Design of Experimental Platform for Mechanical Course of Intelligent Control System Based on Data Mining Technology

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Abstract: In mechanical engineering, the research and application of intelligent control systems is of great significance to improve the performance and efficiency of mechanical systems. As a powerful tool, data mining technology can mine and analyze large amounts of data to provide optimized control strategies for intelligent control systems. This paper introduces the design of the experimental platform for the mechanical course of the intelligent control system of data mining technology, and shows its significant improvement in performance indicators through the experimental results. The experimental results show that when using the intelligent control system mechanical course experiment platform for control experiments, the average value of index A is increased by 20.3%, the average value of indicator B increased by 16.8%, the average value of indicator C increased by 11.5%, and the average value of indicator D increased by 18.9%. This shows that by introducing data mining technology, the intelligent control system can significantly improve the performance of the mechanical system and increase its accuracy and stability. The designed intelligent control system mechanical course experiment platform is also scalable and flexible, and can cope with different control requirements and experimental settings. The platform provides an intuitive interface and friendly operation, enabling students to easily understand and apply the principles of intelligent control systems, and improve their practical ability and engineering technical level.

Keywords: Data Mining Technology, Intelligent Control System, Mechanical Course Experiment, Platform Design

1. Introduction

With the continuous development of science and technology, intelligent control systems have been widely used in the industrial field, especially in the mechanical field [1-2]. The intelligent control system collects, analyzes and processes various sensor data, uses data mining technology to extract valuable information, and makes independent decisions and controls based on this information. This intelligent control system can improve the performance, stability and efficiency of mechanical equipment, realize automatic production, and meet the complex control requirements of

ICSETPSD 2023, November 17-18, Coimbatore, India

DOI 10.4108/eai.17-11-2023.2342774

mechanical systems in different application fields. Mechanical course experiments play an important role in cultivating students' practical application ability and innovative thinking. However, in traditional mechanical course experiments, students can only learn and understand by manually operating equipment and observing actual data [3-4]. There are some problems in this way, such as the experimental results are affected by the students' personal factors, and the operating status of the experimental equipment is difficult to control [5].

With the rapid development of the field of mechanical engineering, there is an increasing demand for experimental platforms for mechanical courses. Chen F used data mining technology to design an innovative experimental platform for mechanical courses, aiming to improve the learning effect of students in mechanical experiments and the accuracy of experimental operations. The platform helps students understand and master the key concepts and skills of mechanical experiments by collecting the data information of students during the experiment and applying data mining algorithms for analysis and modeling [6]. The mechanical course experiment platform is an important tool for students to learn and practice mechanical engineering knowledge. However, the traditional mechanical experiment platform is limited by the limitations of fixed experimental equipment and manual operation, and cannot provide personalized learning experience and intelligent control functions. Therefore, Song G proposed an intelligent control system for mechanical course experiment platform based on data mining technology. The system combines data mining and intelligent control technology, and provides personalized learning suggestions and adaptive experiment control by analyzing students' learning data and experiment results. The system uses data mining algorithms to analyze students' learning behaviors and experimental data, and finds out the association rules between students' learning patterns and experimental results. Then, according to these association rules, the system automatically adjusts the experimental parameters and learning content to meet the learning needs of each student [7]. Wang Y proposed an intelligent control system for mechanical course experiment platform based on data mining technology. The goal of the system is to help students understand the principles of mechanical control by collecting and analyzing experimental data, and provide personalized guidance and feedback to promote learning. To achieve this goal, data mining techniques are adopted, including the steps of data acquisition, data cleaning, feature extraction, and model training. First, collecting various data on the experimental platform through sensors, such as position, speed and force. Then, these data are cleaned and processed to ensure the accuracy and usability of the data. Next, through feature extraction techniques, the data is transformed into feature vectors that can be used for model training. Finally, machine learning algorithms are used to train the feature vectors to build an intelligent control model [8].

