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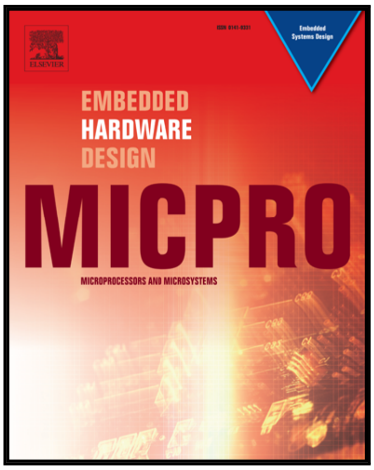

Research on university laboratory management and maintenance framework based on computer aided technology

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Research on university laboratory management and maintenance framework based on computer aided technology

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Abstract: The management and maintenance of university laboratory is an important part of university work. With the rapid development of computer technology, computer-aided technology is widely used in the management and maintenance of university laboratories. This paper first analyzes the current situation of university laboratory management and maintenance, and points out the importance of computer-aided technology to manage and maintain university laboratory. Then, through the introduction of the Internet of things, the information collection, sensor technology, and other modules are used to build the university laboratory management system. Finally, by giving the credit security evaluation model of university laboratory management, the experiment of university laboratory security maintenance is completed on the data of different years. The experimental results show that the model constructed in this paper can evaluate the security situation of university laboratory management well. Through the use of the management framework and safety assessment and maintenance model, colleges and universities can ensure the orderly operation of the laboratory, through effective management and data analysis, reduce the potential safety hazards in the laboratory, and avoid unnecessary security problems.
Key words: computer aided technology; university laboratory; Internet of things management system; credit security evaluation model; laboratory security

1 Introduction

Laboratory is the cradle of science and technology, and safety, health, environmental protection and energy conservation are the basic elements of the laboratory [1-3]. In order to prevent accidents in advance, it is necessary to protect the safety of laboratory personnel and equipment in an all-round way. Based on the Internet plus, the intelligent laboratory adopts advanced information technology and hardware and software to collect, process, supervise, store, transmit and invoke laboratory information such as experimental teaching, scientific research and management, and make [4-5] resources fully optimized. Laboratory safety education is one of the important contents of safety management. Enriched safety education can improve people's understanding and safety quality, and it is also the first and most important barrier to ensure the safety of laboratory personnel. At the same time, University Laboratories also undertake scientific research and complete the task of tackling key scientific and technological problems, and strive to improve colleges and universities [6]. The management level of laboratory is not only the objective need of self construction, but also the objective requirement of modern society for higher education management.

In recent years, the lack of effective monitoring and perception means in university laboratory management has led to low efficiency of laboratory equipment, environmental information and personnel supervision, and low level of laboratory automation and intelligence [7]. With the popularization of the Internet of things technology, the laboratory information management and intelligent monitoring system based on the Internet of things has become practical and feasible [8]. In reference [9], an integrated laboratory management system was proposed for the lack of environmental perception and collection and remote control of equipment. In reference [10], the laboratory management system is designed and implemented from the perspective of information management and automatic monitoring, and the functions of each sub module are tested and verified.

The original laboratory management are built on the conventional system architecture without the intelligent detection and management. In recent researches on the intelligent laboratory, researchers used different intelligent detection and recognition algorithms for the risk early warning and people turnovers analysis. In reference [11], the researchers built an intelligent laboratory management system based on the Internet of Things. Under such management system, all information collected from any forms of sensors are connected into the Internet-of-Things for the management. In reference [12], the authors used the reservoir sensitivity evaluation to establish the intelligent laboratory management system. The system includes modularized and integrated equipment, standardized programmatic procedure and shared platform of testing process and data. It has the ability of automatic data acquisition, analysis and processing, safety warning, process tracking and intelligent process discrimination. For the construction of practice teaching management platform, reference [13] proposed a novel intelligent mobile terminal with the barcode technology. The intelligent mobile terminal is constructed by using the two-dimensional barcode to raise the promotion of the usage rate of the laboratory equipment. To explore the management mechanism of the intelligent autonomous experiment platform, reference [14] provides the 24 hours intelligent independent experimental environment for the users of laboratory. Based on the monitoring control of wireless sensor network, reference [15] collected signals from the sensors and transferred such signals by using the ZigBee wireless nodes.

In view of the current laboratory environment information cannot be real-time monitoring and response, this paper designs and implements a laboratory management system based on the Internet of things. Through the optical fiber ring network, the information such as RFID, infrared alarm video, laboratory water and electricity consumption is uploaded to the central server, forming a C / S architecture [16], forming a centralized control mode. The system can realize the visual sharing and management of laboratory resources. According to the reports, curves and data packets generated by the central server, it can be analyzed and verified.

