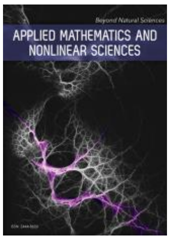
sciendo Applied Mathematics and Nonlinear Sciences, 9(1) (2024) 1-14



Applied Mathematics and Nonlinear Sciences

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Research on education management system based on machine learning and multi-dimensional data modeling

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Submission Info

Communicated by Z. Sabir
Received February 25, 2022
Accepted July 19, 2022
Available online March 21, 2023

Abstract

With the rapid development of modern information technology, especially the continuous improvement of computer network technology, the application of education management system in teaching is becoming more and more extensive. Therefore, education management system and machine learning will become an important combination direction of education. First, design and implement a complete network education management system based on B/S architecture, and design from the overall system design, detailed design and database design. Among them, the computer language combined with the SQL Server database realizes the network teaching function and the education system management function. Then, PSO-SVM machine learning is adopted to make personalized learning course recommendation for students. Multi-dimensional data analysis and feature extraction. Finally, the PSO-SVM proposed in this paper is applied to the education management system for modeling training, and compared with other traditional machine learning personalized recommendation accuracy and likeness of learning course recommendation. The experimental results show that the PSO-SVM proposed in this paper is superior to other traditional machine learning models in terms of personalized learning course recommendation and favorability, with an accuracy rate of 94.7%.

Keywords: Machine learning; Multi-dimensional data; Education management system; Big data technology; Education
AMS 2020 codes: 68T20

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ISSN 2444-8656
https://doi.org/10.2478/amns.2023.1.00072

1 Introduction

With the development of education, the scale of enrollment has continued to expand, and the number of students and enrollment majors have gradually increased. The data volume, business volume and information volume of the education management system have increased exponentially or even dozens of times [1-4]. Huge data brings enormous pressure to the management of education. To meet the objective requirements of continuous development and accelerate the construction of informatization, the development of basic education management system is the only way to improve the management level and work efficiency, and ensure the standardization and scientificization of teachers' work [5-6]. The educational information management system helps to digitize data, enhances the communication between teachers and teachers and parents, improves the management efficiency of schools, and reduces the workload of educators [7-8].

Machine learning is the use of computer technology to calculate and analyze the collected data, and to improve the accuracy of a specific system by continuously improving the calculation method [9]. With the rapid development of decision tree theory and logic-based learning. In decision tree theory, information entropy is used as the expected value of the variable. The smaller the information entropy, the more orderly the system is, and the minimization of information entropy becomes the goal of decision tree [10]. Connectionist learning based on neural networks has developed into a mainstream technology. The BP algorithm is computationally efficient, making it useful in many real-world problems [11-12]. Manual adjustment of parameters may lead to errors, and the learning results will vary greatly. Statistical Learning Support Vector Machines (SVM) [13]. Statistical learning has risen rapidly, and SVM has become its representative technique. The narrow interpretation of deep learning is a multi-layer neural network [14]. The development of computer hardware processing technology and data storage technology. Deep learning brings broader development and applications. Deep learning technology has quickly swept the entire field of artificial intelligence [15-18]. Advances in processor technology have also enabled artificial intelligence to function with data and high computing power.

The network education management system adopts the B/S structure mode for the overall design [19]. Computer language as the main programming language. The back-end database server uses the relational database management system SQL Server [20]. The functions of the education management system include student management, course management, grade management and teacher management. Students can realize online learning, online examination and online question answering through the education management system. Teachers can realize online teaching, online grading and online Q&A through the education management system, providing students with an online learning platform [21]. In this paper, the main points of innovation are:

1) The education management system mainly transforms the traditional classroom teaching method into the Internet mode for presentation, which saves traditional educational resources and enables students to achieve the purpose of efficient online learning.

2) The education management system mainly realizes the functions of online teaching, online question answering, learning resource sharing, teaching management, online examination and system management.

3) The education system management functions include student login information management, student data import, password query, course selection information import and grade import, etc.

4) Teaching management realizes the functions of student registration, student registration management, course management, information management of teachers and teaching management personnel.

