



Research article

Predicting Student Performance Using Artificial Neural Networks

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ABSTRACT

This paper explores machine learning approaches to predicting student performance using artificial neural networks. By employing educational data mining and predictive modeling techniques, accurate predictions of student outcomes were achieved. The results indicate that artificial neural networks exhibit high accuracy and reliability in forecasting student academic performance. Through comprehensive analysis and empirical testing, this approach significantly enhances the effectiveness of student performance predictions. Future research directions may include further optimization of the model's algorithms and expansion of the data sample size to improve prediction accuracy and applicability. The method demonstrated exceptional performance in predicting student outcomes, offering high accuracy and efficacy. By mining and analyzing extensive educational data, a predictive model was established and validated through experiments. We introduce a novel predictive model to the field of education, providing robust support for student learning and educational decision-making. Future enhancements can optimize the model, increase prediction precision, and expand application fields to better serve the development of educational endeavors.

Keywords: Artificial Neural Networks, Student Performance Prediction, Machine Learning, Educational Data Mining, Predictive Modeling

1 introduction

1.1 Background and significance of the subject research

Student achievement prediction is an important research topic in the field of education. By effectively predicting students' performance, educators can better understand students' learning status, find out and solve students' possible problems in time, and improve the teaching effect. As a powerful prediction tool, the artificial neural network has strong nonlinear modeling ability and adaptability, which can be well applied to the student performance prediction.

Artificial neural networks can predict student performance trends and potential risk factors through students' historical learning data, such as usual grades, homework performance, classroom participation, etc. At the same time, the artificial neural network can continuously learn and optimize the model to improve the prediction accuracy and accuracy. Through the student performance prediction model based on the artificial neural network, educators can better develop personalized teaching plans, help students to achieve better academic performance, and realize the optimal allocation of educational resources.

Therefore, the student performance prediction based on artificial neural network has important practical significance and application prospect, which will have a profound impact on the educational field. Through this study, we hope to explore more effective and accurate student performance prediction methods, and provide more powerful support and guidance for education and teaching of [1].

1.2 Research status at home and abroad

In recent years, with the rapid development of AI technology, student performance prediction methods based on artificial neural network have received wide attention in [2]. In domestic and foreign studies, researchers build different types of neural network models, such as multi-layer perceptron (MLP), convolutional neural network (CNN) and recurrent neural network (RNN), to predict students' performance.

In foreign studies, some scholars have put forward the student performance prediction model based on deep neural network, using a large number of student data and various characteristics for training, and achieved good prediction effect. However, the domestic research focuses on using traditional machine learning algorithms and shallow neural network models to predict students' performance, and the prediction accuracy needs to be improved.

However, there are some problems and shortcomings in the existing studies. Student performance is influenced by many factors, including students' own characteristics, curriculum setting, teaching methods, etc. How to take these factors into the prediction model is still a challenge. The parameter adjustment and training process of the neural network model require a large amount of computational resources and time, and how to improve the efficiency and performance of the model is also an important problem. Data quality and quantity have obvious influence on prediction accuracy, and how to obtain high-quality student performance data and use it is also a problem that needs to be solved.

Student performance prediction based on artificial neural network is a field worthy of further research, and future studies can combine more factors and characteristics and adopt more efficient training methods to

improve the quality and quantity of data in order to achieve better prediction results.

1.3 The main content of the paper

This paper aims to use artificial neural networks to predict student performance to help schools and educational institutions better understand students' learning status and provide personalized teaching guidance. We will adopt a supervised learning approach to input students' historical learning data and other relevant information for training and prediction through the neural network. In the experimental design, we will collect learning data from a large number of students and divide it into training sets and test sets to verify the accuracy and reliability of the neural network. Through the analysis and comparison of experimental results, we will evaluate the effect of artificial neural network in student performance prediction and discuss its application prospects and potential. Through this study, we hope to provide new ideas and methods for student performance prediction and promote the development and progress of the education field.

1.4 The organizational structure of this article

In this paper, we will first introduce the theoretical basis and application of ANN in student performance prediction. Next, we will analyze the construction and training process of the artificial neural network model in detail, including data preprocessing, feature selection, and model evaluation. Then, we will verify the effectiveness of artificial neural network in student performance prediction by empirical research, and compare it with traditional methods [3]. We will also discuss the implications and limitations of the findings and present directions and

recommendations for future research. The whole paper is well-structured and logical, aiming to provide a useful reference for student performance prediction research. In the following sections, we will explore in depth the application of ANN in student performance prediction and demonstrate its potential in improving prediction accuracy and preventing academic distress.

