Research on Personalized Teaching Strategies Selection based on Deep Learning

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Abstract. Traditional classroom teaching model can no longer meet the needs of students' ability development. As a new model actively advocated in the modern education concept, personalized teaching focuses on the development needs of students and emphasizes respect for students' individualized growth. In this work, we utilize deep learning method to recommend teaching strategies for different features of students. Specifically, the proposed method includes the construction of a multi-layer neural network model, which can analyze students' multi-dimensional learning data and behavior patterns, so as to recommend the most suitable teaching strategies for individual students. Through data collection and preprocessing, model architecture design, model training and optimization, the model gradually improves the accuracy of prediction and recommendation. Experimental analysis verifies the effectiveness of the model through field teaching experiments, and the results show that the personalized teaching strategy based on deep learning can significantly improve the learning effect and participation of students.

Keywords: Personalized Teaching, Strategies Selection, Deep Learning, Individual Development.

1   INTRODUCTION

The traditional unified mode of teaching can no longer meet the educational needs of the current information age. With the support of technologies such as the Internet, big data, and artificial intelligence, scholars continue to explore new teaching models, and personalized teaching has emerged as the times require, and has become an active model in modern educational concepts [1]. Personalized teaching is centered on the developmental needs of students, emphasizing respect for the development of students' individuality, and improving educational effectiveness and students' all-round development by using advanced technology to analyze and meet the unique needs of each student.

Many countries, such as the United States, Japan and Europe, have formulated strategic plans for the development of education, and invested a lot of energy and funds in the practice of personalized teaching, exploring the development path of this emerging teaching model, and realizing the transformation of the education model with technical support. The development of personalized teaching abroad has undergone three major changes, namely the changes led by the teaching system, educational informatization and data intelligence [2]. Different scholars have defined and divided personalized teaching from different perspectives, and generally believe that personalized teaching is a mode that uses intelligent technology to build a smart teaching environment to meet the personalized needs of learners. This teaching mode is based on the deep integration of technology and teaching, the teaching process is reengineered and wisdom generated, and teachers and students are provided with unlimited participation and self-worth improvement development space [3].

Individualized teaching believes that teaching staff should pay attention to the individual differences of students and carry out targeted teaching. In its 1972 report, the United Nations also emphasized that the most important purpose of education is "to promote the comprehensive and harmonious development of the individual". Scholars have elaborated and discussed personalized teaching from different theoretical perspectives, such as cognitive psychology, constructivism, multiple intelligences theory, and self-determination theory [4].

Effective personalized teaching for students' differences can be achieved through a variety of implementation strategies and methods, including hierarchical teaching, group teaching, self-selected teaching, project-based teaching, and flipped classroom. Foreign scholars also use information technology and artificial intelligence technology to support the implementation of personalized teaching, and have developed various software platforms and tools, such as intelligent tutor systems, adaptive systems, recommendation systems and visualization systems, so as to realize the personalized customization of teaching content, personalized guidance of teaching process and personalized evaluation of teaching effect [5]. These research and practices not only improve the effectiveness of personalized teaching, but also provide students with a richer and more personalized development space.

Individualized teaching is an educational philosophy and method that respects students' individual differences and provides teaching content, methods and paths suitable for each student's learning characteristics and needs [6]. The aim is to promote the all-round development and potential development of each student, and to cultivate their self-directed learning ability and innovative spirit. Personalized teaching includes not only the individualization of teachers' "teaching", but also the individualization of students' "learning", which always runs through the concept of taking students as the main body [7]. In the teaching process, teachers guide students and provide appropriate teaching content according to the differences in students' learning experience and personality thinking, so as to stimulate the potential of each student and explore and develop their strengths.

2   RELATED WORK

Scholars have used information technology and artificial intelligence to support the implementation of personalized teaching, and developed various software platforms and tools, such as intelligent tutor systems, adaptive systems, recommendation systems and visualization systems, so as to realize the personalized customization of teaching content, personalized guidance of the teaching process and personalized evaluation of teaching effects [8]. Existing research has focused on technology-based model design to explore ways to personalize teaching.