Aiming at the above proposed problems for university laboratory management and maintenance, this paper proposes a novel management and maintenance framework based on computer aided technology to improve laboratory revolution efficiency. The organization of this paper is given as follow: Section 1 gives the introduction of novel methods for the management and maintenance of the laboratory. Section 2 illustrates the problems that faced by the current laboratory management and the strategy of the laboratory situation analysis. Section 3 shows the mainly used application of computer aided technology in laboratory intelligent management. Section 4 gives the credit security evaluation model of university laboratory management, including Evaluation dimension and Normalization of safety credit. Section 5 exhibits our experimental results on four key labs management and maintenance.

2 Laboratory management and maintenance status

2.1 Problems faced by laboratory management

Laboratory management involves many problems such as equipment, personnel, funds and so on [17]. For the mainly encountered problems, we divided into three categories:

(1) Instruments and equipment, less management personnel and a large amount of report work.

At the beginning of each semester, the laboratory needs to submit various forms to various departments. If the University builds a big data with laboratory as the basic unit to realize data sharing, the school departments can also effectively access the data needed, and the report workload will be greatly reduced.

(2) Laboratory safety risks exist objectively.

The safe operation of the laboratory is an important foundation to ensure the normal teaching and scientific research order of the school, the personal safety of teachers and students, and the harmony and stability of the campus [18]. At present, the laboratory control is relatively weak, and the laboratory opening process cannot be effectively controlled.

(3) Experimental teaching reform puts forward higher requirements for laboratory management.

The Ministry of education requires colleges and universities to encourage students to carry out innovation and entrepreneurship training and practice in accordance with the principle of "interest driven, independent practice, focusing on process" [19]. It is easy to cause management confusion and low management efficiency.

2.2 Current situation analysis of laboratory management and maintenance strategy

At present, many departments are responsible for the laboratory safety work in domestic colleges and universities, and the focus of relevant departments is different. In this management system of block management of different functional departments, it is easy to cross and duplicate some management responsibilities, resulting in low management efficiency [20]. At the same time, each laboratory faces different user groups and uses different instruments and equipment. If all of them carry out the same laboratory safety education, it will waste a lot of manpower, material and financial resources, and cannot achieve the corresponding education and prevention effect. Some laboratories used a lot of sensors to collect running data, including temperature, humidity, smell, and other kinds of sensors. The synthetic data from any kinds of sensors are uploaded to a cloud computing center for data mining. The mined results from the sensors of big data will instruct the management and maintenance for the laboratory, especially for people's behavior statistics and risk early warning of man-made disaster.

In the era of continuous development of information technology, good and real data statistics and mining can provide strong support for policy-making [21]. With the help of the real computer-aided technology laboratory management data, this paper puts forward a model of security credit, through which the user's security knowledge and skills can be quantified, thus laying the foundation for the safety management and maintenance architecture of each computer-aided laboratory. The credit security is one of the most important things for the management of a laboratory. For example, the chemistry and biology laboratories often contain many deadly materials, which will cause life danger with wrong operation way. Therefore, the entered people will be well-trained to be safe for doing such chemistry and biology experiments, all information of the people participated in the experiments will be recorded in the credit of such people. Then, the harm will be terminated before wrong operations.

3 Application of computer aided technology in laboratory intelligent management

The intelligent laboratory management platform of computer-aided technology integrates online management, remote monitoring and other laboratory management and services by using the Internet of things, information collection, sensor technology, etc. The management platform realizes four management functions: informatization of management mode, such as the transformation from traditional manual management mode to network-based information management; business processing process, such as reasonable arrangement of laboratory business, standardized operation, system and specific work complement each other; Open management and control process, such as resource inquiry, appointment, authorization, swipe card identity authentication, remote door, electricity, video monitoring control; management data systematization, such as automatic collection of real data from business processes for scientific decision-making, as shown in Figure 1.

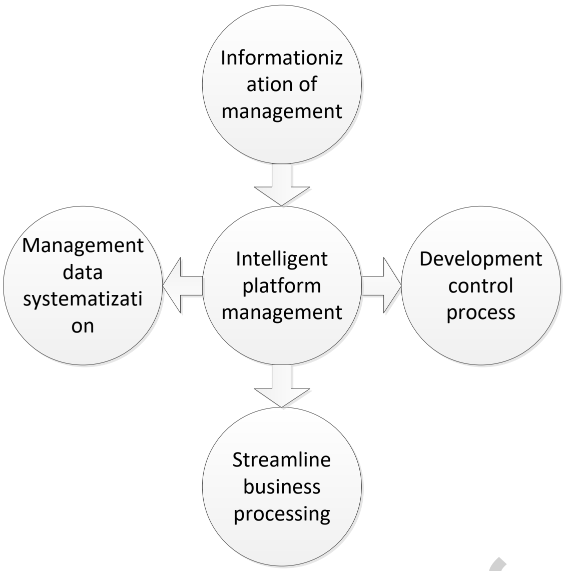


Figure 1 Functions of intelligent management platform

From the structure of Figure 1, we can find that the functions of intelligent management platform contained four mainly parts, management data systematization, informationization of management, development control process, and streamline business processing. The systematization data management includes the original data statistics and analysis by using manual controlled methods and the intelligent algorithms. For the development control process, the intelligent algorithms will give the optimal strategy for the laboratory. Streamline business processing is the basic procedure of the laboratory. The key module of the intelligent management platform is informization management. That is to say, the management is radically changed to a machine-learning algorithm-guided approach.