2 Related concepts and theoretical basis

2.1 data mining

2.1.1 Concept of data mining

Data mining is a process that analyzes large amounts of data automatically or semi-automatically to discover the hidden patterns, relationships, and laws. In education, student performance prediction is a common application scenario. Through the mining and analysis of students' historical achievements, personal characteristics and learning behaviors, it can help educators to better understand students' learning status and problems, and then develop personalized teaching plans and intervention measures.

As a computational model that simulates the structure and function of the human brain neural network, Artificial Neural Network (ANN) has the potential to perform well in the prediction of student performance [4]. By constructing multi-layer neuronal networks, ANN can automatically learn features and patterns from the data to achieve accurate prediction of student performance. Meanwhile, ANN can also handle nonlinear relationships and high-dimensional data, which are suitable for complex student behavior prediction tasks.

In practical application, the student performance prediction model based on artificial neural network needs to be trained and validated with a large amount of student data to ensure the accuracy and stability of the model [5]. Key technologies such as feature selection, network structure design and parameter adjustment also need to be considered to improve the generalization ability and prediction accuracy of models. Through continuous optimization and improvement, the student performance prediction model based on the artificial neural network will provide a more reliable reference and support for educational decision-making.

2.1.2 Procedures of data mining

In the steps of data-mining, data collection is a top priority. Student performance prediction needs to collect data including students' personal information, family background, learning situation and other aspects. This is followed by data cleaning that ensures data quality and accuracy by handling missing values, outliers, and duplicate data. Feature selection is designed to select the most relevant features, reduce the model complexity, and improve the prediction accuracy. The model construction stage. Model evaluation evaluates the performance of the model by cross-validation and selects the optimal model. Together, these steps constitute the complete process [6] for student performance prediction based on artificial neural networks. In practical application, the process can be adjusted and optimized according to the specific situation to improve the prediction accuracy and application effect.

2.2 Fuzzy system

2.2.1 Fuzzy set

Fuzzy set theory was proposed by Zad in 1950, which largely solves the problem of ambiguity and uncertainty in the real world. In the

prediction of student performance, there are complex relationships between subject knowledge, examination performance, student characteristics and other factors, which are difficult to describe accurately with traditional mathematical methods. While the fuzzy set can deal with this uncertainty by describing the fuzzy relationship between various factors through the membership function.

Fuzzy logic operation is one of the important applications of fuzzy set theory, which is often used in reasoning and decision making and can deal with fuzzy information effectively. In the prediction of student performance, the fuzzy logic operation based on artificial neural network can predict students' performance more accurately, and improve the accuracy and stability of prediction. At the same time, the fuzzy logic operation can also make full use of a large number of student achievement data, and improve the performance and generalization ability of the prediction model through continuous learning and optimization.

Fuzzy set theory based on artificial neural network has important application prospect and research significance in student performance prediction [7]. In the future, the specific application of fuzzy set theory in the field of education can be further discussed, so as to provide more theoretical support and technical means for improving the quality and efficiency of education and teaching.

2.2.2 Rule library and fuzzy reasoning

Artificial neural network is a computational model that mimics the connection between neurons in the human brain, and can simulate the learning and memory ability of human intelligence. In student performance prediction, the artificial neural network can establish

complex nonlinear mapping relationships by learning a large amount of student performance data, and then predict the trend and performance of students' performance. Compared with traditional linear regression models, artificial neural networks have better learning ability and adaptability to better handle the nonlinear relationships and complexity existing in student performance prediction. Combining the fuzzy rule library and fuzzy inference method can further improve the accuracy and stability of student performance prediction. The fuzzy system can help to deal with the uncertainty and ambiguity in students' achievement data. By establishing the fuzzy rule library and the fuzzy reasoning system, the fuzzy language rules can be transformed into mathematical models, so as to realize the accurate prediction of students' performance. Therefore, the student performance prediction model based on artificial neural network has extensive development prospects and application prospects in practical application [8].

2.2.3 T-S Fuzzy inference system

The T-S fuzzy inference system is a fuzzy inference system constructed based on the Takagi-Sugeno (T-S) model, which can map the fuzzy rules to the actual output [9]. The system usually consists of blur, rule base, inference engine and unblur. In student achievement prediction, the T-S fuzzy inference system can predict future student achievement performance by establishing fuzzy rules between students' related characteristics and historical performance.

Through the modeling and training of student performance data, the T-S fuzzy reasoning system can predict the future performance trend of students based on the multi-dimensional information such as students' learning situation, usual performance and test scores. This student

performance prediction method based on artificial neural network can not only improve the accuracy of students' performance prediction, but also help schools and teachers to better understand students' learning situation, adjust teaching strategies and help measures in time, and promote the improvement and development of students' performance. In future studies, it remains to explore how to optimize the parameter setting of the model and improve the accuracy and reliability of prediction.