Based on the Thinkn Learn mobile web platform, Ahmed [9] researched induced self-directed inquiry and explored how mobile technology can support the development of students' self-directed learning and inquiry skills. Alelaiwi et al. [10] discussed the real-time interaction between teachers and students through streaming media servers in engineering courses, which can effectively improve the interactivity of teaching and the effect of instant feedback. These studies demonstrate the application potential of information technology in different educational scenarios, and provide strong technical support for personalized teaching and real-time interaction.

Based on the E-Learning system, Conlan [11] uses a professional technical approach to build a teaching model that explains how to provide appropriate support for different students from the perspective of teaching strategies. The model analyzes students' learning data and behavior patterns to develop personalized instructional strategies to meet each student's unique needs. This approach not only focuses on students' learning progress and grades, but also takes into account their learning styles and interests, and aims to provide a comprehensive and personalized learning experience that improves learning outcomes and student engagement.

Specht [12] designed a model based on a digital learning system that emphasizes the ability to provide learning services for learners of all styles. Through intelligent algorithms and big data analysis, the model identifies the learning styles, interests, and needs of different students, and then recommends learning content and teaching methods in a personalized manner. This technology-based personalized learning service not only improves student learning efficiency and effectiveness, but also enhances the interactivity and engagement of the learning process, allowing each student to learn and grow in the environment that works best for them.

3   METHODOLOGIES

In this section, we explore a method of personalized teaching strategy selection based on deep learning. Specifically, a deep learning model is constructed to recommend the most suitable teaching strategy for individual students by analyzing students' learning data and behavior patterns.

3.1   Deep Learning Model

Collect multi-dimensional learning data of students, including learning progress, completion time for each unit, progress percentage, test scores, score per quiz, correctness, class participation, attendance, number of classroom interactions, homework completion, homework submission time, completion quality, online learning behavior, video viewing time, and number of clicks. These data are cleaned, normalized, and feature extracted to form a data matrix $X^{n \times m}$, where n is the number of students and m is the number of features.

A multi-layer neural network model is constructed, and the model structure includes an input layer, several hidden layers and an output layer. The input layer contains m nodes, each corresponding to a student's characteristics, such as learning progress, test scores, class participation, and so on. Hidden layer consists of several layers, each with h_i nodes. The activation function uses ReLU, which is defined as Equation 1.

$$ReLU(z) = \max(0, z) \tag{1}$$

Through the ReLU activation function, the model can capture nonlinear relationships and enhance the expressive ability of the model. The output layer contains k nodes, corresponding to different teaching strategies. Using the Softmax activation function, convert the output values to a probability distribution, which is expressed as Equation 2.

$$Softmax(z_j) = \frac{e^{z_j}}{\sum_{k=1}^{K} e^{z_k}} \tag{2}$$

Through the Softmax function, the model is able to output the probability of each teaching strategy and select the one with the highest probability as the recommended result. The model parameters include the weight matrix W and the bias vector b. Forward propagation calculates the output of each layer as shown in Equation 3.

$$z^{(l)} = W^{(l)} * a^{(l-1)} + b^{(l)}$$
$$a^{(l)} = ReLU(z^{(l)}) \tag{3}$$

Using the supervised learning method, the loss function is defined as cross-entropy loss and expressed as Equation 4.

$$L = -\frac{1}{n} * \sum(y_{ij} * \log(\widetilde{y_{ij}})) \tag{4}$$

Where y_{ij} is the actual label and $\widetilde{y_{ij}}$ is the predicted probability. The model parameters were optimized by the backpropagation algorithm and gradient descent

3.2   Optimization Mechanism

To improve the generalization ability and accuracy of the model, apply the L2 regularization term, which is expressed as Equation 5.

$$L_{reg} = L + \frac{\lambda}{2} * \sum ||W^{(l)}||^2 \qquad (5)$$

Regularization helps to prevent model overfitting and merging to improve generalization ability, and Dropout reduces the model's dependence on a specific path by randomly discarding some nodes during training, thereby preventing overfitting. Hyperparameter tuning uses grid search or random search to select the best combination of hyperparameters, such as learning rate, batch size, and number of nodes in the hidden layer, to optimize model performance.

