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THE SECURITY AND PROTECTION SYSTEM OF ELECTROMECHANICAL EQUIPMENT IN SMART CAMPUS USING THE IMPROVED DATA MINING ALGORITHM

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Abstract. In order to improve the maintenance and management efficiency of campus electromechanical equipment and reduce or even avoid the safety risks brought by campus electromechanical equipment, this work uses the data mining algorithm to design the security and protection system of campus electromechanical equipment. First, this work constructs the campus electromechanical equipment classification model using the Bayesian algorithm of data mining algorithm and designs a simulation experiment to verify the effect of the classification model. Then, the security and protection system for the campus electromechanical equipment is designed. It includes the system business process, system function design, system core module's function design and system implementation. Finally, a simulation experiment is designed to verify the system's performance. The results show that: (1) Bayesian algorithm is superior to the K-Nearest Neighbor (KNN) algorithm in both classification effect and running time. (2) When the browser concurrency in the system increases, the server processor and memory usage also increases, but the value meets the expected requirements. It shows that the system has a certain browser concurrency-bearing capacity. Moreover, as the browser concurrency of the system increases, the response time of the test also increases, but the value meets the expected requirements. This work aims to improve the maintenance efficiency of campus electromechanical equipment and provide a reference for the safety protection work of electromechanical equipment in other enterprises or units.

Key words: data mining, campus electromechanical safety, Bayesian algorithm, K-Nearest Neighbor algorithm, simulation experiment

1. Introduction. Foreign developed countries have studied the informatization of equipment management since the 1970s. At present, the equipment management system has been quite popular abroad, especially in the United States. Many public places, such as hospitals, schools and enterprises, have used information technology to varying degrees, and the management of instruments and equipment is quite standardized [1]. The Asset Management Solution equipment operation management system developed by Fisher-Rosemount is relatively complete [2]. The Maximo equipment management system developed in the United States takes preventive maintenance as the means and cost management as the core to achieve economic optimization and benefit maximization. Currently, the system has been applied worldwide, with over 5000 installations in major enterprises, especially in safety, education, aerospace, medical, and machinery manufacturing [3]. Moreover, foreign scholars consider using the knowledge base to summarize common faults, thereby helping users automatically find and solve faults. Such systems are often referred to as expert systems [4]. The early expert system is adopted to help medical staff make medical diagnoses and help managers make decisions on problems. They usually need to establish a perfect knowledge base and inference rules to give corresponding conclusions according to the problem phenomenon. This kind of system has been widely used in fault management systems worldwide.

China starts relatively late in the research of equipment information management. Since the 1980s, in response to enterprise development needs, some domestic scholars have conducted research on equipment management informatization. Over the years, enterprises and universities in some regions of China have developed lots of excellent equipment management software, which has improved the efficiency of fixed asset management and made certain technological progress. The software all have the functional modules required by general enterprises to manage equipment and instruments, including basic equipment information management, equipment bidding and purchasing, equipment operation and maintenance prompts, equipment repair forecast and

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repair cost estimation, equipment depreciation and scrapping, which basically achieve automatic management [5]. For example, Guangzhou Zhengtai PMISS.0 equipment integrated management system can realize the integrated management of equipment information [6]. HSWZ001 construction equipment management software of Tsinghua Sware Company computerizes the establishment of equipment archives account, account accounting, equipment maintenance and equipment scrapping [7]. The College Teaching and Scientific Research Instrument and Equipment Management System developed by the Beijing University of Chemical Technology, which many colleges currently use, can complete the accounting management of equipment and the task of reporting various data required by the Ministry of Education [8]. Besides, Zhao et al. (2021) pointed out that the equipment manager can use the electronic information platform to access the equipment data with the highest efficiency through the establishment of electronic equipment drawings, technical manuals, and parameter report archives for the convenience of equipment repair and maintenance. Moreover, this kind of electronic archive is easier to preserve than paper materials [9]. Huazhong University of Science and Technology has developed an equipment information management system based on Java EE technology architecture on the basis of traditional architecture. Java EE is a crucial development platform directly built based on the Java 2 standard [10].