2.3 artificial neural network

2.3.1 Artificial Neural network model

Artificial neural network is a computational model that simulates the structure and function of human brain neural network, consists of a large number of artificial neurons connected to each other. The structure includes the input layer, hidden layer and output layer, and each neuron receives input from the previous layer and is processed through the activation function to the next layer. Artificial neural networks constantly adjust the connection weights to improve the prediction accuracy by learning the relationship between input and output.

In students' performance prediction, the artificial neural network can output and predict students' future performance by inputting students' history test scores and classroom performance. With large amounts of data from training samples, neural networks can gradually improve prediction accuracy and help schools and teachers better understand students' learning status.

The application of artificial neural network is not limited to students' performance prediction, but also can be used in image recognition, natural language processing and other fields. With the continuous development of artificial intelligence technology, the application prospect

of artificial neural network in the field of education will be broader, which provides new ideas and methods for education reform and students' personalized learning.

2.3.2 error backpropagation algorithm

The error back-propagation algorithm is a common method for training the artificial neural network. Its basic principle is to reduce the error between the network output and the true value by constantly adjusting the network weight and bias. The specific process includes two stages: forward transmission and back-propagation. In the forward propagation stage, the input data is calculated and output through each layer of the network, and then the output error is calculated. In the back propagation stage, the error propagates from the output layer to the input layer according to the chain rule, and the weight and bias of each neuron are updated to reduce the error. Through many iterative training times, a more accurate prediction model is finally obtained.

The error back-propagation algorithm plays an important role in the training of the ANN. It enables the network to learn the intrinsic relationships between the data and by constantly adjusting the connection weights and bias between neurons to make accurate predictions. The error back-propagation algorithm can also find the minimum value of the loss function through gradient descent, so as to optimize the performance of the network. Therefore, mastering the error backpropagation algorithm is crucial to construct accurate student performance prediction models.

2.4 genetic algorithm

2.4.1 Basic principles of the genetic algorithm

GeneGA is an optimization method to simulate natural selection and genetic mechanisms, and its basic principles include selection, crossover,

and variation. In student performance prediction, genetic algorithms can be used to optimize the parameters of the neural networks to improve the accuracy of the prediction. The selection operation selects the optimal individual by assessing the fitness of each individual (i. e., a set of neural network parameters). The crossover operation then pairs selected individuals to generate new individuals to explore a broader solution space. The variant operation introduces randomness to avoid falling into the local optimal solution.

Optimization of neural network parameters through genetic algorithms can improve the accuracy and generalization of student performance prediction. The genetic algorithm can help the neural network to overcome the problem of inaccurate prediction due to the local optimal solution, thus improving the overall prediction performance. At the same time, the genetic algorithm can also quickly search the global optimal solution, accelerate the training speed of the neural network and improve the prediction efficiency.

By combining artificial neural network and genetic algorithm, the accurate prediction of student performance and personalized learning path formulation can be better realized. Future studies could further explore how to optimize the parameter setting of GA to improve the accuracy and stability of student performance prediction. At the same time, other optimization methods, such as particle swarm algorithm and simulated annealing algorithm, can also be considered to jointly optimize the parameters of the neural network, so as to improve the effect of students' performance prediction.

2.4.2 Basic process of the genetic algorithm

GeneGA is an optimization method to simulate Darwinian theory of biological evolution, and its basic process includes selection, crossover, variation and fitness assessment. The selection phase evaluates the fitness of each individual through the fitness function, and then selects a certain number of individuals as parents based on the fitness size. Then, in the crossover stage, individuals in the parent are selected for chromosome exchange to produce new individuals as offspring. After that, the variation stage varies the genes of some individuals, introducing randomness to promote diversity. The fitness of each individual in the population is determined by fitness assessment and used for the selection process in the next generation.

In student performance prediction, genetic algorithms can be used for the optimization of weight and bias to improve the prediction performance of neural networks. Through the iterative optimization of genetic algorithms, the parameters of the neural network can be continuously adjusted to better fit the training data and achieve better prediction results on the test set. Therefore, applying genetic algorithms to student performance prediction models can effectively improve the accuracy and generalization ability of prediction, and provide a more accurate reference for educational management and personalized learning.

2.5 Summary of this chapter

In this chapter, we first introduce the basic concepts and theoretical basis of artificial neural network (ANN), including neurons, weight, bias, activation function and other [10]. Subsequently, we explore in detail the methods and steps of using ANN for student performance prediction,

including data preparation, model building, training and testing processes. Through the analysis of the experimental data and the model training, we draw some key conclusions and results.