3.1 Software module of intelligent management platform

The software modules of intelligent management platform include experimental teaching management [22], asset equipment management, laboratory open management, laboratory data filling system for various management departments, laboratory security access management, laboratory consumables and other management modules, so as to facilitate the daily management of the laboratory and reduce the filling of laboratory reports (see Figure 2). The statistical analysis module includes the statistics of laboratory power on and off, equipment utilization rate, curriculum statistics, development experiment usage statistics and laboratory in and out statistics.

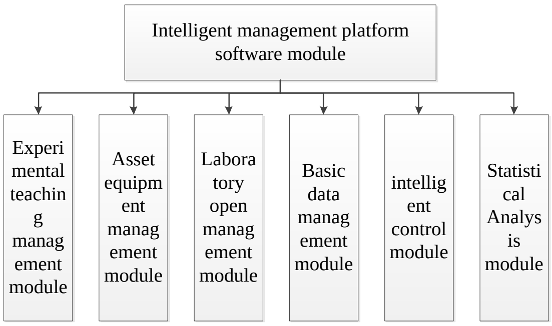


Figure 2 Software module of intelligent management platform

From the structure of Figure 2, we can find that the software module of intelligent management platform contained five mainly parts, they are teaching, asset equipment, opening, intelligent and statistical analysis modules. The teaching module and asset equipment module are aim to train qualified participants in the experiment to safety use the dangerous asset equipment in the laboratory. The opening module is used to manage the normal operations of the asset equipment in the laboratory. The data, intelligent, and statistical analysis modules are built on the could computing service and big data mining. To collect, mine, and analyze the sensors data during operations of the asset equipment and the running of laboratory, the in-line intelligent algorithms and statistical algorithms are used to analyze such data.

3.2 Hardware module of intelligent management platform

The hardware modules of the intelligent management platform include intelligent access control, power supply, video monitoring management, etc., to facilitate the remote control of the laboratory. Figure 3 is the wiring diagram of University Laboratory of computer aided technology. The strong current connection mode of each classroom is the same. The electric control box is connected to the electric control box from the top of the original air switch in the classroom, and then the output of the electric control box is connected to the lower part of the air switch to ensure that the electric control box can control the electricity when the air switch is disconnected. When the electric control box is disconnected, it can be pushed artificially to open the air, which can ensure the normal use of equipment power. The card reader is connected with the data analyzer. The data analyzer transmits the physical address of the card to the central control box through RS485. The central control box is connected with the electric control box to realize intelligent access control and electronic control.

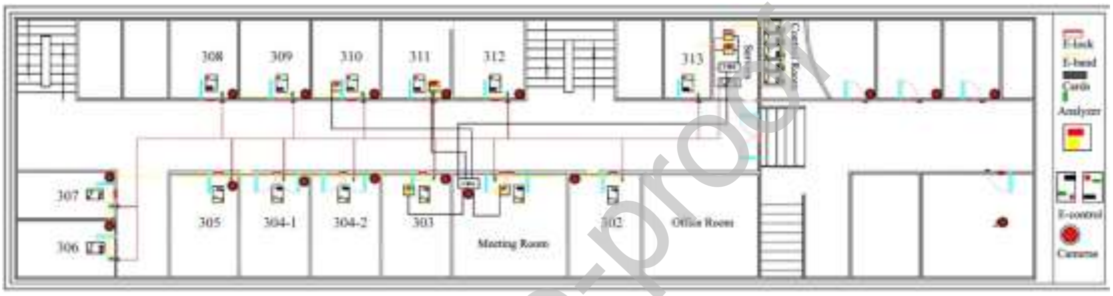


Figure 3 Wiring diagram of university laboratory based on computer aided technology

3.3 Overall scheme of university laboratory management and maintenance based on computer aided technology

The schematic diagram of system design is shown in Figure 4. The laboratory management system based on the Internet of things is divided into three levels: the data acquisition system is the sensing layer, the communication link composed of ZigBee [23] and optical fiber ring network is the network layer, and the central server and its upper computer are the application layer. Among them, the optical fiber ring network composed of optical switch transforms the information of sensing layer into network information, which has the characteristics of large scalability and strong system stability [24].