In summary, the current equipment management informatization in China has just started. Moreover, equipment management in China is deeply affected by the traditional management mode. The equipment automation level of many schools and units is still deficient, and they do not pay enough attention to equipment information processing, so there is still a big gap compared with foreign countries. Based on this, this work studies the safety protection of campus electromechanical equipment based on a data mining algorithm. The innovation is to use the improved statistical classification algorithm of data mining algorithm - Bayesian algorithm to classify and recognize campus electromechanical equipment. This algorithm has a good classification effect. This work aims to improve the management level of the electromechanical equipment fault prediction and maintenance plan generation system in colleges in the maintenance process to reduce or even avoid the security risks brought by campus electromechanical equipment.

2. Theoretical basis and model design.

2.1. Research on classification model of electromechanical equipment based on Bayesian.

(1) Bayesian classification. Bayesian classification is a classification method based on the classical Bayesian probability theory using the knowledge of probability statistics [11]. Its main idea is to predict the possibility that an item to be classified belongs to each category through Thomas Bayes, and take the category with the greatest possibility as the category of the item to be classified. Thomas Bayes is the conditional probability of random events h and D:

$$P(h|D) = [P(D|h)P(h)]/P(D) \tag{2.1}$$

$P(h|D)$ refers to the conditional probability of event D when event h occurs. It indicates the probability of event h under the premise that event D has occurred [12].

The Bayesian classification covers many types of algorithm models, of which naive Bayesian classification algorithm and Bayesian network are two commonly used. Naive Bayes classifier (NB algorithm), which is a supervised learning method, is a simple and effective classifier. In some application fields, its performance is comparable to that of artificial neural networks and decision trees. The algorithm assumes that attributes are independent based on Bayesian probability. This assumption greatly reduces the construction complexity of the Bayesian application model and makes it suitable for classification tasks in data mining. Meanwhile, this assumption also limits the application scope of the algorithm to some extent [13, 14].

(2) Bayesian-based equipment classification model. The specific goal of the classification management of campus electromechanical equipment is to maximize the accuracy of equipment classification for existing or new campus equipment and minimize the time spent on equipment classification.

Thereby, the NB algorithm (naive Bayesian classification algorithm) is used as the classifier of campus equipment to classify and manage thousands of school equipment [15]. Figure 2.1 displays each module of the classifier and the specific classification process.

Figure 2.1 suggests that the overall classification process of the equipment management system can be divided into three modules.

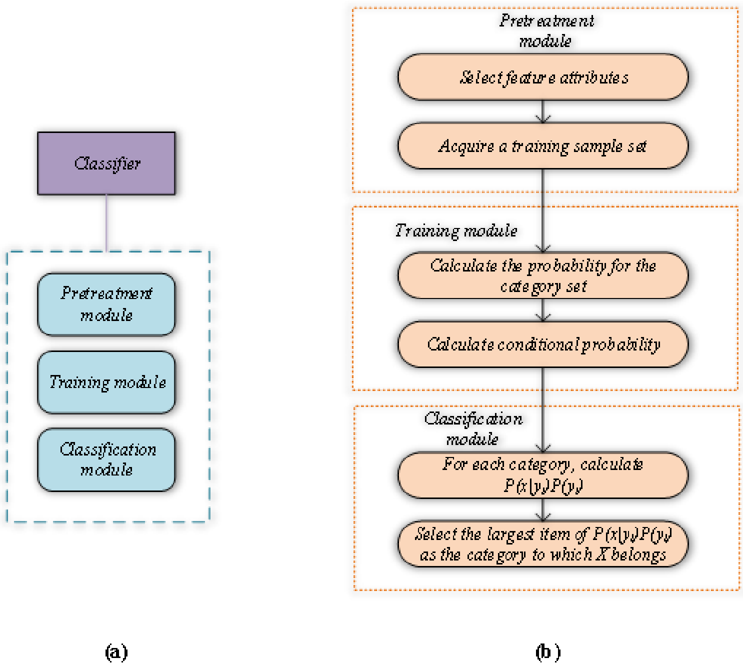

Fig. 2.1: Each module of the classifier and the specific classification process (a) Text classifier module diagram; (b) Classification process of the equipment management system

The first module is the pretreatment module of classifier construction. The main goal of this module is to select the characteristics that can best represent the equipment category from the numerous electromechanical equipment lists of the school. First, each item of data on the equipment list is input as a set of text data to be classified. Then, according to the classification problem's specific situation, the set's feature attributes (these attributes are the attributes that can describe the equipment features) are selected. The classified feature attributes are appropriately taken as the feature attribute set of the classifier to be constructed in the next step. Moreover, it is also essential to randomly select a part of the data to be classified from all the unclassified data object sets to be classified as the sample set, and manually classify the sample set, so that the training sample set is obtained after classification.