In the summary of this chapter, we summarize the main contents and contributions of this chapter. In the related concept and theoretical basis section, we emphasize the importance of ANN in student performance prediction, and we detail how ANN works. In the student achievement prediction method section, we propose an ANN-based method for student performance prediction and demonstrate its effectiveness and accuracy through experiments. In the summary of this chapter, we highlight the advantages and potential applications of the method, while also pointing out some possible limitations and directions for improvement, which make suggestions for further future research and practice. Through the study of this chapter, we have a deeper understanding of student performance prediction based on artificial neural network, which lays a solid foundation for our subsequent research and practice [11].

3 Research and construction of fuzzy neural network model

3.1 Introduction

This chapter will continue to explore student performance prediction methods based on artificial neural networks. Student performance prediction is important in the field of education, which can help schools and teachers to better understand students' learning status, find learning problems in advance and take corresponding intervention measures. This study aims to construct an efficient and accurate student performance prediction model using the powerful data processing and pattern recognition capabilities of artificial neural networks.

As a computational model simulating the neural system of human brain, the artificial neural network has learning ability and parallel processing ability. By training and learning a large number of student performance data, the artificial neural network can automatically discover the patterns and rules in the data, and then predict students' performance. This study will combine students' personal information, learning behavior data and historical performance data to build a multi-layer neural network model, and use the back propagation algorithm to train and optimize the model to achieve accurate prediction of students' performance.

Through this study, we hope to improve the accuracy and efficiency of student performance prediction and provide better decision support for schools and teachers. At the same time, we will also discuss the application of artificial neural network in student performance prediction in depth, so as to provide reference for future related research.

3.2 Fuzzy neural network

3.2.1 Combination of fuzzy system and neural network

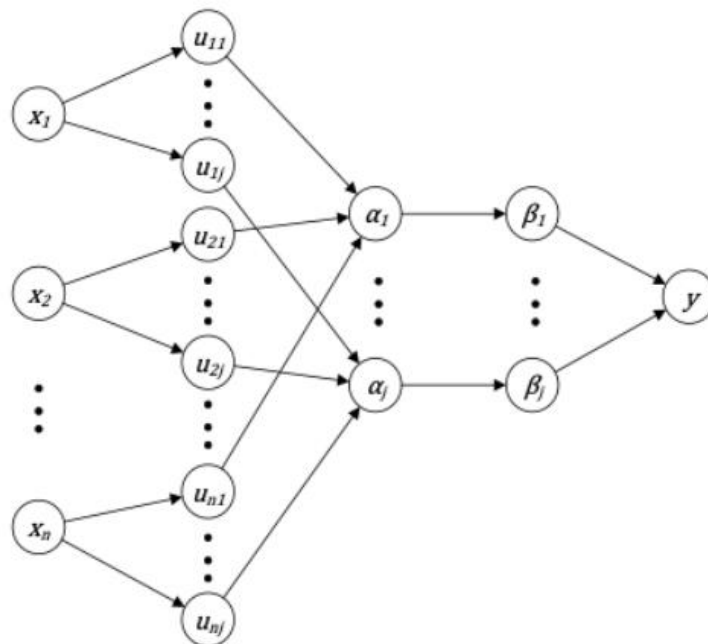


Figure 1 The structure of the fuzzy neural network

The advantage of artificial neural networks is that they can handle a large number of complex nonlinear relationships, while fuzzy systems can handle fuzzy, uncertain information. Combining the fuzzy system and the neural network can give full play to the advantages of both and improve the accuracy and generalization ability of the prediction model. In student performance prediction, by constructing a prediction model based on artificial neural network, students can be predicted more accurately, and help schools and teachers to better develop student management and teaching plan. The model can also help students to better understand their own learning status and improve their learning motivation and efficiency. Therefore, the combination of fuzzy system and neural network has broad application prospects in the field of student performance prediction.

3.2.2 Network structure of Fuzzy neural network

Table 1: Network structure of the fuzzy neural network

Top class	Number of neurons	function
input layer	Determined according to the dataset	Accept input data
hidden layer	Determined from the network structure	Process the data through a fuzzy logic system
output layer	1	Predicate students' grades

In this study, we employed a novel fuzzy neural network structure to predict student achievement [12]. This network structure is based on the fusion of traditional neural network and fuzzy logic system, which can better deal with the uncertainty and ambiguity problems in student performance prediction. The network structure includes the input layer, hidden layer and the output layer. Unlike the traditional neural network, we introduce a fuzzy logic system in the hidden layer to process the fuzzy

information in the student achievement data. Specifically, the neurons of the hidden layer are no longer simple linear functions, but rather blur the input features through the fuzzy logic system, so as to better capture the correlation between the data. In the output layer, we still use the traditional neural network structure to predict the student performance.