Finally, the experiment is based on PSO-SVM machine learning [22-24] for personalized recommendation courses, and this model is compared with other traditional personalized recommendation models.

2 Education management system framework

The practice framework in the education management system will surely become the frontier field of innovation and competition in colleges and universities. It is a new idea to build an education management system and comprehensively improve the quality of education management. At the same time, constantly sum up experience and deficiencies in the process of practice, and promote education and teaching reform and management innovation. The specific education management framework is shown in the Figure 1.

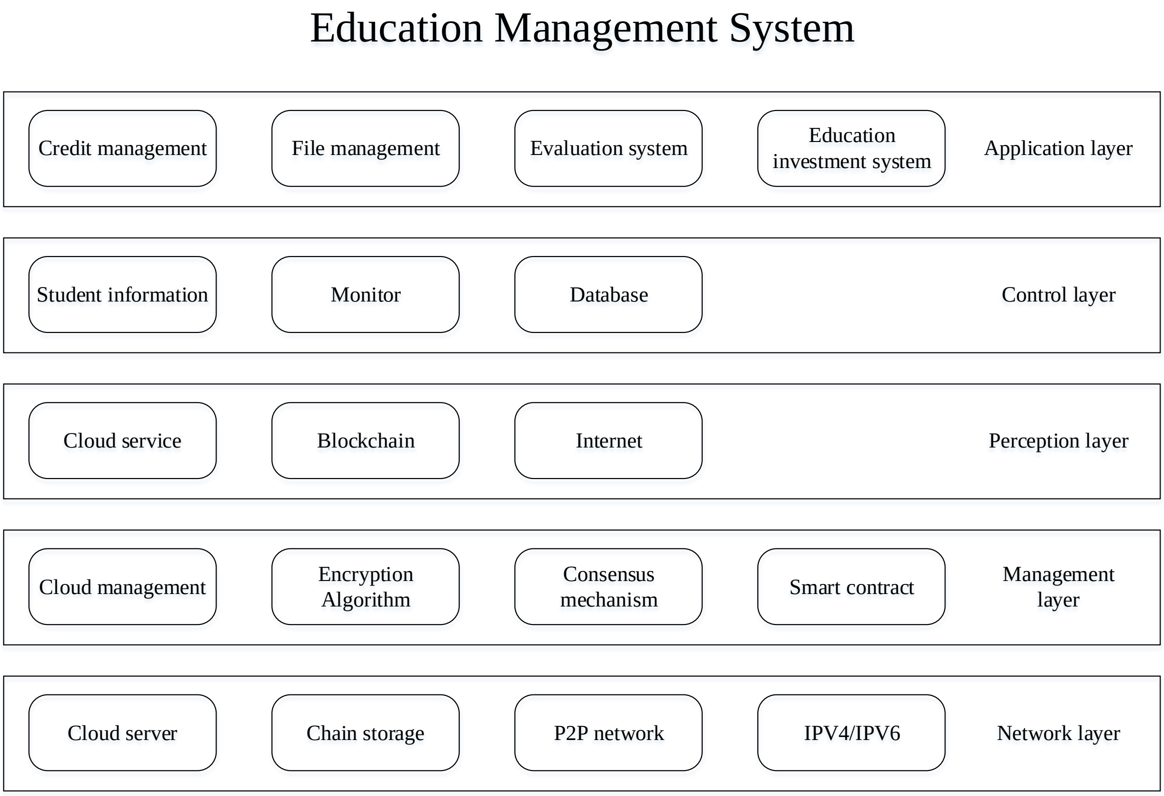

Figure 1. Education management system

1) The education management system includes basic education and educational process. The education system doesn't just contain a lot of student profile information. Mining effective information from these data and using machine learning to learn the rules can enhance the accuracy and scientificity of student education management.

2) Feasibility of decision-making in education management system. Based on multi-dimensional data, the education management system can visualize the status and development of teaching quality, and provide a scientific basis for teaching dynamic adjustment and decision-making. The education management system can monitor the status and trend of teaching quality in real

time. The education management system can not only construct teaching in different categories and at different levels.