The above description reveals that this stage requires manual classification of the training sample set, which is the only part of the NB algorithm that requires manual implementation. This result will greatly impact the construction of the subsequent classification model. It can be said that the quality of the relevant equipment feature attribute set output by this module and the training sample set obtained through manual classification determines the classification quality of the constructed NB algorithm. This module is the basis of the NB algorithm.

The second module is the classifier training module. This module aims to generate the classifier of instances, so this module is also the core of the entire NB algorithm. At this time, the classifier calculates the occurrence frequency of each category in the training samples manually classified previously. The prior probabilities of each feature attribute corresponding to each category are also calculated together, and then these probabilities are recorded for the next classification stage. In this stage, the input is the feature attribute set and the training sample set, and the output is the classifier.

The third module is the classification module. The main goal of this module is to use the classifier produced in the second stage to classify other object data to be classified except for the training sample set. The working objects of this module are the constructed equipment classifier and other data objects to be classified. The data object to be classified has a functional mapping relationship with its category, which is the final output.

(3) Bayesian-based mathematical model for equipment classification. The classification of campus electromechanical equipment is briefly described as follows. A large number of teaching equipment purchased by the school can actually be classified into different equipment categories. For example, according to the category of electromechanical equipment, they can be divided into electronic products and instruments. They can be divided into special equipment and general equipment according to the department using the equipment. They can be divided into consumables and low-value consumables according to equipment cost. Therefore, the above equipment classification problem can be described by the following formalized mathematical model:

1. $x = \{a_1, a_2, a_3, , a_m\}$ is set as a campus device to be classified. Each a is a feature attribute of x used to describe the characteristics of this device, such as projection, computer, and optical fiber.
2. There is equipment category set $C = \{y_1, y_2, y_3, , y_n\}$, such as electronic products and instruments, special equipment and general equipment.
3. The conditional probability $P(y_1|x), P(y_2|x), , P(y_n|x)$of the equipment to be classified for each equipment classification is calculated.
4. If $P(y_k|x) = max\{P(y_1|x), P(y_2|x), , P(y_n|x)\}$,$x \in y_k$.

The above problem description shows that the key to solving the problem now is how to calculate the conditional probability of the device object to be classified for each existing device classification in step 3.

The process of step 3 can be divided into the following sub-processes to solve this problem:

1) From all the equipment sets to be classified, it is necessary to randomly find a subset of the equipment objects to be classified, and manually classify them into each equipment category. The set thus obtained is called the training sample set.
2) The conditional probabilities of the characteristic attributes $a_1, a_2, a_3, , a_m$ of each device corresponding to each device category $y_1, y_2, y_3, , y_n$ are calculated, counted and estimated.
3) If the feature attributes of each device are conditionally independent, the following deduction can be made according to Thomas Bayes:

$$P(y_i|x) = \frac{P(x|y_i)P(y_i)}{P(x)} \tag{2.2}$$

For all equipment categories, the denominator is equivalent to a constant, and the numerator can be maximized. It is assumed that each feature attribute is conditionally independent, so the following equation is obtained:

$$P(x|y_i)P(y_i) = P(y_i)\prod_{j=1}^{m} P(a_j|y_i) \tag{2.3}$$

Hence, the classification of campus equipment can be solved through the above mathematical calculation logic. Figure 2.2 is the architecture of the electromechanical equipment classification mathematical model based on this.

(4) Design of simulation experiment.

Naive Bayesian and K-Nearest Neighbor (KNN) classification algorithms are the most commonly used in text classification. They are both relatively simple and effective classification algorithms. The two algorithms have the same advantages and disadvantages in most text classification experiments. In this experiment, the two algorithms are applied to the actual equipment classification, and the common equipment data in the school equipment inventory are adopted to compare the classification accuracy and time efficiency. According to this, this experiment selects a college as the research object and conducts a simulation experiment design for 200 pieces of electromechanical equipment owned by it. In the experiment, 100 pieces of electromechanical equipment are randomly selected as the training sample set, and the equipment names in the training sample set are manually sorted and classified. The training sample set is divided into six categories: consumables, low-value consumables, instruments and meters, electronic products, special equipment, and general equipment.