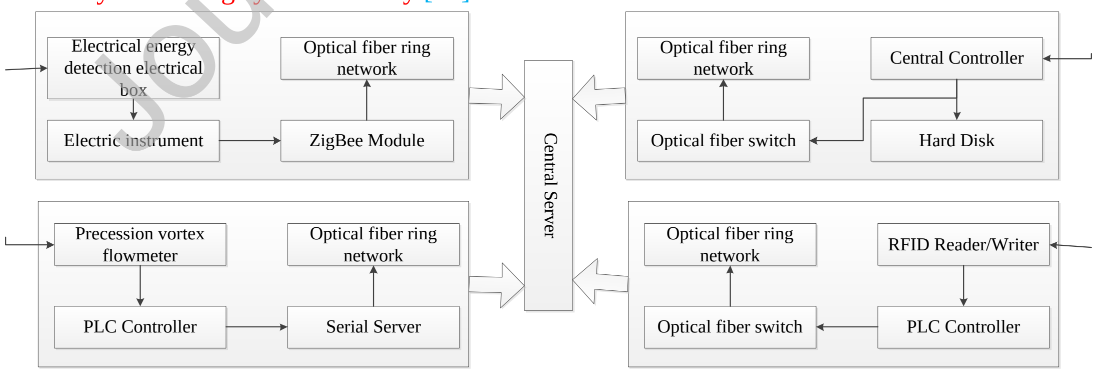


Figure 4 Structure of laboratory management system based on Internet of things

In order to verify the reliability and integrity of the function, automatic identification optical fiber and infrared alarm function cameras were installed in five laboratory rooms. Add one circuit of electric energy meter in each machine room and main electric room. Add a flow meter to the toilet. The central server is located in the control room with a central control cabinet and an industrial computer console. One channel RFID and M1 card is in the central control cabinet. The control cabinet is equipped with hard disk video recorder, PLC, RFID, optical fiber switch and other electrical equipment.

3.4 Data acquisition of university laboratory based on computer aided technology

The data acquisition module can be regarded as the perception layer of the Internet of things. It can collect information about environment, water and electricity, access control and laboratory personnel. According to the needs of laboratory management, the external environment data collected by the system mainly include electricity, water flow and video. After the data are transmitted to the central server, the data are displayed and analyzed.

(1) Electricity collection

The main function of power monitoring is to obtain the power consumption of the laboratory, generate reports and make statistics on the power consumption according to the demand; real time monitoring and dealing with the sudden situation of power consumption in the laboratory. In order to achieve this purpose, a special electric energy detection box is installed in the laboratory, and the current signal in the electrical box is transmitted to the power instrument through the mutual inductor, which completes the acquisition of conventional electric energy signal. At the power instrument end, it is transmitted to ZigBee module through RS-485 serial port protocol. Considering the advantages of ZigBee technology, such as low power consumption, low cost, reliability and scalability, it is suitable for wireless power transmission in multiple laboratories. At the ZigBee terminal, the data is encoded to meet the baud rate, parity check code, parity check and data bits required by the watt hour meter communication. ZigBee coordinator has its own protocol conversion function, which converts the communication into TCP / IP protocol format and enters the optical fiber ring network through the router.

(2) Video capture

Several independent video monitoring nodes are set up in the system, and the infrared camera and client software are used to realize the video data acquisition and transmission, as shown in Figure 5. In the upper computer, that is, the video information integration center part, on the one hand, the initialization parameters are distributed to each independent video node, on the other hand, the configuration software is used to access their IP addresses to access the monitoring screen.

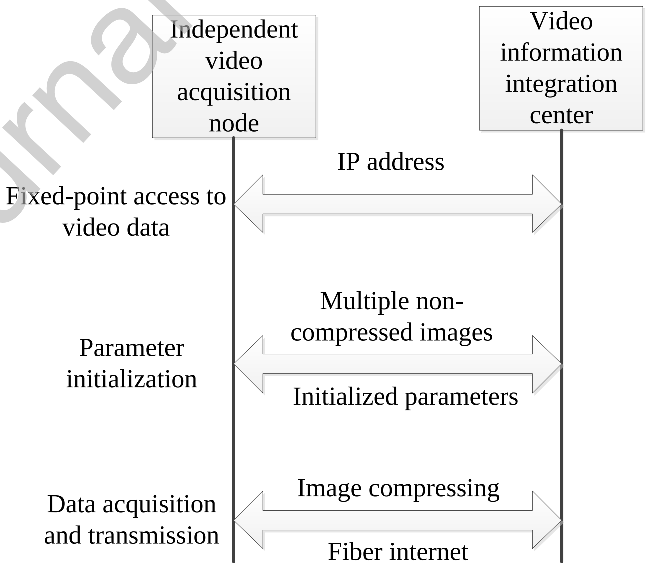


Figure 5 Schematic diagram of video monitoring data transmission process

(3) Water flow collection

Water flow acquisition and processing mainly realizes the real-time monitoring of laboratory water safety, which is mainly composed of the core function module of flowmeter [25]. In the system, two toilet pipes are equipped with Precession Vortex flowmeter. As shown in Figure 6 is the design schematic diagram. The Precession Vortex flowmeter is an automatic metering flowmeter. The single hole flow can monitor the water flow changes in real time and display on the monitoring interface. After the water flow is detected, the DAC circuit on the flowmeter converts the digital quantity into the analog current signal of about 4 ~ 20mA, and converts it into the water flow of about 0.6 ~ 6m3. In order to read the value of the flowmeter remotely, the transmitted current is sent to the acquisition instrument. In the acquisition instrument, the collected flow data is transmitted to the main station of PLC controller, and the data is converted into PPI / tcpip protocol through the serial server, and enters the optical fiber ring network.