3) The academic management system allows for the collection and analysis of data related to student learning in courses, thesis publication, academic exchange and employment development in real time, which can strengthen the ability to analyze the trend of students' behavior.

4) The data collected by the education management system establishes data specifications to ensure the authenticity and effectiveness of the data. Real and reliable data is valuable data. Unify data collection standards and continuously improve information in the education system.

5) Strengthen the integration of education management systems, break through the framework of existing education management systems, continuously optimize the discipline structure, and promote the development of frontier disciplines, emerging disciplines and interdisciplinary disciplines.

6) Deeply excavate the value of multi-feature data. The above-mentioned reformed education management data is larger in scale, more diverse in types, and richer in levels. Based on the education management system, it should use big data correlation analysis to deeply mine effective information and explore the hidden laws behind behaviors. Predict the development trend of student groups and individual behaviors, and provide accurate data support for the scientific decision-making of the school management department.

3 Characteristics of data acquisition and preprocessing

3.1 Multidimensional data acquisition

The data corpus used in our study comes from the survey questionnaire on the development of informatization in the education management system of teachers in a university in M province and the informatization survey questionnaire. In the determination of schools, a total of 1873 questionnaires and more than 40,000 text corpora were selected as the training data set used in this experiment. Each university contains at least 10 university faculty questionnaires. The questionnaires are all network datasets collected in a university education management system from 2019 to 2020. Using the web-based questionnaire, the multi-dimension includes the following characteristics:

1) The background information of university teachers and their schools, the gender of the investigators, educational background, teaching years, and the number of in-service teachers in the school.

2) Numerical table of application of digital resources of university teachers, such as the frequency of teachers' use of the system in each educational management link.

3) University teachers' participation in the education system, including the number of training participations, duration, number of models, etc.

4) The development of education management system training by universities, such as the number of times the school conducts management system learning, the proportion of teachers who participate in management system learning in schools, etc.

3.2 Data preprocessing

In the process of data mining technology collection, both algorithms and predictions have highly unified data for the data. For example, it is easy to mix irregular characters and other special symbols in the original collected data. The original collection of education management data is based on teachers' evaluation goals and evaluating students' data in different scenarios and dimensions. Some of the data problems make it impossible to directly use the original data for direct use and need to be normalized. Data normalization processing includes data processing cleaning, unifying data format, reducing noise and integrating high-quality data. Normalized processing not only reduces mining costs, but also improves operational efficiency. The specific data pre-processing process is illustrated in Figure 3. And the specific steps include the following:

1) Data cleaning: irrelevant variables deal with unnecessary data. Outlier handling removes unreasonable values. Missing processing complements or eliminates missing data.

2) Data transformation and reduction: Data is transformed or unified into a unified format suitable for collection. Data reduction techniques can reduce the original data to a data set. Data integration refers to the centralized integration of multi-featured data sources.

Table 1. Original dataset FAQ

Original dataset FAQ	
noisy data	wrong, large error data
incomplete data	invalid sample
data redundancy	data duplication
data inconsistency	different characteristics