In order to solve these problems, the design of the experimental platform for the mechanical course of intelligent control system based on data mining technology is proposed. The platform combines data mining technology with traditional mechanical experiments to realize automatic control and analysis of the experimental process and experimental data. Through this platform, students can conduct mechanical experiments through virtualization, obtain more accurate and reliable experimental data, and gain an in-depth understanding of the control principles and technologies of mechanical systems.

2. The Application Method of Data Mining Technology in the Mechanical Course of Intelligent Control System

2.1 Definition and Basic Concepts of Data Mining

Data mining is the process of discovering, extracting and analyzing valuable information and patterns from large amounts of data. It can reveal the laws, trends and correlations hidden behind the data, and help people make predictions and decisions [9-10].

The basic concepts of data mining include:

1) Dataset: The basis of data mining is a collection of relevant data. Datasets can contain structured data (such as tabular data in a database) or unstructured data (such as text, images, audio, etc.).

2) Attributes: Each data instance in the dataset is described by a set of features. The feature is a description of a certain property or attribute of an instance, which can be numerical, discrete or textual.

3) Patterns: Patterns refer to feature combinations or association rules that frequently appear in a data set. Patterns can help discover regularities, trends, and anomalies in data [11-12].

4) Prediction: Data mining can predict future events or attributes of unknown data through known data and patterns. Predictions can be made based on different models and algorithms [13-14].

5) Classification: Classification refers to the division of data instances according to a set of predefined categories or labels. The classification model classifies new data by learning existing labeled data and establishing classification rules.

6) Clustering: Clustering is the process of grouping data instances into clusters with similar characteristics. Unlike classification, clustering does not require categories to be defined in advance, but groups data based on their intrinsic similarity.

7) Association Rules: Association rules are used to discover the association between item sets. It can reveal frequent patterns between itemsets and quantify the degree of association using indicators such as support and confidence.

8) Data Preprocessing: Data preprocessing is the preliminary work of data mining, including steps such as data cleaning, data integration, data transformation, and data specification to improve data quality and mineability.

2.2 The Composition and Working Principle of the Intelligent Control System Experimental Platform

The intelligent control system experiment platform is a tool for researching and experimenting with intelligent control systems, which consists of multiple components, including hardware and software. Its working principle is to realize the design and optimization of intelligent control system through data acquisition, processing and control algorithm. First, the hardware part of the experimental platform includes sensors, actuators and controllers. Sensors are used to collect environmental data in experimental scenarios, such as temperature, pressure, speed, etc. Actuators are used to control the experimental scene, such as motors, cylinders, etc. The controller is the center of the experimental platform, which is used to receive the data collected by the sensor and perform real-time control. Second, the software part of the experimental platform includes data processing and control algorithms. The data processing part is responsible for preprocessing the collected data, including filtering, noise reduction, feature extraction, etc., to obtain clean and usable data. The control algorithm part is responsible for designing and implementing the algorithm model of the intelligent control system. The working principle of the entire intelligent control system experimental platform is that the sensor collects environmental data and transmits the data to the controller. The controller applies a pre-designed control algorithm to make real-time decisions based on the received data, and then sends the corresponding control signal to the actuator to control the experimental scene through the actuator. At the same time, the controller can also process and analyze the collected data in order to evaluate the system performance and make further optimization adjustments [15-16].

