Research on the Optimization of High School Biology Education Management System Based on Deep Learning

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Abstract. In order to improve the efficiency and quality of the high school biology education management system, this paper studies the application of deep learning technology in education data analysis. By collecting and processing big data, course content and personalized teaching are optimized, and automated management tasks reduce the burden on teachers. The results show that the system significantly improves the accuracy and efficiency of teaching and management, promoting the intelligent and refined development of education.

Keywords: deep learning; high school biology; education management system.

1 Introduction

With the advancement of educational informatization, the application of deep learning technology in education management has shown great potential, especially in the optimization of high school biology education management systems. This research focuses on how to use deep learning algorithms to analyze educational big data, achieve personalized teaching and content optimization, and explore its application prospects in automating educational management tasks. The aim is to promote the development of high school biology education towards intelligence and refinement, ultimately enhancing the overall quality and efficiency of education.

2 Application Prospects of Deep Learning in the Field of Education Management

Deep learning has enormous potential in the field of education management, particularly in the application of high school biology education management systems. It can significantly improve teaching efficiency and quality[1]. By analyzing students' learning data with deep learning algorithms, teachers can more accurately identify students' learning needs and achieve personalized teaching. Deep learning can also optimize course content by analyzing test questions and teaching feedback to predict educational trends, helping teachers adjust teaching plans. In addition, deep learning technology

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can automate numerous educational management tasks, such as learning progress tracking and evaluation report generation, freeing teachers from tedious administrative work and allowing them to spend more time interacting with students, as shown in Figure 1.

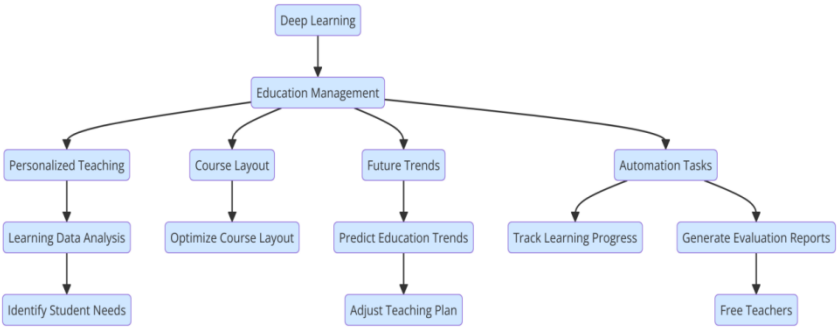

Fig. 1. Application Prospects of Deep Learning in the Field of Education Management

3 Design of Optimization Methods for High School Biology Education Management System

3.1 Collection of High School Biology Education Big Data

In the optimization process of the high school biology education management system, collecting big data is the key first step, aimed at providing sufficient training and application data for deep learning algorithms. Specific methods of data collection include: real-time collection of students' learning behavior data through educational platforms and online learning systems, such as login times, learning duration, question responses, and interaction frequency. Combined with students' exam scores and regular assessment results, a comprehensive learning performance profile is formed. Teachers' teaching feedback and classroom performance evaluations will also be systematically recorded to supplement student data, providing a more comprehensive educational profile[2]. All this data will be securely uploaded to the cloud server using encryption technology to ensure information security and privacy protection. Before data processing, data cleaning and formatting are required to ensure data quality and consistency, laying a solid foundation for subsequent deep learning analysis.as shown in Figure 2.

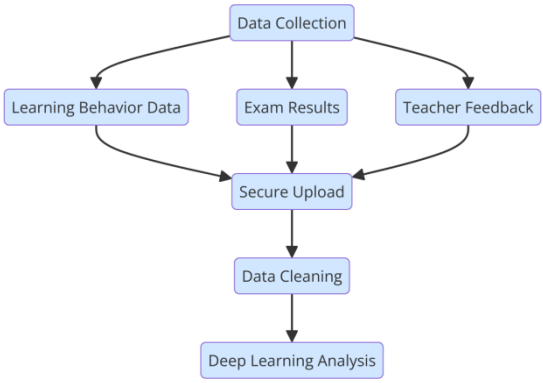

Fig. 2. Data Collection for High School Biology Education Management System

3.2 Extraction of Educational Data Features Based on Deep Learning

It is crucial to extract educational data features based on deep learning to ensure that the data can be effectively utilized to optimize teaching and learning processes[3]. This process primarily involves the application of mathematical and algorithmic techniques, such as principal component analysis (PCA), to reduce dimensionality of collected educational data. This algorithm calculates principal components using the following formula, aiming to reduce redundant information in the dataset while retaining the most critical features:

$$PCA(X) = XW \tag{1}$$

Among them, X Represents the original data matrix, W it is an eigenvector matrix derived from the data covariance matrix. The application of convolutional neural networks to extract spatial features from data is particularly effective in processing student images or complex interactive data. CNN usually involves multiple layers of filters in the feature extraction process, and its operation can be described by the following formula:

$$F_{l+1} = \sigma(W_l * F_l + b_l) \tag{2}$$

Here, F_l and F_{l+1} respectively represent the feature maps of continuous layers, W_l which are weight matrices, $*$ represent convolution operations, b_l are bias terms, but σ are nonlinear activation functions, such as ReLU. Furthermore, utilizing recurrent neural networks (RNNs) to process sequential data, such as changes in student learning progress or time series grades. RNN processes data through the following update formula:

$$h_t = \sigma(W_{hh}h_{t-1} + W_{xh}x_t + b_h) \tag{3}$$

Among them, h_t is in the hidden state of time t, x_t is in the input feature of time t, is the weight matrix, W_{hh} and W_{xh} is the b_h bias term. These algorithms work together to extract deep and multidimensional features from large-scale educational data, providing scientific data support for educational decision-making [4].

3.3 Feature Matching for Education Data Classification and Management

Feature matching technology is used to achieve classification and management of educational data, which is a crucial step to ensure data can be effectively used for learning analysis and educational decision-making. The core of feature matching lies in utilizing machine learning algorithms such as Support Vector Machine (SVM) and k-Nearest Neighbors (k-NN) algorithm to classify and manage different categories of educational data. The SVM algorithm classifies different categories of data by constructing an optimal hyperplane, aiming to maximize the margin between different category data. The mathematical representation of SVM is:

$$\min_{w,b} \frac{1}{2}\|w\|^2 \tag{4}$$

$$subjecttoy_i(w \cdot x_i + b) \geq 1, foralli \tag{5}$$

Among them, w is the normal vector to the hyperplane, b is the bias term, x_i is the feature vector, and y_i is the class label. The k-Nearest Neighbors (k-NN) algorithm classifies data points by measuring the distances between data points. Each data point is assigned to the majority class among its nearest k neighbors. Distance calculation in k-NN typically uses Euclidean distance, given by the formula:

$$d(x,y) = \sqrt{\sum_{i=1}^{n}(x_i - y_i)^2} \tag{6}$$

Here, x and y are two feature vectors, and n is the number of features in the vector. Decision trees are also commonly used in classification tasks, especially in educational data management. They form decision paths by recursively selecting optimal features for splitting. The information gain calculation formula for decision trees, used to select the best features, is as follows:

$$IG(D,f) = H(D) - \sum_{\upsilon \in Values(f)} \frac{|D_\upsilon|}{D} H(D_\upsilon) \tag{7}$$

Among them, $H(D)$ is the entropy of dataset D, $Values(f)$ is all possible values of feature f, and D_υ is the subset when feature f takes value υ **. By applying

these algorithms, the high school biology education management system can accurately classify and manage large amounts of educational data, thereby supporting effective allocation of personalized teaching and educational resources to students[5].