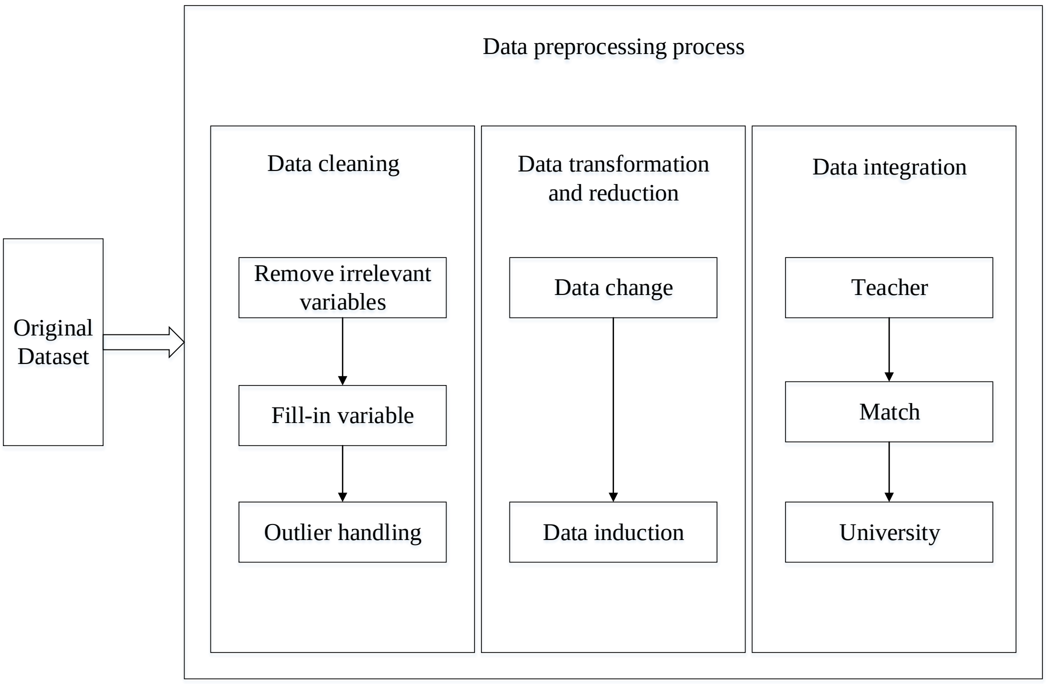

Figure 2. Data preprocessing process framework

3.3 EMD data processing principle

The empirical mode decomposition (EMD) is called the Hilbert-Huang transform [25]. Empirical mode decomposition can decompose the fluctuations of different time scales in the data step by step to obtain several features with different scales. The features include the eigenmode function and a residual component. The decomposition method of EMD can be divided into several parts as follows:

1) First, determine the maximum and minimum values based on the input data. Fit the upper and lower lines using the cubic sample function. When calculating the mean envelope value $\boldsymbol{m_1(t)}$.

2) Then, the original data $\boldsymbol{x(t)}$ is subtracted $\boldsymbol{m_1(t)}$ to obtain low-frequency data components $\boldsymbol{h_1(t)}$:

$$h_1(t) = x(t) - m_1(t) \tag{1}$$

3) At the same time, sometimes the value $\boldsymbol{h_1(t)}$ cannot be determined. $\boldsymbol{h_1(t)}$ will replace $\boldsymbol{x(t)}$. The processing goes through K times, and finally approaches 0 and ends. of which amount $\boldsymbol{c_1(t)}$:

$$c_1(t) = h_{1k}(t) - m_{1k}(t) \tag{2}$$

4) Finally, when processing the data, the endpoints are processed here using a polynomial fitting algorithm to prevent the divergence of the extreme value endpoints of the original data. The original series is then decomposed into a superposition of components and overall trends:

$$x(t) = \sum_{i=1}^{n-1} c_j(t) + r_m(t) \tag{3}$$

4 Modeling based on PSO-SVM

The penalty coefficient C in the SVM model and the parameters of the selected kernel function. The PSO algorithm optimizes the hyperparameters of the SVM, so that the SVM model can achieve the ideal classification effect in the education management system. At the same time, in order to select the most suitable kernel function for this model, multiple rounds of experiments are carried out, and finally the optimal parameters are selected according to the experimental results, as shown in Figure 2.

1) For different kernel functions, the particle population is first trained and initialized to 40. The number of training iterations is 15000 epochs. RBF optimizes parameters for c and gamma respectively. For the kernel function, the c, gamma, r and d parameters need to be trained to optimize. Kernel function the sigmoid kernel function needs to be optimized for the c, gamma and r functions. Randomly initializes the particle’s velocity and position.

2) The fitness of the model needs to be calculated, and the classification accuracy of PSO is calculated.

3) Constantly search for the optimal speed and position during training.

4) Calculate the fitness value of the updated position.