2.2. Design and research of campus electromechanical equipment management system. The last section is to use the Bayesian algorithm in the data mining algorithm to design and research the campus electromechanical equipment classification model. This section will further design the security and protection

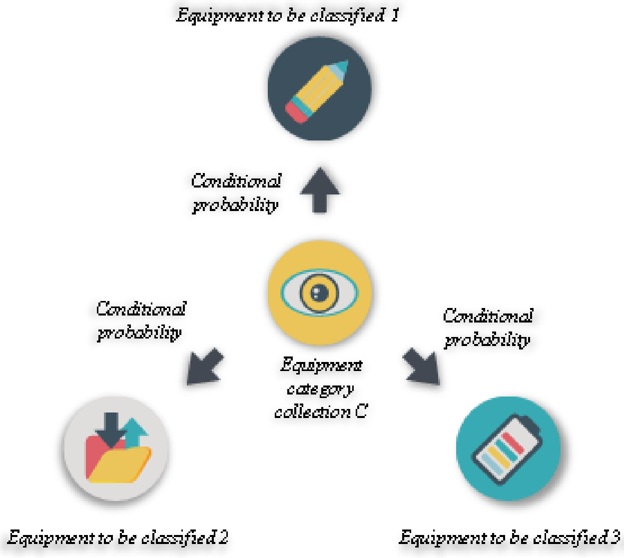

Fig. 2.2: The mathematical model

system of campus electromechanical equipment. It aims to realize fault prediction and intelligent maintenance of campus electromechanical equipment through the system.

2.2.1. System business process analysis.

1) Business process of equipment routine check management. Figure 2.3 presents the designed business process of routine equipment checks according to college's current management characteristics of electromechanical equipment.

Figure 2.3 suggests that the participants in the process of routine equipment checks include the equipment supervisor and the equipment administrator. Equipment routine check refers to the periodic inspection and maintenance of various equipment parameters in equipment management [16]. The equipment supervisor assigns routine check business to specific equipment administrators in routine equipment checks. The equipment administrator needs to set the routine check object, add specific routine check parameters, set specific check cycles, process the routine check data effectively, and finally view the corresponding check report.

2) Process analysis of fault declaration and maintenance management business. Figure 2.4 shows the designed fault declaration and maintenance business process.

Figure 2.4 suggests that in the fault declaration and maintenance management business process, the equipment user department first applies for the equipment fault, then fills in the corresponding application form and submits it to the equipment management department for declaration and approval. The approved information shall be fed back to the equipment user department to formulate a maintenance plan for the failure. The failure repair needs to be approved and submitted to the equipment repair department. Then, it is submitted to the repair and material preparation department. After the repair is completed, it needs to be submitted to the equipment user department for acceptance and settlement.

3) Consigned processing business management process. Consigned processing refers to directly delegating the corresponding equipment maintenance work to the relevant third-party units for specific equipment maintenance when the corresponding technical difficulties or the maintenance department's maintenance workload is too large to complete the corresponding maintenance tasks on time [17]. In the process of consigned processing, the user department of the equipment first makes a repair plan for the equipment, and then the equipment management department approves the plan. After that, the equipment maintenance department proposes corresponding consigned processing suggestions based on the repair task.

