} w_{ij} x_i \quad j = 1, 2, \ldots m$$

the output state O_j:

$$O_j = f\left(I_j - \theta_j\right) \quad j = 1, 2, \ldots m$$

The actual output of the output layer neuron node O_k (y_k):

$$I_k = \sum_{j=1}^{m} w_{jk} O_j \quad k = 1, 2, \ldots l$$

The error for each sample E:

$$E = \frac{1}{2} \sum_{k=1}^{1} (d_k - y_k)^2$$

The sample set R has r samples and the overall error of R is:

$$E_R = \sum_{r=1}^{R} E_r = \frac{1}{2} \sum_{r=1}^{R} \sum_{k=1}^{l} (d_{rk} - y_{rk})^2$$

If $E < \varepsilon$, the process ends when the sample set is fully trained. If $E > \varepsilon$, let $t = t + 1$ and end the process when the iteration is completed. Otherwise, calculate δ_k, δ_k, $w_{jk}(t + 1)$:

$$\delta_k = (d_k - y_k)y_k(1 - y_k)$$

$$\delta_j = f\left(I_j\right)\left[1 - f\left(I_j\right)\right]\sum_{k=1}^{n}\delta_k w_{jk}$$

$$w_{jk}(t + 1) = w_{jk}(t) + \Delta w_{jk} = w_{jk}(t) + \eta(d_k - y_k)(1 - y_k)y_j O_j$$

Return 5), correct the threshold value and continue the iteration.

3.2 Simulation Experiments

Project-Based teaching Indicator System
A tiered setting was used to divide the indicators into three levels (Table 1).

Weight Setting
According to the common assessment methods of Project-based teaching method, set initial weights and generate initial weight matrix.

Initial weighting matrix of first-level indicators:

$$\mathrm{W} = (\mathrm{W_{PRO}}, \mathrm{W_{PA}}, \mathrm{W_{MV}}, \mathrm{W_{EA}}, \mathrm{W_{RES}}) = \left(0.32,\ 0.12,\ 0.1,\ 0.18, 0.28\right)$$

The initial weight matrix of secondary and tertiary indicators is:

$$P_1 = \begin{pmatrix} 0.13 & 0.19 & 0.1 \\ 0.15 & 0 & 0 \\ 0.08 & 0 & 0 \\ 0.11 & 0.11 & 0.13 \end{pmatrix}$$

$$P_2 = \left(0.3\ 0.18\ 0.22\ 0.3\right)$$

$$P_3 = \left(0.35\ 0.45\ 0\ 0.2\right)$$

$$P_4 = \begin{pmatrix} 0.1 & 0.18 & 0.18 & 0.05 \\ 0.2 & 0.3 & 0 & 0 \end{pmatrix}$$

$$P_5 = \left(0.3,\ 0.2,\ 0.2,\ 0.3\right)$$

Table 1. The three-level indicator system

First-level indicators	Second-level indicators	Third-level indicators
Project (PJ)	Project content (PC)	Operation process (PCP)
		Operati (PCD)
	Project level (PL)	
	Project time (PT)	
	Expected target(PE)	Knowledge Objectives (PEK)
		Emotional Objectives (PEQ)
		Skill Objectives (PEA)
Participants (PA)	Professional Matching (PAM)	
	Level Matching (PAL)	
	Operation Matching (PAP)	
	Knowledge Match (PAK)	
Manager (MA)	Degree of control (MAC)	
	Condition Matching (MAR)	
	Information collation (MAS)	
Environment (EV)	Hardware (EVH)	Space (EVHS)
		Instrumentation (EVHE)
		Experimental Materials (EVHM)
		Experimental Materials (EVHI)
	Software (EVS)	Specification (EVSN)
		Data/Information(EVSI)
Result (RES)	Expected Target Matching (RT)	
	Analysis (RA)	
	Evaluation (RE)	
	Processing (RD)	

4 Experimental Procedure and Analysis of Results

1) The Data Preparation

By collecting teaching project data, questionnaire data and archived experimental data, etc., the data are extracted and used as input training set by weight calculation. Considering the data accuracy control, the normalization process is performed using the following formula:

$$i'_k = \frac{i_k}{1 - i_k}$$

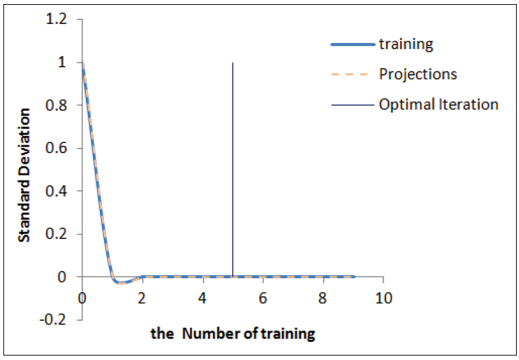

Fig. 2. The standard deviation of the network training

2) BP Neural Network Training
   Set the number of input neurons m = 25, $n = \log_2 m$, the number of neurons in the hidden layer: n = 5. The network is trained several times using the training set data and then the resultant network closest to the target value is saved.
3) Analyzing Results
   The standard deviation of the network training results is shown in Fig. 2:

From Fig. 2, the training parameters of the neural network are continuously adjusted, including w_{ij}, w_{jk}, θ_j, θ_k, etc. then comparing the error between the network output and the desired output. After the Nth training, if the error increases instead, the training will be forcibly ended. In the experiment, the optimal error control will be obtained at the 5th training.

5 Conclusion

The project-based teaching method is an effective way to cultivate practical and operational talents. The project-based teaching method focuses on whether the desired training objectives are achieved. A model of the Project-based teaching process is constructed in the hope of better controlling the implementation of Project-based teaching. BP neural network learning algorithm is one of the most widely used artificial neural network algorithms. According to the analysis of the simulation experiment results, the Project-based teaching process model constructed by applying BP neural network learning algorithm has a better teaching implementation effect.

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