5) For individual optimal and global optimal. If the individual fitness value is better than the previous individual optimal, then the current fitness value is optimal, and the corresponding position is set as the individual optimal position. If the current particle fitness value is better than the global optimal fitness value, the current particle fitness value is set as the global optimal fitness value, and the corresponding position is set as the global optimal position.

6) Termination of judgment. If the termination condition is met, the algorithm stops and returns the optimal parameters and accuracy.

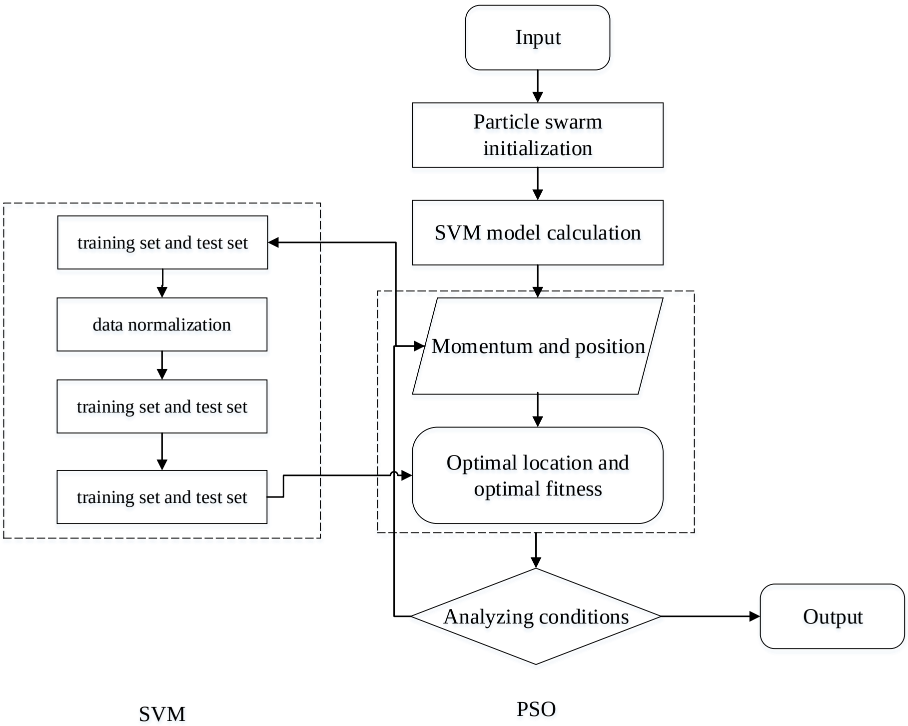

Figure 3. PSO-SVM algorithm flow chart

4.1 Particle swarm optimization algorithm

The particle's current vector is multiplied by the inertia weight for acceleration, and the inertial motion is carried out according to its own speed. The self-awareness part represents the particle's thinking about itself at the last moment. The social cognition part represents the information sharing and mutual cooperation of particles in the group in the particle swarm optimization algorithm, hereinafter referred to as PSO. A massless particle i can be represented by the position vector x_i and vector v_i, the formula is as follows:

$$x_i = \{x_1, ..., x_i, D\}^T \in \xi^D \tag{4}$$

$$v_i = \{v_1, ..., v_i, D\}^T \in \xi^D \tag{5}$$

Among them, the massless particle is i. The evolution process of particles in the swarm is shown in the formula:

$$\begin{cases} v_i(t+1) = wv_i(t) + c_1 r_1(pBest_i - x_i(t)) + c_2 r_2(gBest - x_i(t)) \\ x_i(t+1) = x_i(t) + v_i(t+1) \end{cases} \tag{6}$$

where t represents the number of training iterations. and uniformly distributed random numbers r_1, r_2 between [0,1]. $w \geq 0$ represents the inertia weight coefficient.

4.2 Support vector machines

SVM is support vector machine, which has relatively good performance indicators in classification tasks. SVM is a machine learning algorithm derived from the basis of statistical learning theory. SVM can be accurately classified and applied in the case of small sample size. The core idea of SVM is to find a hyperplane that can separate different categories of data, and maximize the distance.