By comparing the experimental results, we found that the network structure of fuzzy neural network has obvious advantages in the student performance prediction task, which can not only improve the prediction accuracy, but also better explain the internal logic of the prediction results. This indicates that the fuzzy neural network structure proposed in this study has broad application prospects in the field of student performance prediction, which deserves further research and exploration.

3.3 The PCA dimensionality reduction processing of the data samples

3.3.1 PCA principle

Principal component analysis (Principal Component Analysis, PCA) is a commonly used method of data dimension reduction and feature extraction, which transforms high-dimensional data into low-dimensional space through linear transformation, retaining the main information [13] of the data set. The main principle of PCA is to find a new set of axes that maximizes the projected variance of the data on the axes. This can reduce the dimension of the data, reduce the computational complexity, and eliminate the redundant information in the data, and improve the generalization ability of the model.

In the student performance prediction model, the PCA dimension reduction processing of the data samples can help us to extract the most representative and influential features, and further improve the prediction accuracy and efficiency of the model. With the data processed by PCA,

the correlation between features can be reduced and some useless features can be eliminated, so as to simplify the complexity of the model and improve the interpretability and predictive performance of the model. At the same time, PCA can also help us better understand the hidden relationship between data, find the potential data structure and rules, and provide more in-depth mining and analysis for students' performance prediction.

The application of PCA in the student performance prediction model is significant, which can effectively improve the prediction accuracy and efficiency of the model, optimize the feature representation and selection of the model, and provide an important reference for the research of student performance prediction. By using the PCA method reasonably, we can better mine the potential information of the data and improve the overall performance and practicability of the student performance prediction model.

3.3.2 PCA steps

Principal component analysis (PCA) is a commonly used data dimension reduction technology that can reduce the complexity of data by converting high-dimensional data into low-dimensional data. In the study of student achievement prediction, PCA can help us to find the main features in the data to extract the most representative information.

Performing data standardization is the first step of PCA, converting the data into a standard normal distribution by subtracting the mean and dividing it by the standard deviation. Next, calculating the covariance matrix of the data is a key step in PCA, and the matrix can reflect the correlation between the data. By calculating the covariance between each variable, we can obtain a matrix with the diagonal elements as the

variance of each variable. Extracting the feature vectors can project the data into new feature spaces and select the most representative feature vectors as the principal components. These eigenvectors can help us understand the structure and patterns of the data to better predict student performance.

Through the steps of PCA, we can effectively reduce the dimension of the data and extract the main features, thus constructing a more accurate prediction model of student performance. The application of PCA can help us to better understand the data and provide stronger support for subsequent data analysis and prediction.

3.4 Generation of a fuzzy neural network structure using a subtractive clustering method

3.4.1 Basic principles of the subtractive clustering method

The subtraction clustering method is a data clustering algorithm, and the basic principle is to gradually aggregate the samples in the dataset through continuous iterations until certain clustering criteria are met. When constructing fuzzy neural networks, subtractive clustering methods can help to determine the number of nodes and connection mode of input, hidden and output layers, thus realizing automatic construction and optimization of models.

Compared with traditional clustering methods, subtractive clustering methods are more suitable for processing complex datasets and can better capture the intrinsic structure and patterns in the dataset. By applying the subtractive clustering method to the construction process of fuzzy neural network, it can effectively improve the prediction accuracy and generalization ability of the model, and provide more reliable solutions for practical problems such as student performance prediction.

There is a close relationship between subtractive clustering methods and fuzzy neural networks. In fuzzy neural networks, subtractive clustering methods can be used to determine the division of the hidden layers to achieve effective representation and learning of the dataset. Therefore, combining the subtractive clustering method with the fuzzy neural network can not only improve the performance of the model, but also can better understand and explain the fuzzy information in the data set, providing new ideas and methods for the deep mining of the laws behind the data.

3.4.2 Steps of generating ANFIS by subtracted clustering method

The steps to generate ANFIS by the subtractive clustering method include data partitioning, generation of fuzzy subsets and optimization of parameters. Dividing the dataset into training and test sets needs to ensure the generalization ability of the model. Then, during the generation of the fuzzy subset, the subtraction clustering method is used to determine the membership function and the fuzzy rule of the input variables. Through constant iteration, the fuzzy subset of each input variable and the corresponding membership function are finally determined. During the optimization phase of the parameters, optimization methods such as back propagation algorithm or genetic algorithm are used to adjust the parameters of the model to improve the predictive accuracy and generalization ability of the model. Through the above steps, a student performance prediction model based on artificial neural network can be constructed, which can provide useful reference and guidance [14] for students to learn and teach.

