Study on Student Classification Management Based on Bayes Network Optimized by PSO

Yang Yu*
Agricultural University of Hebei
Baoding 071001, China

Abstract — With the implementation and propulsion of reform in quality-oriented education, the current teaching management mode cannot adapt itself to the development requirements of quality-oriented education, especially the individualized cultivation of talents. As the traditional student classification management method is weak in the generalization ability and needs a large sample size, we put forward a student classification management model of Bayes network optimized by PSO based on the evaluation index of student classification management. Through the comparison of the Bayes optimized by PSO (PSO-Bayes), Bayes, SVM and BP4, it is found that the algorithm proposed in this paper can effectively improve the accuracy rate of student classification management in colleges.

Keywords - PSO; Bayes network; exam-oriented education; classification management; expert evaluation method

I. INTRODUCTION
With the implementation and propulsion in the reform of quality-oriented education, the unified management and exam-oriented management modes in the condition of traditional exam-oriented cannot adapt to the development of quality-oriented education, especially the individualized cultivation of talents. The final purpose of student classification management is to fully develop the personality of various students. Besides, in China’s history of education, the educational principle of teaching students according to their merits was proposed very early and this principle stresses educating and teaching students with different methods or different educational contents in accordance with their various characteristics [1]. Therefore, we carry out classification management for students based on the educational principle of teaching students according to their merits; we adopt different management modes, make varied student management objectives and establish student archives based on different types of students or different characteristics of the same type of students. Student classification management can help to develop different qualities of different students, fully develop one’s individuality, cultivate talents’ spirit of innovation, and cultivate each one as an individual needed by the society. It can be seen from the existing references that the research methods of student classification management mainly fall into three types: questionnaire method [2], expert grading method [3] and comprehensive evaluation method [4]. Even though the questionnaire method is simple, feasible and strong in operability, its evaluation result is easily affected by the level of questionnaire design, distribution and quantity of samples, and other factors. The expert grading method is strongly authoritative, doesn’t need a large number of sample data, and is short in the evaluation time, but its evaluation results excessively relies on experts’ experience and levels. Although the comprehensive evaluation method integrates the advantages of both expert grading method and questionnaire method, the whole evaluation process is time-consuming and laborsome. As the traditional student classification management method is weak in the generalization ability and needs a large sample size, we put forward a student classification management model of PSO-Bayes network based on the evaluation index of student classification management.

II. PSO
The particle swarm optimization algorithm (PSO), which is a swarm intelligence algorithm proposed by Kennedy et al [5-6] under the inspiration of the bird flock’s foraging behavior, realizes the optimization of foraging path through the cooperative assistance and completion among bird flocks. During the foraging process, particles will trace extreme values in the particle swarm. The two extreme values are respectively the optimal solution of particle in the current status \( p_{best} \) and the optimal solution of the whole group in the current status \( g_{best} \).

The speed and location of particle can be updated through formula (1) and formula (2) [7]:

\[ v_{id}(t+1) = v_{id}(t) + c_1 \times \text{rand1} \times (p_{id} - x_{id}(t)) + c_2 \times \text{rand2} \times (p_{g} - x_{id}(t)) \]  
\[ x_{id}(t+1) = x_{id}(t) + v_{id}(t+1) \]  

In the formulas above, \( x_i \) and \( v_i \) respectively signify the current location and speed of particle \( i = 1, 2, ..., m \); \( d = 1, 2, ..., n \); \( \text{rand}_1 \) and \( \text{rand}_2 \) signifies random numbers between \([0, 1]\); \( c_1 \) and \( c_2 \) are learning factors (\( c_1, c_2 > 0 \)).
III. BAYES NETWORK

As for a group of variables \( X = \{X_1, X_2, \ldots, X_n\} \), each variable is given a specific value \( \{x_1, x_2, \ldots, x_n\} \); \( \text{parents}(x) \) signifies the parent node set of \( x \); thus, its joint probability density can be expressed with formula (3) [8-9]:

\[
P(x_1, x_2, \ldots, x_n) = \prod_{i=1}^{n} P(x_i | \text{parents}(x_i))
\]

Fig. 1 shows a typical Bayes network. Each node means the corresponding variable [10].