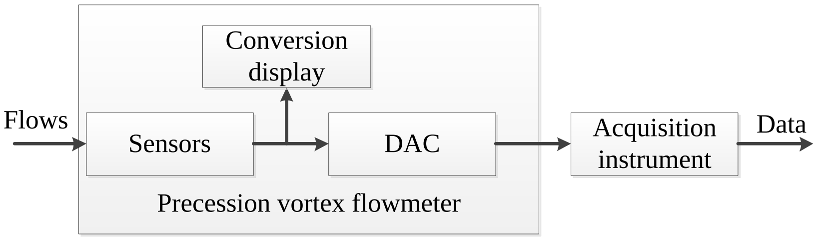


Figure 6 Water flow collection of Precession Vortex Flowmeter

(4) Access control information collection

Access control system collector uses RFID radio frequency technology to identify the target and obtain its related information. The access control acquisition system is mainly composed of three parts: tag, card reader and antenna, in which the tag is composed of coupling elements and chips, each tag has a unique electronic code, which is attached to the object to identify the target object; the card reader is the device to read or write tag information; the antenna transmits RF signal between the tag and the reader. The workflow of access control collection is shown in Figure 7. Once the reader with RFID technology detects a certain range of tag signals, it is compared with the information in the access database of the upper computer. When the data meet the conditions, send the command to PLC to control the corresponding equipment. Compared with the traditional card access control acquisition system, the designed system avoids tedious manual operation and is more intelligent.

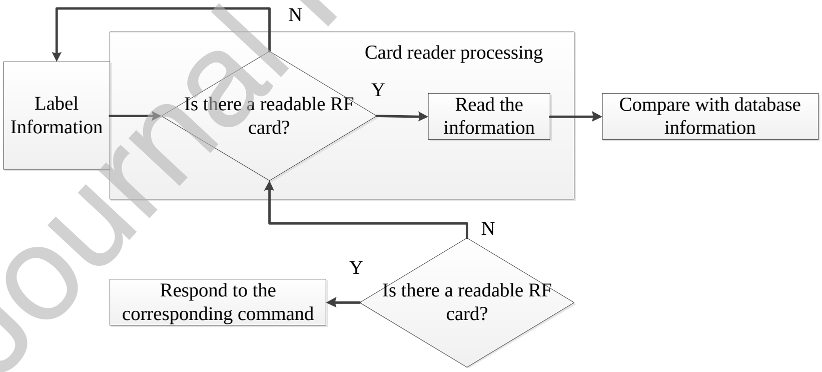


Figure 7 Workflow of access control collection

3.5 Communication link and host computer management of University Laboratory

The communication link and the upper computer play the roles of network layer and application layer respectively in the system. The communication link provides the communication connection between the monitoring equipment and the central server, and the upper computer is responsible for the data acquisition and the realization of human-computer interaction. In the design, the communication link mainly adopts the scheme of optical fiber ring network. Using multiple switches and electrical port to optical port equipment, all kinds of signals are converted to electrical Ethernet, and then to optical port. Any location in the network can access the network equipment of other nodes, which greatly increases the scalability of the system. Then, all communication protocols are converted into TCP / IP form, and then all Ethernet devices are connected by optical fiber transceiver to form optical fiber ring network. In each sub module, different industrial protocols are adopted according to different devices, such as AIBUS communication protocol, MODBUS protocol, etc. The upper computer is composed of three layers: user interface (UI) layer, business logic layer and data service layer. The upper computer architecture program is mainly implemented based on MVC pattern structure. MVC mode is divided into three parts: model, view and controller. In this system, the data of each module, the output display interface and the processing and control of the central server from the optical fiber ring network are taken as the derivative mode of MVC, and the MFC written in C + + language is used as the main interface and controller.

4 Credit security evaluation model of university laboratory management

Through the comprehensive processing and evaluation of massive information data, security credit evaluation mainly includes six dimensions: user characteristics, behavior preference, learning ability, examination results, course attendance and accident history. Finally, the user's safety credit score is calculated by normalization.

4.1 Evaluation dimension

Safety credit mainly includes six dimensions: user characteristics, behavior preference, learning ability, examination results, course attendance and accident record, which reflects the safety awareness and safety behavior of users from all aspects. In single dimension evaluation, the highest score of each dimension is 100, and the lowest score is 0. User characteristics are mainly analyzed from user identity and user background. Users' identities are mainly divided into undergraduate, master's and doctoral students. Compared with undergraduates, master's and doctoral students have the advantage of knowledge accumulation in security credit; user's background mainly refers to the user's college and professional background, especially for liberal arts majors. At the same time, different professional grades have different accumulation of security knowledge [26].