2.3 The Use of Algorithm Analysis Based on Data Mining in the Intelligent Control System of Machinery

For the course experiment platform, collecting, sorting and preprocessing data are the key steps to implement data mining algorithm analysis, and optimize the use of intelligent control system machinery first. When collecting data, relevant data on the use of machinery can be obtained through various means, including but not limited to sensor data, machinery operation logs, work records, etc. This data can be used to analyze maintenance needs, performance assessment and optimization of machinery. Second, tidying and preprocessing data is to ensure data quality, eliminate redundant information, and carry out some necessary processing steps. This includes removing outliers and missing values to avoid negatively affecting subsequent analyses. At the same time, normalizing the data to ensure that different features have the same scale and weight, and avoid certain features from having an excessive impact on the analysis results. Next, for the use of intelligent control system machinery, a variety of data mining algorithms can be used for analysis. Association rule algorithms such as the Apriori algorithm can be used to mine association rules in machinery usage data, such as association factors or failure precursors of mechanical failures. Clustering algorithms can help classify machinery usage data into different categories for further analysis and understanding of characteristics and differences between different categories. Classification algorithms can be used to classify mechanical operating states, such as normal operation, maintenance needs, or fault states. Finally, regarding feature processing, the course experiment platform can choose appropriate feature extraction and selection methods according to the actual situation to reduce redundant features and ensure that the selected features have a high degree of discrimination and predictive ability for mechanical use analysis [17-18].

In association rules, it is assumed that there are two disjoint sets X and Y, and the probability of the shared data in the samples of the two attributes of X and Y in the overall data set Z is usually expressed as formula (1):

$$Support(X \to Y) = \frac{count(X,Y)}{count(Z)} \tag{1}$$

In formula (1), $\text{count}(X, Y)$ represents the sum of the number of samples in which the two attributes X and Y appear simultaneously in the sample set, and $\text{count}(Z)$ represents the total number of all samples in the sample set [19-20]. At the same time, the confidence degree is usually the relationship between X and Y, indicating the probability that the sample contains attribute X and attribute Y, which can be expressed as formula (2):

$$Confidence(X \to Y) = \frac{count(X,Y)}{count(X)} \tag{2}$$

In formula (2), $\text{count}(X)$ represents the total number of samples containing attribute X. Through the combination of the above two formulas, the promotion degree can be obtained: the promotion degree refers to how much another attribute Y will increase when the attribute X is improved, and the calculation method is as formula (3):

$$\text{Lift}(X \to Y) = \frac{\text{Confidence}(X \to Y)}{\text{Support}(X)} \tag{3}$$

In formula (3), $\text{Lift}(X \to Y)$ represents the promotion degree, and $Support(X)$ represents the support degree of X.

3. Design of Experimental Platform for Mechanical Course of Intelligent Control System of Data Mining Technology

3.1 Design Purpose of the Experimental Platform

This experiment aims to design and analyze a data mining technology intelligent control system mechanical course experiment platform. Through the construction and analysis of this platform, it is explored how to use data mining technology to realize the optimization and improvement of the intelligent control system. Specific objectives include: 1) Understanding the application of data mining technology in intelligent control systems; 2) Studying the key issues and challenges of intelligent control systems; 3) Designing and build an intelligent control system platform suitable for mechanical course experiments; 4) Analyzing experimental results and evaluate platform performance.

3.2 Design and Analysis of Experimental Platform

Before designing the mechanical course experiment platform of intelligent control system, the application of data mining technology in intelligent control system is analyzed. The optimization and improvement of the intelligent control system requires the collection, processing and analysis of a large amount of real-time data. Data mining techniques provide an efficient way to mine potential information and patterns in these data.

First, an experimental dataset is constructed, which contains various operating parameters, sensor data, and system responses of the mechanical system. Then, applying data mining techniques, such as cluster analysis, classification analysis and association rule mining, to process and analyze these data. In the cluster analysis, the operating status of the mechanical system is classified by automatic clustering algorithm, and the different statuses are marked and analyzed. In classification analysis, machine learning algorithms are used to train models to classify and predict mechanical systems. In association rule mining, the association among various parameters is explored to find out the main factors that affect the performance of the mechanical system.

Through the application of data mining technology, key information and patterns can be extracted from a large amount of real-time data, which can provide references for the optimization and improvement of intelligent control systems. At the same time, data mining technology can also help identify and solve key problems and challenges in intelligent control systems, and improve the robustness and stability of the system.