![Figure 1 Typical Bayes network](image)

Let the prior probability of \( h \) be \( P(h) \) and the prior probability of \( D \) be \( P(D) \). If the conditional probability of \( D \) is \( P(D|h) \) when \( h \) is workable, the posterior probability of \( h \) can be expressed in formula (4) when \( D \) is given [11-12]:

\[
P(h|D) = \frac{P(D|h)P(h)}{P(D)}
\]

As shown in formula (7), in order to realize the Bayes network inference, the precondition is to give many prior probabilities.

IV. STUDENT CLASSIFICATION BASED ON PSO-BAYES NETWORK

A. Selection of evaluation index

The evaluation index system of college student classification management constructed by combining the relevant documents at home and abroad and the practical conditions of college student classification management and education in China consists of three layers of indexes, which are respectively the evaluation objective layer, criterion layer and sub-criterion layer. Besides, the evaluation index system has 1 level-I index, 5 level-II indexes and 15 level-III indexes, as shown in Table 1 [13].

<table>
<thead>
<tr>
<th>Objective layer (layer A)</th>
<th>Criterion layer (layer B)</th>
<th>Sub-criterion layer (layer C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Execution of the policy of classification management and education of college students ( U_1 )</td>
<td>Institution setting of classification management and education of college students ( U_{11} )</td>
<td>( U_{11} )</td>
</tr>
<tr>
<td>Personnel allocation of classification management and education of college students ( U_{12} )</td>
<td>Development planning of classification management and education of college students ( U_{13} )</td>
<td>( U_{13} )</td>
</tr>
<tr>
<td>Subject of classification management and education of college students ( U_2 )</td>
<td>Improvement of educatees’ consciousness level of student classification management ( U_{21} )</td>
<td>( U_{21} )</td>
</tr>
<tr>
<td>Educators’ influence on others’ thoughts ( U_{22} )</td>
<td>Educators’ qualities and structure ( U_{23} )</td>
<td>( U_{23} )</td>
</tr>
<tr>
<td>Level improvement of an educator’s consciousness of student classification management after a student classification management and education phase ( U_{24} )</td>
<td>Systematicness of the student classification management and education plan ( U_{31} )</td>
<td>( U_{31} )</td>
</tr>
<tr>
<td>Scientificity of student classification management and education procedure ( U_{32} )</td>
<td>Creativity of student classification management and education methods ( U_{33} )</td>
<td>( U_{33} )</td>
</tr>
<tr>
<td>Information system of classification management and education of college students ( U_4 )</td>
<td>Collection and management of classification management and education information of college students ( U_{41} )</td>
<td>( U_{41} )</td>
</tr>
<tr>
<td>Analysis and application of information on classification management and education of college students ( U_{42} )</td>
<td>Investment situation of classification management and education of college students ( U_{51} )</td>
<td>( U_{51} )</td>
</tr>
<tr>
<td>Input and environment of classification management and education of college students ( U_5 )</td>
<td>Internal environment for classification management and education of college students ( U_{52} )</td>
<td>( U_{52} )</td>
</tr>
<tr>
<td>External environment for classification management and education of college students</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

TABLE 1 TABLE OF EVALUATION INDEXES OF COLLEGE STUDENT CLASSIFICATION MANAGEMENT
B. Fitness function

Since Bayes network’s weight and threshold value need to be optimized, its fitness function is shown below on the premise of guaranteeing minimum error of student classification [14-15]:

\[
\text{Minimize Fitness}(w_j, b_j) = \sum_{i=1}^{n} (o_i^j - d_i^j) \quad (5)
\]

C. Student classification based on PSO-Bayes network

The flow of student classification algorithm based on PSO-Bayes network is shown below:

Step 1: Normalize the evaluation index data of student classification management;

Step 2: Set the maximum number of iterations of PSO to be Iteration, population size to be popsize and learning factors to be \(c_1, c_2\);

Step 3: Input the constructed training samples into the Bayes network; use formula (5) to calculate the fitness function value of each particle; search for the location and optimal value of each individual particle and global optimum particle;

Step 4: Update the particle speed and location;

Step 5: Calculate and evaluate the fitness size; update the location and speed of individual particle;

Step 6: If \(\text{gen} > \text{Iteration}\), save the optimal solution; when \(\text{gen} = \text{gen} + 1\), turn to Step 4;

Step 7: Achieve the prediction of classification management of college students based on the optimal parameters \(w_j, b_j\) corresponding to the optimal locations of individual particles.