Definition 1 User characteristics S_1:

$$S_1 = \alpha \times (P_e + P_g) + \beta \times (P_m + P_r) \quad (1)$$

where α represents the weight of educational level and professional grade in the evaluation. β represents the weight of professional nature in the evaluation, and meets the conditions $\alpha + \beta = 1$; P_e, P_g, P_m, P_r refers to the weight of education, grade, major and high-risk specialty. The behavior preference is mainly analyzed from the user's operation behavior. The user's operation habits can often reflect the user's habits in real life, such as whether the user has a good habit of logging in and logging out, and whether there is cheating in the user's study and examination.

Definition 2 Behavior preference S_2:

$$S_2 = \sum \alpha \times P_c - \sum \beta \times P_e \quad (2)$$

where α and β respectively represent the weight of a certain kind of good habits and bad habits. P_c and P_e represent the frequency of a certain kind of good habits and bad habits. Learning ability is mainly analyzed from users' online learning. The time of people's attention is related to age, learning time and learning difficulty. The user's age directly affects the user's attention in learning. In order to facilitate calculation, linear transformation is used for age.

Definition 3 Age S_3:

$$S_3 = 100 - P_a \quad (3)$$

where P_a is the user's age. The average length of learning time per day and the learning period are the factors that affect the learning level of users. The definition of learning time is given below.

Definition 4 Learning time S_4:

$$S_4 = \eta \times (-(\bar{t}\text{-}P)^2 + 100) \quad (4)$$

where P represents the middle value of normal learning time. According to the normal learning time range of 40-60min, so P should be taken as 50. η is the weight coefficient of different time periods. The 24-hour is divided into four parts: midnight, morning, afternoon and night, and the weight coefficients of each part are 0.1, 0.8, 0.6 and 0.5, respectively. For each type of resources, we define the learning difficulty. The more difficult the learning content is, the higher the user's learning ability is. Therefore, the definition of learning difficulty is given below.

Definition 5 Learning difficulty S_5:

$$S_5 = \sum_{i=1}^{N} P_i / N \quad (5)$$

where N represents the total number of learning resources. P_i represents the difficulty coefficient of the i_{th} resource. The learning ability of all users can be regarded as normal distribution, and the definition of learning ability is given according to Definitions 3-5.

Definition 6 User learning ability S_6:

$$S_6 = 100 \times \frac{\alpha}{\sqrt{2\pi}} e^{-\frac{(P_1 \times S_3 + P_2 \times S_4 + P_3 \times S_5 - \mu)^2}{2}} \quad (6)$$

where P_1, P_2, P_3 are weight coefficients of user's age, learning time and learning difficulty. α is overall weight coefficients. μ is location parameters of normal distribution, $\mu = 75$. The test results are mainly analyzed from the user's test results. The higher the user's test score is, the higher the mastery of safety knowledge is.

Definition 7 Test scores S_7:

$$S_7 = \frac{1}{N} \sum_{i=1}^{N} P_S(i) \quad (7)$$

where N represents the number of tests the user took. $P_S(i)$ represents the test score of the i_{th} security exam that the user took. Course attendance is mainly analyzed from the attendance of users, which can reflect the learning attitude of users from the side.

Definition 8 Course attendance S_8:

$$S_8 = \frac{100 \times \sum_{i=1}^{N} \frac{p_C(i)}{P_C(i)}}{T} \quad (8)$$

where n is the number of attendance. N is the number of expected attendance. T is the total number of courses. The credit history is mainly calculated from the safety accidents and safety precautions of users in the past, which is the most objective way to reflect the safety credit of users. In this paper, the credit history is expressed by exponential function to improve the initial rate of change.

Definition 9 Credit history S_9:

$$S_9 = -e^{-(\alpha \times N_p - \beta \times N_a)} + 100 \quad (9)$$

where α, β Denote the weight of accident prevention and the weight of safety accident occurrence respectively, $\alpha + \beta = 1$. N_p and N_a respectively represent the number of accident prevention and the number of safety accident occurrence.

4.2 Normalization of safety credit

In this paper, the security credit evaluation method is mainly through the evaluation of each dimension, and finally comprehensive calculation of the user's safety credit score. The level of security credit score can reflect the user's security knowledge and security technology. Then, how to normalize the six dimensions into safety credit, this paper uses six dimensions to calculate the safety credit, and puts the six dimensions into a six dimensional coordinate system. The safe credit value is calculated as follows:

$$S = \sqrt{S_1^2 + S_2^2 + S_3^2 + S_4^2 + S_5^2 + S_6^2 + S_7^2 + S_8^2 + S_9^2} \quad (10)$$

5 Safety accident analysis and prediction algorithm

In the college laboratory management and maintenance of computer-aided technology, the prediction of security events is the most important, which is mainly based on the six dimensions of user safety credit. Firstly, according to the six dimensions of users, users are clustered into three categories: high-risk groups, potential risk groups and safe groups. The classification methods of users will be introduced in detail below. Then, according to the crowd faced by the laboratory, high-risk groups and potential problem groups will be analyzed, and knowledge loopholes will be analyzed from learning content and examination results, so as to predict safety accidents.