4 System Performance Testing and Analysis

4.1 Preparation of High School Biology Education Data Samples

To ensure the accuracy and comprehensiveness of system evaluation, detailed analysis was conducted on educational data from 10 students. These data samples will be used to assess the system's performance in handling and managing educational information. Table 1 provides specific classifications of collected data points:

Table 1. Sample Table of High School Biology Education Data

Student ID	Login Count	Study Duration (hours)	Interaction Count	Exam Score (%)	Assignment Submission Rate (%)	Latest Assessment Score
1	45	30.5	120	92	100	95
2	50	29	110	89	100	92
3	47	31	115	85	90	88
4	42	28.5	105	87	95	90
5	48	30	125	93	98	94
6	46	30.2	130	90	99	91
7	43	29.5	108	84	85	83
8	49	32	135	91	97	93
9	44	27	102	80	88	82
10	51	33	140	94	100	96

The data in the table include student ID, login count, study duration, interaction count, exam score, assignment submission rate, and latest assessment score. These data will be used for system performance testing to assess the efficiency and accuracy of the system in handling real-world operations.

4.2 Setting Deep Learning Algorithm Running Parameters

To ensure optimal performance of the high school biology education management system's deep learning algorithms, it is crucial to set the running parameters appropriately [6]. These parameters directly affect the training efficiency of the algorithms and the accuracy of the models. During the process of system performance testing and analysis, precise adjustment of these parameters can significantly enhance the algorithms' capability to recognize and process educational data features, as shown in Table 2.

Table 2. Deep Learning Algorithm Running Parameters

Parameter Name	Value
Learning Rate	0.01
Batch Size	32
Epochs	100
Units in Hidden Layer	50
Activation Function	ReLU
Optimizer	Adam
Loss Function	Cross-Entropy
Regularization	L2
Regularization Coefficient	0.001
Dropout Rate	0.5

By adjusting these parameters, it is possible to effectively control issues like overfitting and underfitting, thereby optimizing the model's generalization ability. The learning rate determines the speed of weight adjustments, with smaller values preventing instability from excessive adjustments. The batch size affects the computational load per iteration, with moderate values balancing training speed and resource consumption. The number of epochs determines how many times the entire training dataset is learned, with sufficient epochs aiding the model in better learning data features [7].

4.3 System Performance Testing Process

During the performance testing process of the high school biology education management system, meticulous testing and analysis of system performance are crucial to ensure stability and functionality [8]. The testing process includes load testing, accuracy testing, response time testing, and user acceptance testing, comprehensively evaluating the system's performance and efficiency under different conditions. According to the system load testing data in Table 3, it is observed that as the number of concurrent users increases, system response time and error rate significantly rise. Under low load conditions, the system response time is 0.5 seconds with no errors, effectively handling concurrent requests from 50 users. As the number of users increases to 200, the response time increases to 1.2 seconds with an error rate of 0.5%. Under high load conditions, specifically with 500 users concurrently online, the response time extends to 2.8 seconds with an error rate of 1.0%, indicating performance degradation during high concurrent request handling, necessitating further optimization.

Table 3. System Load Testing Data

Test Scenario	Concurrent Users	System Response Time (seconds)	Error Rate (%)
Low Load	50	0.5	0
Medium Load	200	1.2	0.5
High Load	500	2.8	1

Accuracy testing data demonstrates that the high school biology education management system exhibits high accuracy in handling learning behavior data and educational outcome data. For learning behavior data, out of 1000 submissions, the system successfully processed 995 submissions with 5 failures, achieving an accuracy rate of 99.5%.

Similarly, for educational outcome data, out of 800 submissions, the system successfully processed 796 submissions with 4 failures, maintaining a 99.5% accuracy rate. This high accuracy indicates that the system's algorithms and data processing mechanisms can effectively identify and process input data, with very few processing errors stemming from minor input inaccuracies or exceptional conditions. These results support the system's high reliability and performance in practical applications, as shown in Table 4.

Table 4. Accuracy Testing Data

Data Type	Submissions	Successful Processes	Failed Processes	Accuracy (%)
Learning Behavior	1000	995	5	99.5
Educational Outcome	800	796	4	99.5

Response time testing data reveals the performance of the high school biology education management system across different functional modules [9]. As depicted in Figure 3, the data upload module shows an average response time of 1.3 seconds, with the fastest response time at 0.8 seconds and the slowest at 2.1 seconds, indicating some variability but overall acceptable response time. The data query module performs exceptionally well with an average response time of 0.8 seconds, fastest response time of 0.5 seconds, and slowest of 1.5 seconds, demonstrating high efficiency in handling query requests. The report generation module exhibits relatively longer response times, averaging 2.0 seconds, with the fastest at 1.2 seconds and the slowest at 3.0 seconds, attributed to the more complex data processing and formatting involved in report generation.