After the model training is completed, personalized teaching strategy recommendations are generated based on the current status and historical data of students. The output is a probability distribution for the instructional strategy, which is expressed as Equation 6. The results select the strategy with the highest probability as the recommended outcome.

$$\hat{y} = Softmax(W^{(l)} * a^{(l-1)} + b^{(l)}) \qquad (6)$$

4   EXPERIMENTS

In order to verify the effectiveness of the deep learning-based personalized teaching strategy selection model, we designed and implemented a series of experiments to evaluate the performance of the model in different scenarios, including prediction accuracy, the effectiveness of recommendation strategies, and the impact on students' learning outcomes. The experiment used a large dataset of multi-dimensional student learning data, including learning progress, test scores, classroom engagement, assignment completion, and online learning behavior.

Initially, the original data is cleaned, normalized and feature extracted to form a data matrix. Then, using the training set data, the multi-layer neural network model was trained by forward propagation and backpropagation algorithms, and the cross-entropy loss function was used to optimize the model parameters by gradient descent. Next, regularization and dropout techniques are applied to prevent overfitting, and hyperparameter tuning is performed through grid search or random search. Figure 1 compares the achievement improvement and student satisfaction for different models.
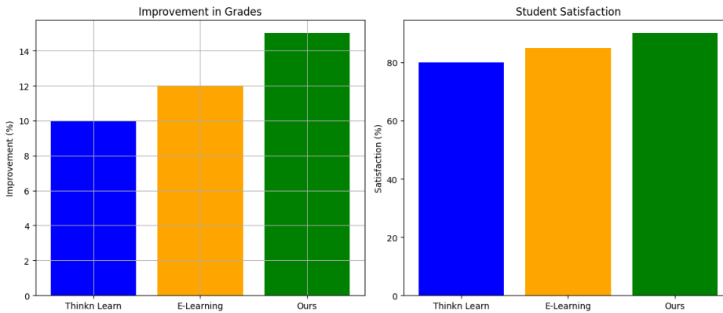
Fig. 1. Achievement improvement and student satisfaction comparison results.

5   CONCLUSION

In conclusion, the study on the selection of personalized teaching strategies based on deep learning shows that the multi-layer neural network model can effectively recommend the most suitable teaching strategy for individual students by analyzing students' multi-dimensional learning data and behavior patterns. The experimental results verify the advantages of the model in improving the prediction accuracy, the effectiveness of the recommendation strategy, and enhancing the learning effect and participation of students. This approach not only significantly improves students' academic performance and classroom engagement, but also increases students' learning satisfaction, proving the potential application value of deep learning in personalized teaching.

REFERENCES

1. Xiao, Meng, and Haibo Yi. "Building an efficient artificial intelligence model for personalized training in colleges and universities." Computer Applications in Engineering Education 29.2 (2021): 350-358.
2. Pardamean, Bens, et al. "AI-based learning style prediction in online learning for primary education." IEEE Access 10 (2022): 35725-35735.
3. Giannakas, Filippos, et al. "A deep learning classification framework for early prediction of team-based academic performance." Applied Soft Computing 106 (2021): 107355.
4. Tetzlaff, Leonard, Florian Schmiedek, and Garvin Brod. "Developing personalized education: A dynamic framework." Educational Psychology Review 33 (2021): 863-882.
5. Lee, Chia-An, et al. "Prediction of student performance in massive open online courses using deep learning system based on learning behaviors." Educational Technology & Society 24.3 (2021): 130-146.
6. Xiong, Zhang, et al. "A review of data mining in personalized education: Current trends and future prospects." Frontiers of Digital Education 1.1 (2024): 26-50.
7. Tapalova, Olga, and Nadezhda Zhiyenbayeva. "Artificial intelligence in education: AIEd for personalised learning pathways." Electronic Journal of e-Learning 20.5 (2022): 639-653.
8. Luan, Hui, and Chin-Chung Tsai. "A review of using machine learning approaches for precision education." Educational Technology & Society 24.1 (2021): 250-266.
9. Ahmed, Mazharuddin Syed. "Technology acceptance of smartphones as mobile learning tools: A contextual comparative study of engineering and education colleges." (2016).
10. Alelaiwi, Abdulhameed, et al. "Enhanced engineering education using smart class environment." Computers in Human behavior 51 (2015): 852-856.
11. Conlan, Owen, et al. "The narrative approach to personalisation." New Review of Hypermedia and Multimedia 19.2 (2013): 132-157.
12. Specht, Marcus, and Daniel Burgos. "Modeling adaptive educational methods with IMS Learning Design." Journal of Interactive Media in Education 2007.1 (2007): 8-8.