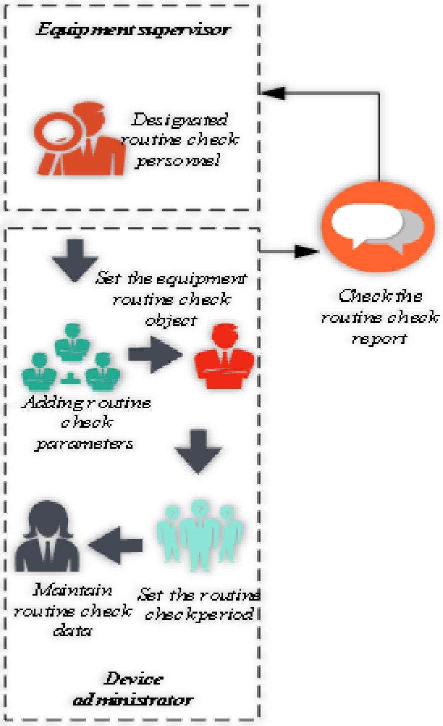

Fig. 2.3: The business process of routine check management

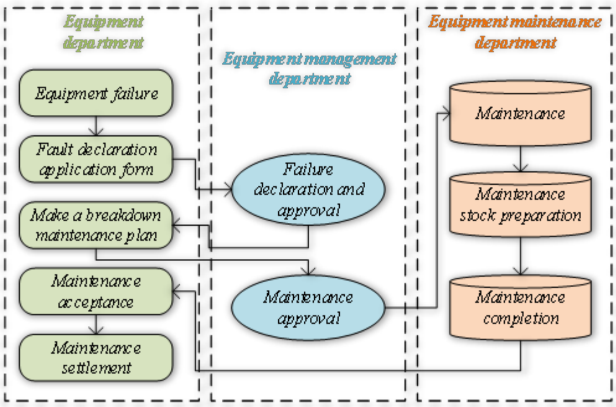

Fig. 2.4: The process of fault declaration and maintenance management business

2.2.2. System functional requirements analysis.

1) Analysis of routine check management requirements. Equipment routine check management is a significant module in the management system of college equipment fault prediction and maintenance plan generation. It mainly assists in the management of basic equipment routine check information during the college equipment failure prediction and the generation of maintenance plans, including the management of routine check position information, equipment routine check object information, equipment routine check data entry management,

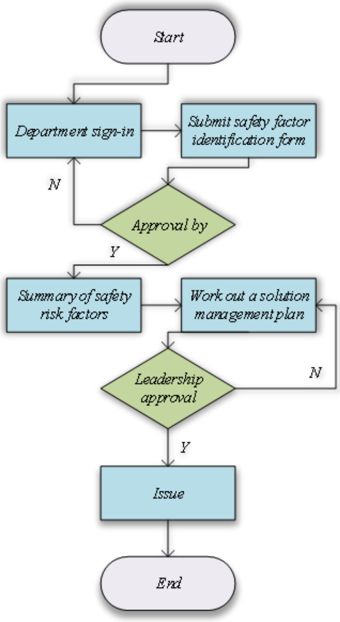

Fig. 2.5: Flow chart of fault prediction and early warning management

and routine check data maintenance.

2) Demand analysis of failure maintenance management. Fault maintenance management is an important module in the management system of college equipment fault prediction and maintenance plan generation. It is mainly used to assist in the management of basic fault repair information during the college equipment fault prediction and maintenance plan generation, including the management of account information in the repair process, the management of consigned processing settlement information, the management of consigned processing order information, and the management of acceptance processing information.

3) Demand analysis of fault prediction and early warning management. The risk early warning management of failures is a crucial module in the management system of college equipment fault prediction and maintenance plan generation. This module is mainly adopted to predict, warn, analyze and manage equipment failures in the process of equipment failure prediction and maintenance plan generation in colleges. The failure risk in the college equipment failure prediction and maintenance plan generation can be avoided in advance by using the model and algorithms.

2.2.3. Function design of main modules of the system.

1) Fault maintenance management design. The fault repair management module first needs to process the newly added fault repair application form, and then click the information to save it. If it fails to save, it needs to submit it again for saving. For those saved successfully, it is essential to go directly to the next step to approve the application form, and then apply for confirmation of fault repair. Only those approved can apply for fault repair. Otherwise, the application needs to be submitted again.

2) Design of fault prediction and early warning management. In order to complete the prediction of equipment failures and the generation of maintenance plans in colleges, it is necessary to establish a perfect risk assessment system and information-based evaluation method. Figure 2.5 is the designed flow chart for fault prediction and early warning management process.

2.2.4. System function realization. The platform of this system includes a hardware platform and a software platform. Table 3.1 shows the specific composition of the platform.

Table 2.1: Composition of system hardware platform and software platform

Composition of system hardware platform	
Platform classification	Specific parameters/models
Processor	Intel(R) Core(TM)2 Auad CPU Q9500 @2.83GHz
Memory	4GB
Composition of system software platform	
Platform classification	Specific parameters/models
Operating system	Windows 7
Database	SQL Server 2005
Development environment	JDK6.0
Development tool	Myeclipse10
Development language	Java
Web server	Tomcat 6.0

Table 2.2: Hardware and software test environment configuration of the system

System test hardware configuration	
Name	Parameter
Server	IBM System X3550 M4
	disk space: 600.0G; RAM: 8G;
Client	Dell OptiPleax 3020
	disk space: 400.0G; RAM: 2G;
System test software environment	
Name	Parameter
Client operating system	Windows 10
Database management system	SQL Server 2012
Application server	Tomcat
Browser software	Chrome