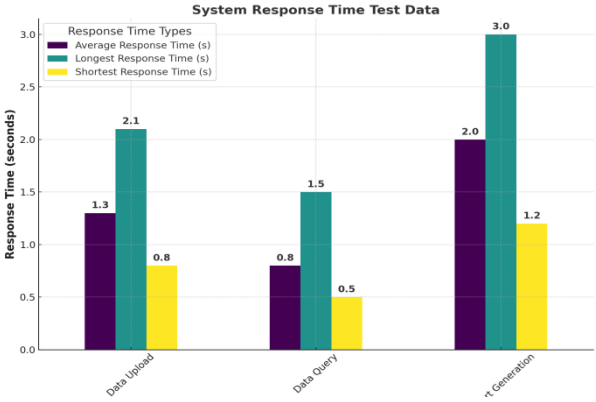

Fig. 3. System Response Time Testing Data

Table 5 presents satisfaction ratings from 40 teachers in the user group, with a score of 8.2 for system satisfaction and 8.5 for usability, indicating high acceptance and good user experience among teachers. In contrast, the student user group, consisting of 60

students, shows slightly lower satisfaction ratings with a score of 7.8 for system satisfaction and 8.0 for usability. This suggests that while students generally acknowledge the overall performance of the system, there are minor dissatisfactions with certain functionalities or interface designs.

Table 5. User Acceptance Testing Data

Test Group	Number of Users	Satisfaction Rating (1-10)	Usability Rating (1-10)
Teacher Group	40	8.2	8.5
Student Group	60	7.8	8

By comprehensively analyzing the system's testing data, it is evident that the education management system performs stably overall with high user satisfaction. Future efforts should focus on optimizing report generation functionality to enhance system efficiency and user experience.

4.4 Analysis of Test Results

After a comprehensive analysis of the testing process of the high school biology education management system, the overall performance of the system in handling and managing educational information was evaluated [10]. By analyzing data from different test items, including system load, accuracy, response time, and user acceptance, we gain detailed insights into the system's performance in real-world applications. Table 6 presents specific data and analysis results based on a sample of 10 students, used to assess the system's performance in handling and managing educational information.

Table 6. Performance Data in Handling and Managing Educational Information

Student ID	Learning Behavior Data Submissions	Successful Processed	Failed Processes	Accuracy (%)
1	50	49	1	98
2	48	47	1	97.9
3	52	51	1	98.1
4	50	49	1	98
5	51	50	1	98
6	49	48	1	98
7	50	49	1	98
8	53	52	1	98.1
9	48	47	1	97.9
10	51	50	1	98

Each student's submissions of learning behavior data range from 48 to 53 times, with consistently high levels of successful processing and very few errors (only 1 error each). The system's processing accuracy ranges from 97.9% to 98.1%, with an average accuracy of 98%. This indicates that the system demonstrates high reliability and stability in handling large volumes of educational data, effectively reducing data processing errors. The high accuracy demonstrates the system's precision and efficiency in capturing

and managing student learning behavior data, ensuring data quality in educational management processes. Such performance not only helps teachers accurately understand student learning statuses and formulate more targeted teaching strategies but also enhances the overall efficiency and practicality of the education management system, providing strong data support for teachers.

5 Conclusion

The optimization of the high school biology education management system based on deep learning technology significantly enhances teaching efficiency and quality. By collecting and analyzing education big data, it achieves personalized teaching and automated management, effectively alleviating teachers' burdens. Future efforts should further optimize system functionalities, improve response speed and user experience, and conduct in-depth research on the application of deep learning algorithms in feature extraction and classification management of educational data, to comprehensively support refined and intelligent management of high school biology teaching.

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