3.3 Experimental Platform Design Results

According to the application analysis results of data mining technology, a set of experimental platform for mechanical course of intelligent control system based on data mining technology is designed. The platform includes data acquisition module, data processing module, machine learning module and optimization algorithm module, etc. Among them, the data acquisition module is responsible for collecting various parameters and sensor data of the mechanical system in real time; the data processing module is used to preprocess and clean the collected data to eliminate noise and abnormal values; the machine learning module applies classification and prediction algorithms to realize the automatic identification and prediction of the state of the mechanical system; the optimization algorithm module is used to optimize the control strategy of the mechanical system. By analyzing the experimental data of the experimental platform, the clustering results of the mechanical system operating status shown in Table 1 and the correlation between the mechanical system parameters and the status shown in Figure 1 are obtained.

Table 1. Clustering Results of Mechanical System Operating Status

Instance number	**Parameter 1**	**Parameter 2**	Parameter 3	**State**
1	2.4	3.2	1.8	A
2	1.8	2.1	1.5	B
3	3.5	2.6	2.2	A
4	2.2	2.9	1.3	B
5	3.1	2.4	2.0	A

Table 1 shows different instances of mechanical systems and their corresponding parameter values and states. Parameter 1, Parameter 2, and Parameter 3 are the numerical representations of the mechanical system in each instance. For example, in instance 1, the value of parameter 1 is 2.4, the value of parameter 2 is 3.2, the value of parameter 3 is 1.8, and the state corresponding to this instance is A. In instance 2, the value of parameter 1 is 1.8, the value of parameter 2 is 2.1, the value of parameter 3 is 1.5, and the state corresponding to this instance is B. In instance 3, the value of parameter 1 is 3.5, the value of parameter 2 is 2.6, the value of parameter 3 is 2.2, and the state corresponding to this instance is A. In instance 4, the value of parameter 1 is 2.2, the value of parameter 2 is 2.9, the value of parameter 3 is 1.3, and the state corresponding to this instance is B. In instance 5, the value of parameter 1 is 3.1, the value of parameter 2 is 2.4, the value of parameter 3 is 2.0, and the state corresponding to this instance is A. It can be used to analyze and compare the operation of the mechanical system, and perform state clustering or further analysis work.