1) First, assume that the dataset is

$$D = \{(x_1, y_1), ..., (x_n, y_n)\}, y_i \in \{-1, +1\} \tag{7}$$

Among them, $\boldsymbol{x_1}$ is the input sample data vector; $\boldsymbol{y_i}$ is the sample label of the corresponding data. The hyperplane is defined as follows:

$$w^T x + b = 0 \tag{8}$$

Among them, the hyperplane represents $\boldsymbol{w} = (\boldsymbol{w_1}, \ldots, \boldsymbol{w_d})$. B represents the distance between the hyperplane and the origin.

2) Then, directly classify the data:

$$\begin{cases} w^T x_i + b \geq +1, y_i = +1 \\ w^T x_i + b \leq -1, y_i = -1 \end{cases} \tag{9}$$

When the distance sum of two heterogeneous support vectors to the hyperplane is the largest, the hyperplane is the searched target plane. And this distance is called “maximum margin” and is defined as follows:

$$\min \frac{1}{2} \| w \|^2 \tag{10}$$

Among them, when the constraint condition $\boldsymbol{w}$ is satisfied, the maximum margin is performed. The following conditions are met:

$$s.t = y_i(w^T x_i + b) \geq 1, i = 1, ..., m \tag{11}$$

3) At the same time, the Lagrange multiplier method is introduced as the kernel function, and the dual representation is as follows:

$$\max \sum_{i=1}^{m} \alpha_i - \frac{1}{2} \sum_{i}^{m} \sum_{j}^{m} \alpha_i \alpha_j y_i y_j k(x_i, x_j) \tag{12}$$

$$s.t = \sum_{i=1}^{m} \alpha_i y_i = 0, \alpha_i \geq 0, i = 1, ..., m \tag{13}$$

The hyperplane model is expressed as:

$$f(x) = \sum_{i}^{m} \alpha_i y_i k(x, x_i) + b \tag{14}$$

Among them, the kernel function represents $\boldsymbol{k(x, x_i)}$. Realize the mapping of multi-dimensional data. The RBF formula is:

$$k(x_i, x_j) = \exp\left(-\frac{\| x_i - x_j \|^2}{2\alpha^2}\right) \tag{15}$$

The polynomial kernel kernel sigmoid kernel formula is:

$$k(x_i, x_j) = (x_i x_j > +c)^d \tag{16}$$

$$k(x_i, x_j) = \tanh(\beta x_i^T x_j + \theta) \tag{17}$$

4) Finally, slack variables $\boldsymbol{\zeta_i}$ need to be added to relax the constraints of the linear SVM. The optimization objective of SVM is defined as follows:

$$\min \tfrac{1}{2} \| w \|^2 + c \sum_{i=1}^{m} \zeta_i \tag{18}$$

$$s.t = y_i (w^T k(x_i, x_j) + b) \geq 1 - \zeta_i \tag{19}$$

Among them, C is a constant greater than 0, indicating the degree of penalty for wrong samples.

5 Experimental results and analysis

5.1 Selection of data samples

In this paper, the data collected by the 1500 education management system and the corresponding multi-dimensional feature parameters are used as the data set of the prediction model (where the data is pre-processed with multi-dimensional feature data by EMD), and the data set is randomly selected as (1,900) training data set, as (900, 1200) validation set and (1200, 1500) test set.

5.2 Experimental environment and parameters

Based on the Tensorflow platform, an experimental study is conducted in this paper. The learning rate of the Sigmoid optimizer used in the training process is chosen to be 0.001. on the other hand, the batch_size is set to 64 and max_seq_len is set to 128. to prevent overfitting problems, Dropout is used with a value of 0.5. the specific hyperparameters of the experimental platform and the parameters of the training environment are shown in Table 2.