5.1 User clustering

After the user's safety credit is calculated according to the safety credit formula, the first clustering is carried out according to the user's safety credit [27]. This clustering is mainly divided into two groups: the safe group and the dangerous group. The clustering principle is as follows:

(1) The safety credit score should be greater than or equal to 220 points. When the safety credit score reaches this level, the average score of users in six dimensions is not less than 90 points, and users have good security knowledge and technology accumulation.

(2) The safety credit score of the dangerous group is lower than 220, and these users still have some deficiencies in safety awareness. According to the first user clustering method, we can distinguish the safe group from the dangerous group, but in the dangerous group, not every user needs to pay attention to it. In this paper, K-means algorithm is used to cluster the dangerous population in the first cluster for the second time [28]. This clustering is mainly divided into high-risk groups and potential problem groups.

The clustering algorithm is as follows:

(1) Firstly, the user credit score is compared with the threshold value of 220. If the user credit score is greater than or equal to 220, the user is classified into the safe group; if the score is lower than 220, the user is classified into the dangerous group;

(2) After actual analysis, the formula is as follows:

$$V = \{a_1, a_2, ..., a_6\} \quad (11)$$

where $a_1, a_2, ..., a_6$ are the six dimensions of a user.

(3) First cluster centers were randomly selected:

$$Center_k = \{C_{1k}, C_{2k}, ..., C_{6k}\} \quad (12)$$

where k should satisfy $k = 2$.

(4) $s \in S$ is the sample set. According to Euclidean formula, the distance between S and all cluster centers is calculated, and s is divided into the set of the nearest center.

(5) The center of the cluster center is recalculated, and the new center point of the point group is obtained by using the average value of the coordinates of each point. If a new center point is generated, perform step 3; if the center point does not change, perform step 5.

(6) Euclidean formula was used to calculate the distance between the two cluster centers and the origin. The cluster whose cluster center is closer to the origin is the high-risk group, and the cluster with a longer distance is the potential problem group.

5.2 Safety accident prediction

According to the previous section, users are clustered into high-risk groups, potential risk groups and safety groups. The safety accident prediction algorithm in this section will focus on high-risk groups and potential risk groups. Safety accidents are defined as five categories: fire or flood accidents, toxic accidents, explosive accidents, mechanical accidents and electrical accidents; safety knowledge learning and examination are also divided into six categories: general knowledge, chemistry, radiation, medical biology, electrical and mechanical. The corresponding relationships defined are shown in Table 1.

Table 1 Corresponding relation of safety accident, learning and examination classification

Category	Type of accidents
General	Fire or flood accidents
Chemistry	Toxic or explosive accidents
Radiation	Toxic accidents
Medical biology	Toxic accidents
Electrical	Electrical accidents
Machinery	Mechanical accident

Type of accident general fire or flood accident chemical toxic accident explosive accident radiation toxic accident medical biological toxic accident electrical electrical mechanical mechanical accident in real life every laboratory or high-risk place faces some fixed user groups, According to the fixed user groups, the user types are divided, and the data of high-risk groups and potential risk groups are extracted for analysis. The probability of each kind of accident depends on the probability of two kinds of people

$$P_c = \alpha \times P_L + \beta \times P_E \tag{13}$$

where P_L and P_E represent the probability of occurrence of high-risk groups and potential risk groups in such accidents. α and β denote the weight coefficient. Then, the probability of a certain type of safety accident for a certain group of people can be directly reflected by the learning situation and examination situation of this group, so the following formula can be obtained:

$$P_L = \frac{1}{group} \sum_{i=1}^{group} \left(1 - \frac{Learn_i}{Total} \right) \tag{14}$$

$$P_E = \frac{1}{group} \sum_{i=1}^{group} \left(1 - \frac{\sum_{j=1}^{N} Exam_{ij}}{Total} \right) \tag{15}$$

where $Learn_i$ represents the number of learning resources of the i_{th} user. $Total$ represents the total number of learning resources of a certain type. $Exam_{ij}$ represents the score of the i_{th} test of a certain type of user. N represents the total number of examinations taken by the user, and $group$ represents the total number of people. The probability formula of a certain type of safety accident can be obtained:

$$P_{group} = \eta \times P_L + \sigma \times P_E \tag{16}$$

where η, σ denote the weight coefficient and satisfies $\eta + \sigma = 1$.

6 Simulation experiment and results analysis

The safety credit evaluation system and laboratory safety accident prediction algorithm are implemented in our network. The analysis of relevant data in the actual operation process can refer to Table 2. The parameter initialization of the relevant weight coefficient pairs in the algorithm can refer to Table 3.