2.2.5. Simulation test of system performance. Table 2.2 shows the hardware and software test environment of the system.

According to the system test environment given in Table 3.2, the final performance test of the system is required during the delivery of the final system. After the corresponding tests, it can be confirmed whether the system can be synchronized with the user's requirements in the actual operation process. The main tool used is Load Runner when testing the performance of the designed management system for college equipment failure prediction and maintenance plan generation. The main indicator information in the performance aspect mainly includes the capacity of the relevant business system in terms of load, some capabilities in terms of the corresponding capacity, and the response time information of the specific business system. By running the Load Runner tool, the system is tested in different time periods, and different access frequency levels (10/min, 100/min, 1000/min and 5000/min) are tested, different operation types (specific operations such as adding, deleting, modifying and querying data information) are tested, and finally the indicator information of the business system in the actual operation process is recorded.

3. Model and system performance test results.

3.1. Classification results of college electromechanical equipment based on the Bayesian algorithm.

3.1.1. Comparison of equipment classification effects under different algorithms. Figure 3.1(a) displays the specific distribution of training sample equipment data under each equipment category through simulation experiments. x-axis is the equipment category and y-axis is the number of training samples. Figure

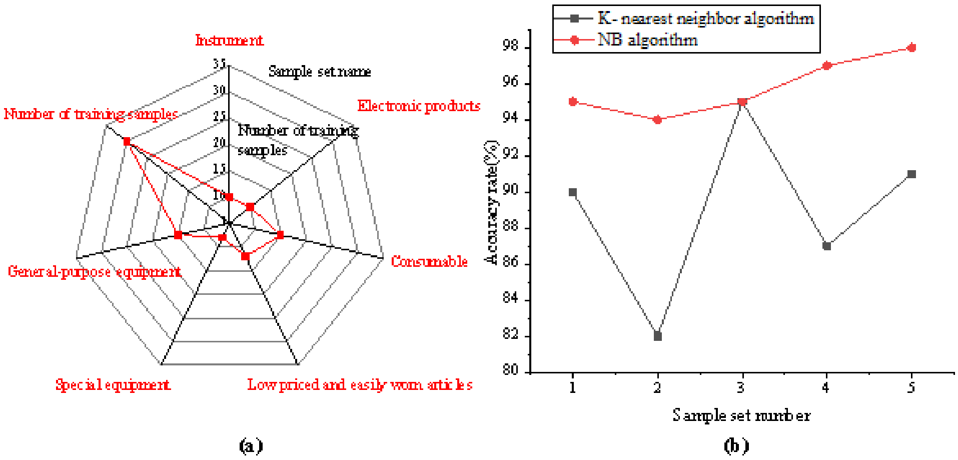

Fig. 3.1: Equipment distribution results of training samples and comparison of equipment classification effects under different algorithms (a) Equipment distribution diagram of training sample; (b) Comparison results of equipment classification effects under different algorithms

3.1(b) shows the classification effect under the two algorithms.

Figure 3.1 shows that under the same sample set, the classification effects of the two classification algorithms are significantly different, and the accuracy of the Bayesian algorithm is higher. It suggests that the Bayesian classification (NB algorithm) is obviously superior to the KNN algorithm in terms of equipment classification.

3.1.2. Comparison of running time required for equipment classification under different algorithms. In order to further compare the classification efficiency of the two algorithms, the running time of the two algorithms for classification is compared based on the same equipment sample set. In the experiment process, the method of gradually expanding the size of the equipment sample set is adopted, so that the running time of the two classification algorithms under equipment sample sets with different sizes is obtained. Figure 3.2 presents the specific experimental comparison results.

In Figure 3.2, the x-axis represents the extent of the sample set increase, and the y-axis represents the time spent running the algorithm. Figure 3.2(a) represents the KNN algorithm, and Figure 3.2(b) is the NB classification algorithm. When the x-axis sample set value is smaller than 100, the running time of the two algorithms is similar. Because of the simplicity of the algorithm, there is little difference. With the increasing number of sample sets, when the value reaches 2500, the running time of the KNN algorithm is significantly longer than that of NB. It shows that the NB classification algorithm is better than the KNN algorithm.

The above experimental results show that the Bayesian-based equipment classification model studied has a shorter running time, higher classification accuracy and better performance than the KNN algorithm.

3.2. Performance test results of security and protection system for campus electromechanical equipment. The system is tested according to the given hardware and software environment. Figure 3.3 displays the system performance.