Table 2. PSO-SVM parameters

Parameter	RBF	Polynomial	Sigmoid
Total group number	40	40	40
Particle dimension	3	4	5
Number of iterations	10000	10000	10000
lower limit	[0.0001,0.001]	[0.00001,0.001,0.2]	[0.00001,0.001,0]
upper limit	[1000,10]	[1000,10,10,10]	[1000,10,10]
Nomial	0	0	0

5.3 Evaluation criteria

To evaluate the predictive performance of the model and measure the error. The RMSE, the MAE, the accuracy rate and the AB favorability are selected. RMSE has high sensitivity to the errors in the measurement data and can reflect the accuracy of the measurement data well. Since the dispersion is absolute valued, MAE will not cancel the positive and negative phases.

$$RMSE = \sqrt{\frac{1}{n}\sum_{k=1}^{n}\left(y_k - y_k\right)^2} \tag{20}$$

$$MAE = \frac{1}{n}\sum_{k=1}^{n}\left|\frac{\left(y_k - y_k\right)}{y_k}\right| \tag{21}$$

$$Accuracy = \frac{1}{n}\sum_{k=1}^{n} q_k \tag{22}$$

5.4 Experiment analysis

In order to verify the effectiveness, the comparison of traditional models is also discussed. Six groups of comparative experiments were set up. The inputs are all weight distribution vectors. Verify the effect of multi-dimensional feature extraction on the model when various models perform vector processing. The structure of the comparative experimental model is as follows.

1) The neural network (NN) is divided into input layer, hidden layer, output layer, each layer has its own particularity. Among them, the input layer is mainly the entrance after feature processing. The hidden layer is used to train the corresponding function. The more nodes there are, the more complex the trained function will be. The output layer outputs the corresponding prediction results, and the more common one is the prediction model.

2) The deep neural network (DNN) has only two layers, the input and the output layer. The neural network mainly uses a neuron model called sigmoid neuron, which is mainly a linear structure.

3) Artificial Neural Network (ANN) is a nonlinear statistical modeling and decision-making method, and a simple ANN model is constructed to calculate the prediction weight model.

4) SVM uses supervised learning to predict data (same as logistic regression).

5) Using the PSO algorithm to optimize the parameters in the SVM modeling can make the selection of parameters more reasonable and avoid the randomness of artificial selection. Build a PSO-SVM prediction model.

6) The EMD method is added to the PSO-SVM model to introduce the prediction of the error. A prediction model based on the fusion of EMD-PSO-SVM method is established.

Table 3. Experimental results

Modele	Evaluation standard		
	RMSE	MAE	Accuracy
NN	0.223	0.174	74.23
DNN	0.227	0.179	77.42
ANN	0.251	0.183	78.98
SVM	0.242	0.189	88.35
PSO-SVM	0.236	0.166	91.22
EMO-PSO-SVM	0.205	0.137	94.71

As can be seen from Table 3, EMO-PSO-SVM has higher accuracy for education management system on the dataset than other models. The best experimental results of other models, EMO-PSO-SVM improves the accuracy by 4.34% and 3.47%. The performance of EMO-PSO-SVM is also significantly improved. Compared with the best performing PSO-SVM among other models, the mean squared error of EMO-PSO-SVM in the above datasets decreases by 2.5% and 4.1%, respectively. The results also show that EMO-PSO-SVM can extract text features more accurately using EMO, resulting in higher and more accurate accuracy. Furthermore, in the case of multi-dimensional fusion datasets, the expressive performance of PSO is better than that of a single SVM prediction model. Other traditional machine learning models tend to extract local features without the concept of time series. However, in text processing, the previous word affects the next word. In general, EMO-PSO-SVM has fewer training parameters, but the training time is longer than other models, and the training efficiency is also worse. Moreover, the EMO method reduces the unimportant data of multi-dimensional data less, is easier to train than PSO-SVM, and is not easy to overfit.