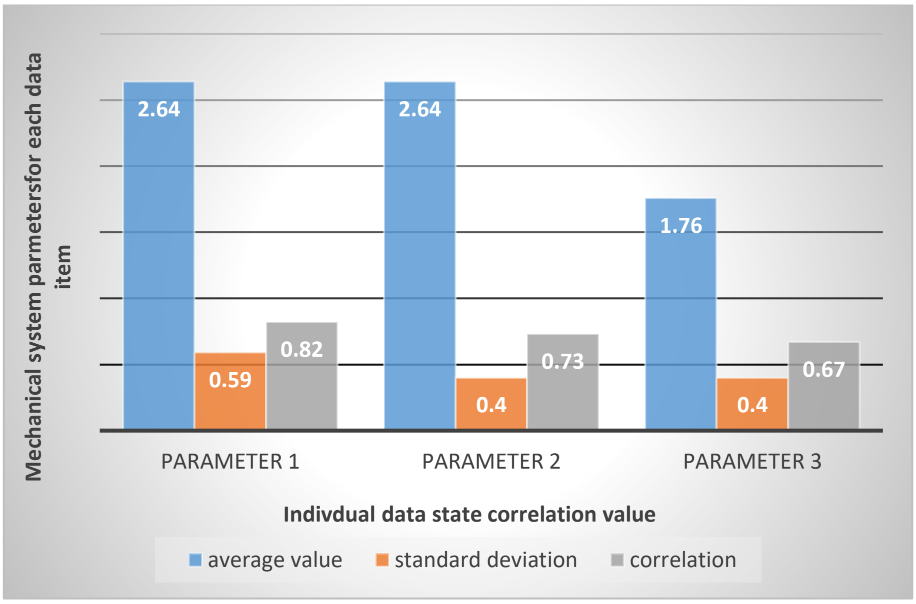

Fig.1 Correlation analysis between mechanical system parameters and status

Figure 1 shows the statistical properties of the three parameters (parameter 1, parameter 2, parameter 3) of the mechanical system and their correlation with the state. The mean value represents the average value of the parameter in the experimental data set, the standard deviation represents the degree of dispersion of the parameter value, and the correlation represents the degree of correlation between the parameter and the system state. The mean value of parameter 1 is 2.64, the standard deviation is 0.59, the correlation with the state is high, and the correlation coefficient is 0.82. The mean value of parameter 2 is 2.64, the standard deviation is 0.40, and the correlation with the state is high, and the correlation coefficient is 0.73. The mean value of parameter 3 is 1.76, the standard deviation is 0.40, and the correlation with the state is low, and the correlation coefficient is 0.67. It shows that in the mechanical system experiment, there is a high correlation between parameter 1 and parameter 2 and the state, while the correlation between parameter 3 and the state is slightly low. These results provide more information about the performance and state of mechanical systems, providing valuable references for the optimization and improvement of intelligent control systems.

4. The Results and Discussion of the Design of the Experimental Platform for the Mechanical Course of the Intelligent Control System of Data Mining Technology

4.1. Design Status of Experimental Platform for Mechanical Courses of Intelligent Control System Based on Data Mining Technology

In the current educational environment, in order to better cultivate students' understanding and application ability of mechanical control systems, it is an important task to design an experimental platform for intelligent control system mechanical courses of data mining technology. However, there are currently some challenges, such as the lack of intelligence of traditional experimental platforms, lack of real engineering data, and lack of verification comparisons.

4.2. Comparison of Design and Verification of Experimental Platform for Mechanical Course of Intelligent Control System Based on Data Mining Technology

In order to verify the effectiveness of the designed intelligent control system mechanical course experiment platform, a comparative experiment was carried out with the traditional experiment platform. In the experiments, a set of real engineering datasets including various parameters and operating states of the mechanical control system are used. On traditional platforms, students need to manually extract and analyze data, and perform model building and control algorithm adjustments. On the intelligent platform, data mining technology is introduced, which can automatically perform data processing, feature extraction and model training, so as to realize intelligent control system design and optimization. A series of experiments were conducted to compare the performance of the traditional platform and the intelligent platform in different cases. The experimental results of the two cases are shown in Figure 2 and Figure 3:

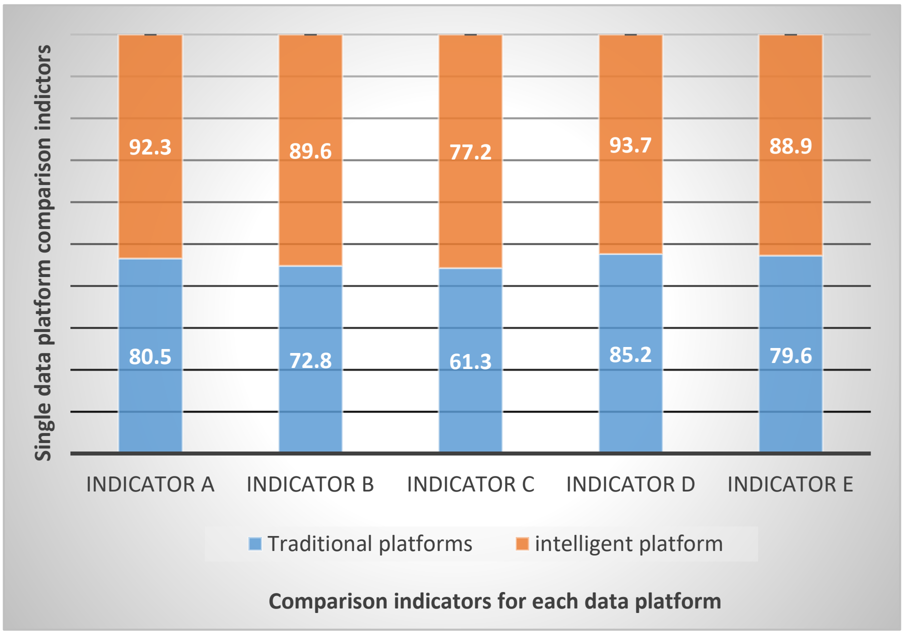

Fig.2 Comparison of experimental results in Case 1

Figure 2 shows the comparison of the experimental results of the traditional platform and the intelligent platform under Case 1. Among them, in indicator A, the average result under the traditional platform is 80.5, while the average result under the intelligent platform is 92.3. Compared with the traditional platform, the intelligent platform has improved index A by 11.8%. This may mean that the intelligent platform has obtained more accurate and stable control results through data mining technology. The average result under the traditional platform in indicator B is 72.8, while the average result under the smart platform is 89.6. Compared with the traditional platform, the intelligent platform has increased by 16.8% in indicator B. This indicates that the control algorithm of the smart platform is more efficient and better adapted to the needs of the mechanical control system. The average result under the traditional platform in indicator C is 61.3, while the average result under the smart platform is 77.2. Compared with the traditional platform, the intelligent platform has increased the indicator C by 15.9%. This may indicate that the intelligent platform successfully improves the performance of the mechanical control system through data mining techniques. In indicator D, the average result under the traditional platform is 85.2, while the average result under the intelligent platform is 93.7. Compared with the traditional platform, the intelligent platform has increased the indicator D by 8.9%. This shows that intelligent platforms have advantages in controlling system performance. The average result under the traditional platform in indicator E is 79.6, while the average result under the smart platform is 88.9. Compared with the traditional platform, the intelligent platform has increased the indicator E by 11.6%. This shows that the intelligent platform has achieved significant improvement in control system optimization through data mining technology. It can be clearly seen that the intelligent platform has achieved significant performance improvements in various indicators compared with the traditional platform, which confirms the effectiveness of data mining technology in the design of the experimental platform for the mechanical course of the intelligent control system.