Figure 3.3 reveals that when the browser concurrency in the system is 10, 100, 500, 1000, and 5000, the server processor utilization reaches 23%, 33%, 49%, 54%, and 67%, respectively, while the memory utilization reaches 23%, 43%, 56%, 64%, and 75%, respectively. It shows that the system has a certain browser concurrency-bearing capacity. Moreover, as the browser concurrency in the system increases, the response time of the test also increases, but the values are in the standard state. To sum up, the system has achieved the expected goal through the experimental test, the degree of perfection of the whole system has passed the test, and the whole system is in a stable operation state.

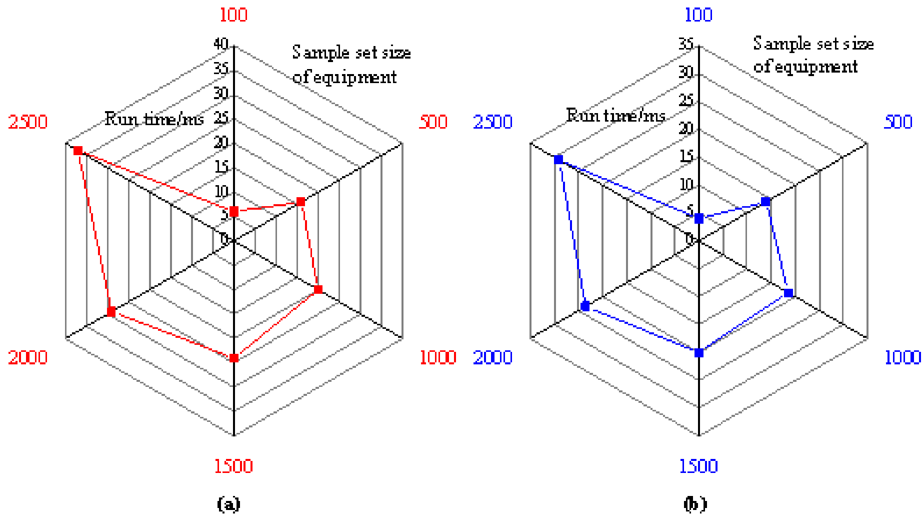

Fig. 3.2: Comparison of the algorithm running time (a) Running time of KNN algorithm; (b) Running time of NB algorithm

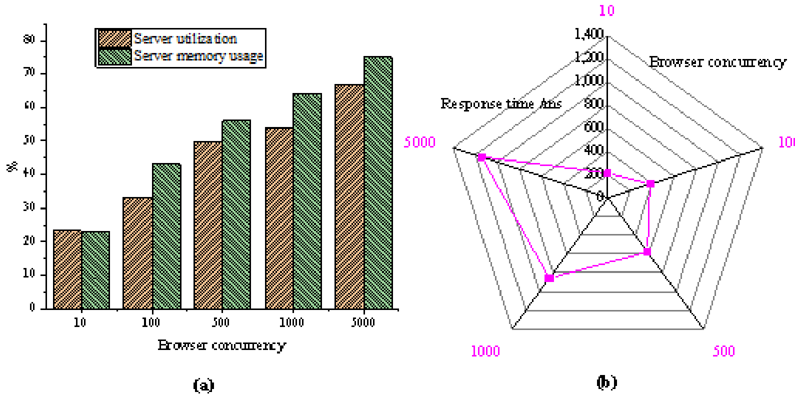

Fig. 3.3: System performance test results (a) System processor and memory usage; (b) System response time

4. Conclusion. In order to achieve the efficient management of campus electromechanical equipment security, this work uses the Bayesian algorithm in data mining technology to effectively classify the electromechanical equipment in colleges. Then, the safety management system of electromechanical equipment in colleges is designed. Finally, the simulation experiment is set to test the classification model and the system's performance.

The results show that: (1) the improved statistical classification algorithm - Bayesian algorithm can be used to efficiently classify electromechanical equipment. (2) The college electromechanical equipment safety management system designed has good processing performance, and can realize the intelligent safety management of electromechanical equipment. The research disadvantage is that the business of the actual college equipment fault prediction and maintenance plan generation system is relatively complex, while the core function modules of the college equipment fault prediction and maintenance plan generation system designed here are relatively simple, and some complex functions cannot be realized. Thereby continuous improvement is needed in the subsequent design. This work aims to improve the efficiency of the department's actual work, provide good services for users, and provide beneficial help for the intelligent safety management of campus electromechanical equipment.

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