Table 4. Training time (/s)

Model	Time
NN	1039
DNN	1823
ANN	247
SVM	332
PSO-SVM	552
EMO-PSO-SVM	356

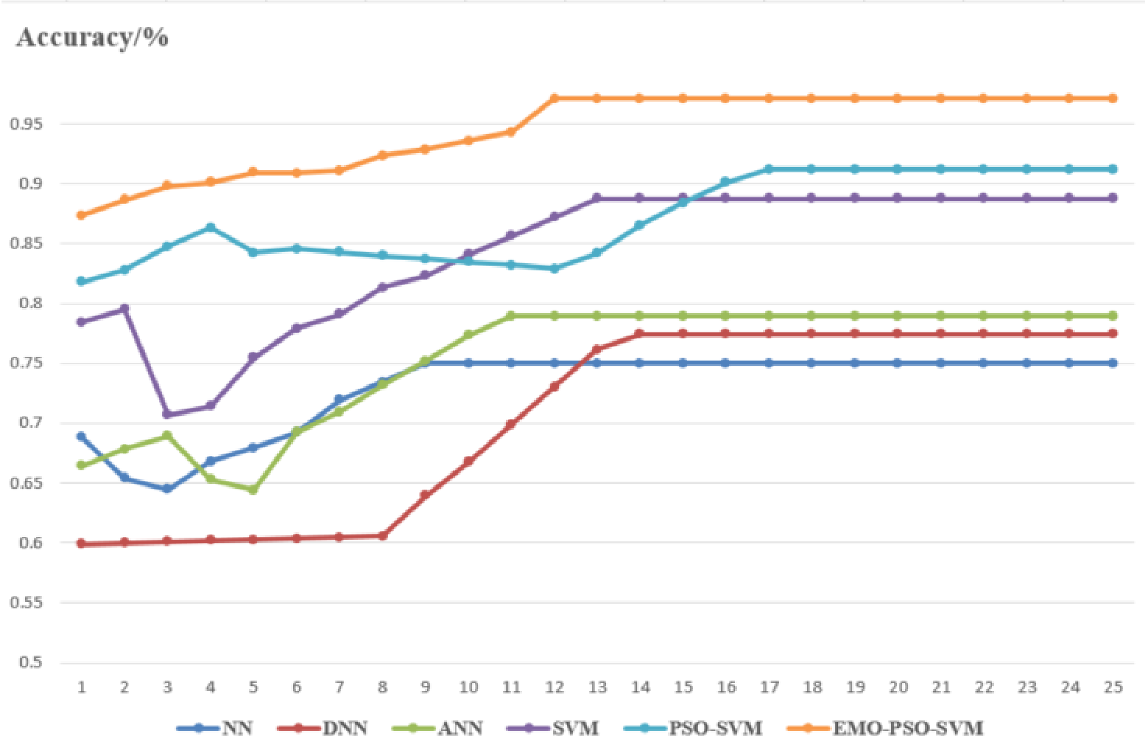

Figure 4. Experimental results

From Figure 4, the accuracy rates of these models are not much different, indicating that the functions of the traditional machine learning model and the model proposed are close. The multi-dimensional data processed by the EMO method significantly outperforms other models. It shows that EMO effectively reduces the complexity of multi-dimensional data. Overall, the EMO-PSO-SVM model performs better. EMO-PSO-SVM can better correlate context and multi-feature fusion data, and combining EMO method to reduce deep features outperforms other models in terms of accuracy and RMSE value.

6 Conclusion

Machine learning is combined with education management system to analyze multi-dimensional data. This paper proposes a system management system based on machine learning and multi-dimensional data modeling. The traditional education management system does not consider the multi-dimensional problem of data and the prediction method used is relatively traditional, and the accuracy rate is not high. In response to these problems, first of all, a complete educational management system is proposed. At the same time, the EMO method is used to analyze and process the collected multi-dimensional data. Then, the EMO-PSO-SVM prediction model for education management system is proposed. Finally, the experimental results show that the EMO-PSO-SVM model proposed in this paper is effective in educational management systems. It can be applied in the study of educational management system. Although the model can be predicted, according to the feasibility analysis, it is necessary to start from practical application in future work, apply it in the education management system of major universities, continuously optimize the model, and improve the model with higher matching degree.

Acknowledgements

Hunan province 2019 teaching reform research in colleges and universities (general education) achievement project, “Research on the design and development of online open course under the background of creating “golden course” education -- Taking decorative pattern design course as an example” (20190691).

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