V. EMPIRICAL ANALYSIS

A. Data pre-processing

To avoid the calculating imbalance during processing of original data of various orders of magnitudes with the Bayes network, reduce the calculation complicity of algorithm, and enhance the performance of Bayes network, the formula of normalized processing is shown below [16]:

\[
x_i' = \frac{x_i - x_{\text{min}}}{x_{\text{max}} - x_{\text{min}}} \quad (6)
\]

In the formula above, \(x_i, (i = 1, 2, \ldots, 5)\) denotes the unnormalized sample data; \(x_{\text{max}}\) denotes the maximum value among the unnormalized sample data in the same group; \(x_{\text{min}}\) denotes the minimum value among the unnormalized sample data in the same group; \(\bar{x}\) means the normalized data.

B. Empirical result

Divide the 205 sets of data of college student classification management collected into two parts; the former 140 sets of sample data are used as the training set; the latter 65 sets of sample data are used as the test set. The detailed data is shown in Table 2 [17, 18].

<table>
<thead>
<tr>
<th>Category of samples</th>
<th>Training set</th>
<th>Test set</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top students</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td>Second best students</td>
<td>22</td>
<td>11</td>
</tr>
<tr>
<td>Average students</td>
<td>55</td>
<td>25</td>
</tr>
<tr>
<td>Second average students</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Low-grade students</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td>Poor students</td>
<td>33</td>
<td>15</td>
</tr>
<tr>
<td>Total</td>
<td>140</td>
<td>65</td>
</tr>
</tbody>
</table>

Figure 2 Diagram for normalization result of evaluation data of college students

Figure 3 Result of Bayes classification
As shown in predictive results in Fig. 3, Fig. 4, Fig. 5 and Fig. 6 and the comparison results through different methods in Table 3, compared with BP, the Bayes optimized by FOA, Bayes and SVM all enhance the accuracy of classification management of college students. Besides, it can be found through comparison that the algorithm proposed in this paper can effectively enhance the accuracy of classification management of college students.

<table>
<thead>
<tr>
<th>Method</th>
<th>FOA_Bayes</th>
<th>Bayes</th>
<th>SVM</th>
<th>BP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantity of erroneous judgements</td>
<td>3</td>
<td>4</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>Correctness</td>
<td>95.38%</td>
<td>93.84%</td>
<td>90.71%</td>
<td>86.15%</td>
</tr>
</tbody>
</table>
It can be seen from Fig. 7 that the PSO-Bayes method can effectively improve the Bayes network and the PSO-Bayes neural network modeling method can reduce 52% of root-mean-square errors and mean absolute errors of data in the test set. Fig. 5 shows the convergence tendency of data frame. The optimal regularization coefficient value is 0.04.

The improved Bayes network does not like the traditional neural network technologies such as cross validation technology. The optimal value is linear optimization; namely, the optimal value and the neural network weight of training data used are optimized simultaneously.

(a) Iteration = 200

(b) Iteration = 300
Figure 8  Iteration diagram of various iterations
(a) $\text{sizepop} = 100$
(b) $\text{sizepop} = 200$
(c) $\text{Iteration} = 500$
(d) $\text{Iteration} = 800$

Figure 9  Iteration diagram of different population sizes
(a) $\text{sizepop} = 100$
(b) $\text{sizepop} = 200$
(c) $\text{sizepop} = 300$
(d) $\text{sizepop} = 500$
As shown in Fig. 8 and Fig. 9, with the increase in the population size and number of iterations, PSO-Bayes network parameters can acquire the optimal value in a faster way and has a better effect.

VI. CONCLUSION

With the implementation and propulsion in the reform of quality-oriented education, the unified management and exam-oriented management modes in the condition of traditional exam-oriented cannot adapt to the development of quality-oriented education, especially the individualized cultivation of talents. Thus, how to realize the precise classification management of college students is of vital realistic and theoretical significance for the classification management of college students. As the traditional student classification management method is weak in the generalization ability and needs a large sample size, we put forward a student classification management model of Bayes network optimized by PSO based on the evaluation index of student classification management. Through the comparison of college student classification management methods including the Bayes optimized by PSO, Bayes, SVM and BP4, it is found that the algorithm proposed in this paper can effectively improve the accuracy rate of student classification management in colleges.

REFERENCES