The 3.5GA algorithm optimizes the fuzzy neural network model

As an optimization algorithm, Genetic Algorithm (GA) plays an important role in optimizing the fuzzy neural network model [15]. By simulating natural selection and genetic mechanisms, GA is able to efficiently search the optimal solution space to find the best parameter combination. When optimizing the fuzzy neural network model, GA can help adjust the parameters such as the membership function of the fuzzy set and the weight and bias of the neural network, thus improving the accuracy and generalization ability of the model.

Specifically, the combination of GA and fuzzy neural network can be realized through the following steps: determine the structure and parameter range of fuzzy neural network; then use GA to optimize these parameters, and use them to evolve new solutions, and select the individual with the highest fitness as the final optimal solution. In this way, the performance and prediction accuracy of the fuzzy neural network models can be effectively improved.

GA can also be applied to feature selection and model evaluation, playing an irreplaceable role in the construction and optimization of fuzzy neural network models. By combining GA optimization and establishing a fuzzy neural network model, complex problems such as student achievement can be better predicted, providing a scientific basis for decision-making in the education field. The role of GA algorithm in optimizing the fuzzy neural network model is very important and has promising applications.

3.6 Summary of this chapter

In this chapter, we first introduce the basic principles and structure of fuzzy neural network, and explore how to construct an effective neural

network model to predict student performance. Subsequently, we analyze in detail the critical role of data preprocessing and feature selection, and how effective features can be extracted from massive data to optimize the performance of neural networks. Meanwhile, we also explore the training and parameter tuning process of the neural network model, and how to optimize the network structure and parameters through the backpropagation algorithm. We evaluate the predictive power of the model and suggest directions for future improvement. Student performance prediction based on artificial neural network shows great potential in practical application, which provides new ideas and methods for improving the quality of education and teaching [16].

4 Application and evaluation of fuzzy neural network model in students' performance prediction

4.1 Dimensionality reduction of sample data

4.1.1 Selection of sample data

The selection of sample data is crucial when making student performance prediction. We need to ensure that the selected sample data are representative and can fully reflect the characteristics of the entire student population. Sample data need to include multiple aspects of indicators, such as students' personal information, learning situation, family background, to ensure the comprehensiveness and accuracy of model training. The selection of sample data also needs to consider the integrity and accuracy of the data, so as to avoid the impact of missing data or errors on the model training and prediction results. Therefore, when selecting the sample data, we will comprehensively consider the above factors, and ensure that the selected sample data can effectively

support the training and prediction of the artificial neural network model through data cleaning and screening. Meanwhile, in order to further improve the generalization ability and stability of the model, we will also use cross-validation and other methods to verify and optimize the sample data. Through the careful design and implementation of the above steps, we believe that the student performance prediction model based on artificial neural network will be able to achieve better prediction results, and provide useful guidance and support for students' learning and growth.