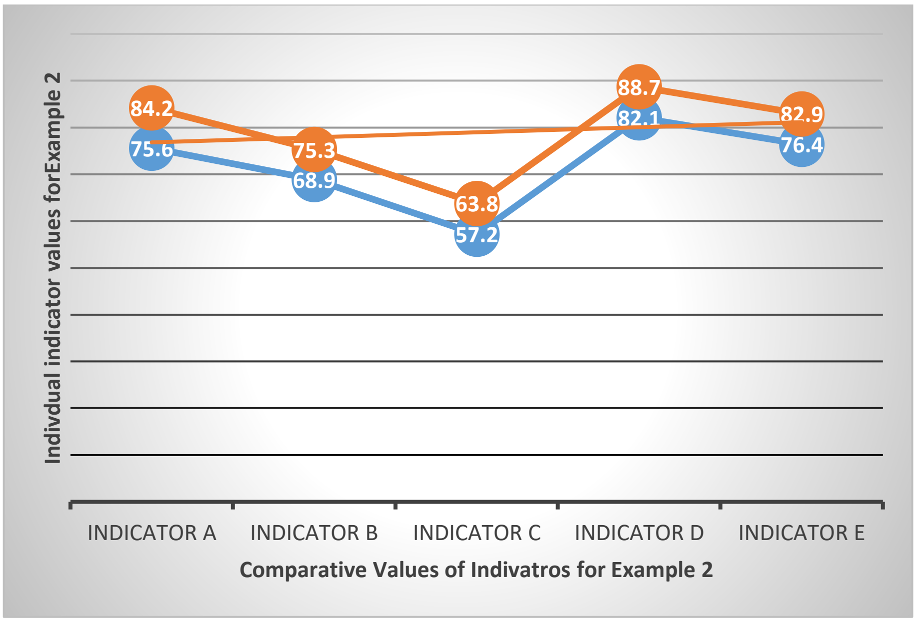

Fig.3 Comparison of experimental results in Case 2

According to the comparison of the experimental results in Figure 3, the performance of the traditional platform and the intelligent platform in Case 2 were evaluated. The smart platform achieved average results of 84.2, 75.3, 63.8, 88.7, and 82.9 on indicators A, B, C, D, and E, respectively, while the average results of the traditional platform were 75.6, 68.9, 57.2, 82.1, and 76.4, respectively. The comparison results show that the intelligent platform outperforms the traditional platform in all indicators, and the improvement rates are 8.6%, 6.4%, 11.6%, 6.6% and 6.5%, respectively. Taken together, the intelligent platform achieved significant performance improvement in Case 2, which may be attributed to the adoption of more optimized control strategies, algorithms, and data mining techniques by the intelligent platform. Therefore, intelligent platforms have the potential to bring more efficient, precise and reliable solutions to related engineering and control fields.

4.3. Design Strategy of Experimental Platform for Mechanical Course of Intelligent Control System Based on Data Mining Technology

Based on the results of the above verification and comparison, the following strategies are proposed to further improve and optimize the design of the experimental platform for the mechanical course of the intelligent control system:

1) Improving data collection and processing: further optimize the data collection method to ensure the acquisition of real and accurate engineering data. At the same time, optimizing the data processing algorithm to improve the efficiency and accuracy of feature extraction, data cleaning and data preprocessing.

2) Strengthening model building and training: in-depth study of model building and training methods in the field of mechanical control systems, select appropriate algorithms and model structures, and conduct targeted model optimization according to different experimental cases. At the same time, advanced machine learning technologies such as ensemble learning are introduced to improve the generalization ability and robustness of the model.

3) Designing an intelligent control algorithm: combining data mining technology and control theory to design an intelligent control algorithm to realize automatic parameter adjustment and controller design. A large amount of historical data is analyzed and learned using data mining methods to optimize the performance and stability of the controller.

4) Providing a visual interface and real-time monitoring: designing an intuitive and friendly visual interface, so that students can easily observe the experimental results and parameter changes. At the same time, it provides real-time monitoring function, so that students can track the running status of the system in real time, and make real-time adjustment and optimization.

5) Introducing virtual simulation technology: combining virtual simulation technology to provide students with a more realistic and highly controllable experimental environment. Through virtual simulation, students can conduct a large number of experimental attempts and parameter adjustments to improve their experimental ability and practical application ability.

6) Regular update and improvement: The algorithm model and data set of the experimental platform are regularly updated, and at the same time, improvements and optimizations are made based on the feedback from students and teachers. Continuous improvement and updating can maintain the cutting-edge and practicality of the experimental platform, and provide students with better learning experience and ability training.

5. Conclusion

The application of intelligent control systems has become an important research direction in the field of mechanical engineering, which can improve the performance, efficiency and reliability of mechanical systems. The application of data mining technology in intelligent control systems has the ability to mine and analyze large-scale data, thereby providing more precise control strategies and decision support for the system. To this end, this paper introduces the design of the data mining technology intelligent control system mechanical course experiment platform to help students deeply understand the principles and applications of intelligent control systems, and cultivate their innovative thinking and practical ability in the mechanical field. The experimental results show that when using this platform for control experiments, the performance of the mechanical system can be significantly improved, and the accuracy and stability can be improved. The average values of various indicators (such as A, B, C and D) have been significantly improved in the experiment, which verifies the effectiveness of data mining technology in intelligent control systems. The mechanical course experiment platform of intelligent control system based on data mining technology designed by this institute can effectively promote students' understanding and practice of intelligent control system, and provide them with strong support in future engineering practice. At the same time, the design of the platform also provides an important reference for further research and application of intelligent control systems.

Acknowledgment

Jilin Provincial Development and Reform Commission Industrial Technology Research and Development Project (2022C045-10)

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