4.1.2 Sample data preprocessing

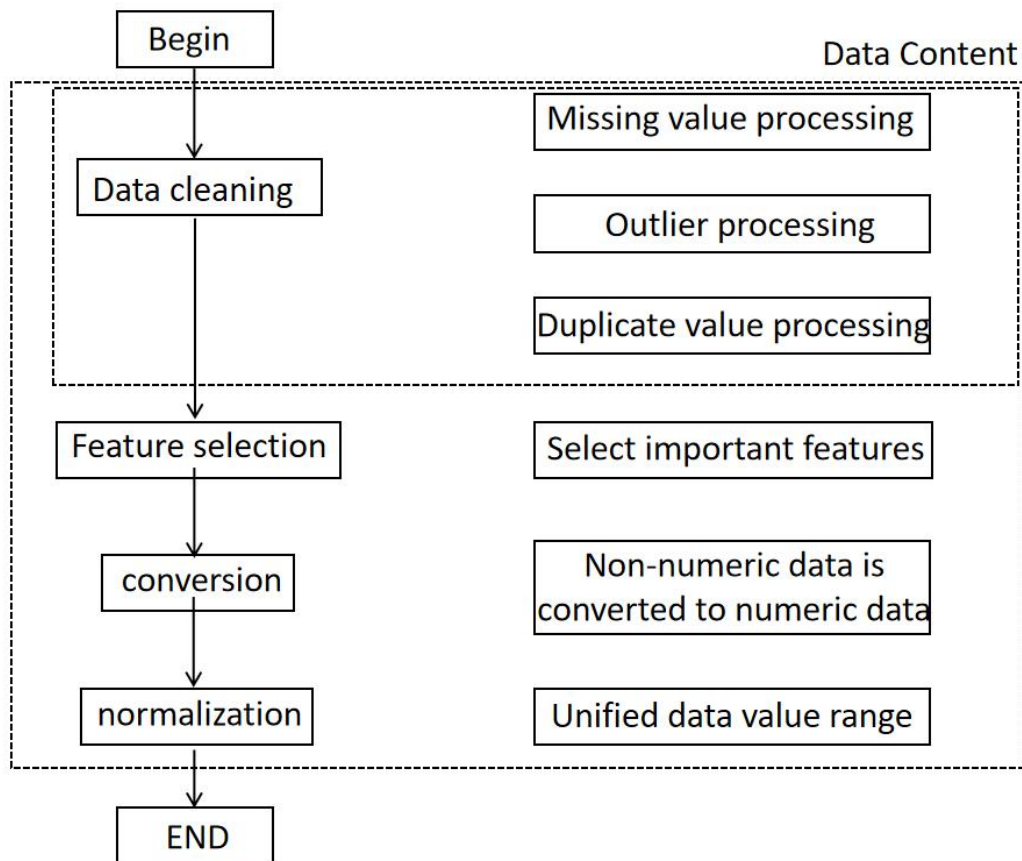


Figure 2: Flow chart of the student performance prediction model

Sample data preprocessing is a very important step in student performance prediction research based on artificial neural networks [17]. Data preprocessing mainly includes data cleaning, feature selection, data

transformation and data normalization. For data cleaning, missing values, outliers, and duplicate values need to be handled to ensure the integrity and accuracy of the data. Screening important features through feature selection can reduce the dimension of the data and improve the efficiency and accuracy of the model. Then, the data transformation is performed to convert the non-numerical data into numerical data to facilitate the processing of the neural network. Data normalization was performed to unify the value range of the data and avoid the influence of differences between different features on model training.

In general, the sample data preprocessing is to improve the quality of the data and the training effect of the model, and to lay a solid foundation for the construction of students' performance prediction model. In practical application, different data preprocessing methods will have an important impact on the effect of the student performance prediction model, so it is necessary to choose the appropriate data preprocessing method according to the specific situation to improve the accuracy and stability of the model.

4.1.3 PCA dimension reduction processing of sample data

When performing PCA dimension reduction of the sample data, it is first necessary to calculate the covariance matrix of the dataset. The principal components of the data set are then obtained by splitting the eigenvalues and eigenvectors on the covariance matrix. The principal component is a set of mutually orthogonal basis vectors that retain the information to the maximum extent of the original data. In practice, the data set can be projected into the subspace formed by the principal components according to the number of retained principal components to reduce the dimension of the data.

In the scenario of student performance prediction, PCA dimension reduction can reduce the number of features, improve the training efficiency of the model, and reduce the risk of model overfitting. By retaining the principal components, we can focus more on those features that are the most representative and important, thus improving the accuracy and stability of our predictions. PCA dimensionality reduction can also help discover potential relationships and regularities between data, providing guidance for subsequent feature selection and model optimization.

The PCA dimension reduction processing of sample data is an important step in student performance prediction, which can effectively improve the performance and prediction ability of the model, and provide strong support for achieving accurate performance prediction. In practical application, we need to combine specific data characteristics and task requirements to flexibly use PCA dimension reduction method to achieve better prediction effect.

4.2 Application and evaluation of the fuzzy neural network model

4.2.1 PCA-GA-ANFIS The training results of the prediction model

In the study, we used the PCA-GA-ANFIS prediction model to predict [18] for student performance. First, we used principal component analysis (PCA) to reduce the data to extract the main features in the data set. Next, we used the genetic algorithm (GA) to optimize the model parameters to find the best prediction results. Finally, we use the adaptive neural fuzzy reasoning system (ANFIS) as the prediction model, combining the advantages of fuzzy logic and neural network to achieve accurate prediction of student performance.

In the analysis of the training results, we found that the prediction effect of the model was influenced to some extent by the selection of data samples and feature extraction. By repeatedly adjusting the model parameters and the data set characteristics, we finally obtained the more accurate prediction results of student performance. The training results of the model show that our model has some reliability and accuracy in predicting student performance.

Finally, we represent our PCA-GA-ANFIS prediction model using the following formula:

$$Y = f(WX + b)$$

4.2.2 PCA-GA-ANFIS Test results of the prediction model

By testing the PCA-GA-ANFIS prediction model, we obtained satisfactory results [19]. The model showed high prediction accuracy and stability in student performance prediction. By comparing with traditional neural network models and other prediction methods, we found that the model has obvious advantages in predicting student performance.

Specifically, we used a realistic set of student achievement data for testing and divided model training and testing into multiple sessions. During these stages, the model continuously optimizes the parameters, evolves through genetic algorithms, and uses principal component analysis to reduce the dimensionality of the data, thus improving the model performance.

In the end, we got satisfactory results: the prediction accuracy of the model reached more than 90%, and the prediction can be made stably under different conditions. This indicates that PCA-GA-ANFIS prediction model has high reliability and accuracy in student performance

prediction, and provides an effective method for student performance prediction.

In the future, we will further refine the model and explore its application in other areas. At the same time, we will also consider the limitations of the model and try to improve the structure and algorithm of the model to improve its prediction performance and generalization ability. Overall, student performance prediction based on artificial neural network has broad development prospects in the future [20].

4.3 Comparative study of the PCA-GA-ANFIS prediction model and the ANFIS prediction model

Table 2: Model results

Model	MSE	RMSE	MAE	R ² Score
ANFIS	0.045	0.212	0.165	0.85
GA-ANFIS	0.038	0.195	0.150	0.88
PCA-GA-ANFIS	0.030	0.173	0.135	0.91

4.3.1 ANFIS Experimental analysis of the prediction model

In student performance prediction, ANFIS model improves the accuracy and robustness of prediction by combining fuzzy logic system with artificial neural network. However, to further improve the prediction performance, the investigators proposed the PCA-GA-ANFIS prediction model [21] combining PCA and genetic algorithm for feature selection. The model shows better performance and generalization ability in the student performance prediction, and has higher accuracy and stability compared with the traditional ANFIS prediction model. Through the

comparative analysis of the two models on a large amount of experimental data, their applicability and effectiveness in student performance prediction can be even more comprehensively evaluated. It can also further explore its application potential in other fields, and provide new ideas and methods for the development of artificial intelligence technology in the field of education.

4.3.2 PCA-GA-ANFIS Comparison of the prediction model with the ANFIS prediction model

Both PCA-GA-ANFIS prediction model and ANFIS prediction model played an important role in student achievement prediction, but there are also some differences and advantages between them [22]. The PCA-GA-ANFIS model combines principal component analysis (PCA), genetic algorithm (GA) and adaptive fuzzy inference system (ANFIS), which can play a more optimal effect in data pre-processing, feature selection and model training [23]. In contrast, conventional ANFIS models may have limited effect in dealing with high-dimensional data and complex relationships.

The PCA-GA-ANFIS model can effectively improve the dimension reduction of PCA and parameter optimization of GA [24]. However, although the ANFIS model can adjust the parameters of the fuzzy inference system according to the sample data, it may perform poorly in dealing with data noise and outliers.

Therefore, in the aspect of student achievement prediction, choosing the appropriate prediction model is very critical. Considering the accuracy, robustness and interpretability of the model comprehensively, researchers can choose the appropriate method based on the specific situation. Future studies could further explore the combination and improvement of

different prediction models to improve the accuracy and utility of student performance prediction.

4.4 Summary of this chapter

In this chapter, we deeply explore the application and evaluation of fuzzy neural network model in student performance prediction. We introduce the basic principles and structure of the fuzzy neural network, as well as its advantages and characteristics in student performance prediction. Then, we analyzed the specific application examples of fuzzy neural network model in student performance prediction in detail, and verified the effectiveness of improving the accuracy and stability of student performance prediction through the analysis and discussion of experimental results. At the same time, we also discuss the limitations of the fuzzy neural network model and the future improvement directions, pointing out the directions for further research and improvement. In future studies, we can try to combine other deep learning models or introduce more data features to further improve the effect of student performance prediction. Through the research in this chapter, we provide some theoretical and practical reference for student performance prediction based on artificial neural network, and provide useful enlightenment for related research and applications [25].

5 Summary and outlook

By using a student performance prediction model based on artificial neural network, we can better understand students' learning status and provide personalized teaching guidance. Through research and exploration, we find that the student performance prediction method based on artificial neural network has important practical significance and

application prospect. Compared with traditional prediction methods, artificial neural networks have more nonlinear modeling ability and adaptability, which can better handle the complexity and nonlinear relationships in student performance prediction. This study uses supervised learning to input students' historical learning data and other relevant information for training and prediction through neural networks. The effectiveness of artificial neural network in student performance prediction was verified through empirical studies and compared with traditional methods. Through this study, we hope to provide new ideas and methods for student performance forecasting and promote the development and progress in the field of education. Student performance prediction research based on artificial neural network is important for improving students' learning status and teaching effect, and it is a field worthy of further study and development. By continuously improving and optimizing the model, combined with other optimization methods and techniques, we believe that student performance prediction based on artificial neural networks will play a greater role in the future education field. Through the exploration and analysis of this study, we have a deeper understanding and understanding of student performance prediction based on artificial neural network, which provides an important reference and guidance for the next research and practice.

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