Table 2 Algorithm analysis of relevant data

Name of parameters	Values of parameters
Number of users	16223
Learning record	87363
Examination record	517263
Operation log	152763
Accident record	119
Attendance record	85634

Since the dataset collected from 2013-2018 is the current complete laboratory running, management, and processing dataset, this paper used such dataset to validate the proposed intelligent management and maintenance algorithms. Meanwhile, the laboratory system from the selected dataset is built on the internet-of-the-things wireless network for running with lots of sensors. The collected data can be intelligent analyzed for the indexes described in Table 2. Therefore, such dataset is very useful for used in the laboratory management and maintenance in the real-world, so the proposed intelligent scheduling algorithm can be tested on such dataset to reflect the logistics vehicle schedule.

Table 3 Parameter initialization of correlation weight coefficient pairs

Name of parameters	Values of parameters
User characteristics	65, 35
Behavioral preference	5, 5
Learning time	0.1/0.8/0.6/0.5
Learning ability	2.5, 75, 0.2, 0.4, 0.4
Credit history	0.5, 0.5
Credit security normalization	0.1

The rationality of the algorithm is verified by the safety credit evaluation of all users and the prediction of safety accidents for four laboratories. According to the user's relevant data, six dimensions of evaluation are carried out, and finally the user's security credit dimension evaluation is given. Refer to Figure 8.

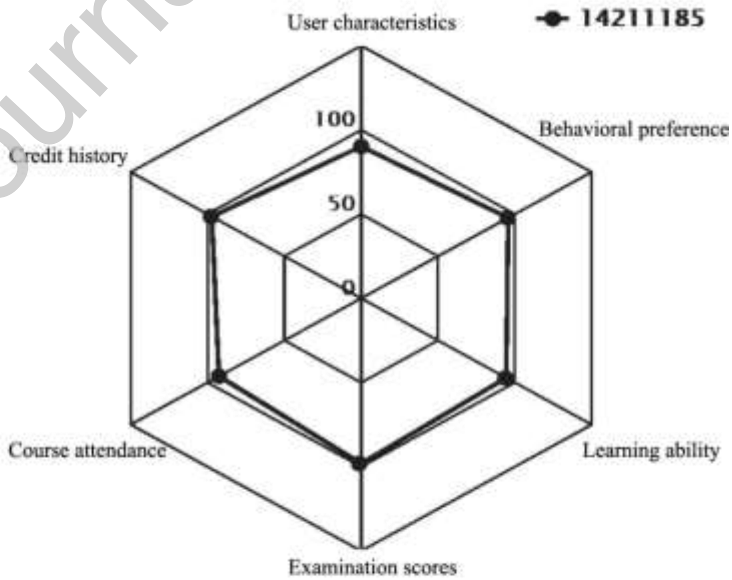


Figure 8 schematic diagram of user's security credit dimension

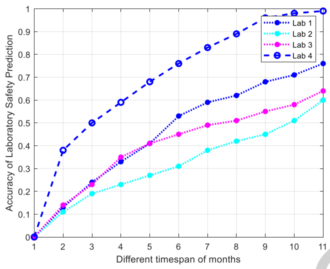
According to the data of different time periods from 2013 to 2018, we evaluated the four laboratories, and Figure 9 shows the situation of laboratory management and maintenance forecast.

From the results given in the figure, we can clearly ensure that, with the passage of time, the effect of laboratory management and maintenance is getting better and better, and the laboratory is safe. The risk of accidents is getting lower and lower. Through the evaluation dimension and the corresponding clustering algorithm designed in this paper, we can complete the management and maintenance of university laboratory through calculation and auxiliary technology. The key point of safety accident prediction is to predict laboratory accidents according to the knowledge loopholes of user groups. Table 4 shows the forecast statistics of safety accidents in four laboratories, indicating the types of accidents and the probability of accidents.

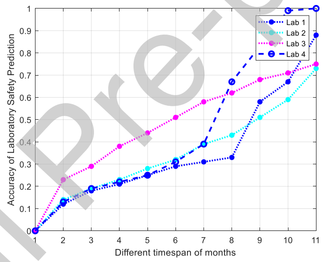
For the selected dataset, there are four different labs running data. We selected all four labs for the validation of our proposed algorithm. In fact, there are six main different accidents during running of a laboratory, including fire or flood accidents, toxic accident, explosive accident, electrical accident, and mechanical accident. The six different accidents are not evenly distributed in the dataset of four different labs. Therefore, we selected all four labs for the accident validation, and Table 4 gives us the prediction results to show the performance of our proposed algorithm.

Table 4 prediction statistics of laboratory safety accidents

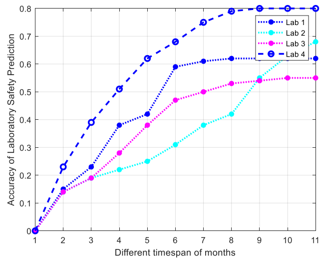
Accident type	Lab 1	Lab 2	Lab 3	Lab 4
Fire or flood accidents	12.63	6.83	11.38	9.46
Toxic accident	51.38	12.56	12.27	48.33
Explosive accident	16.73	22.87	19.21	22.26
Electrical accident	10.56	53.57	15.36	10.67
Mechanical accident	9.63	5.12	41.28	8.86



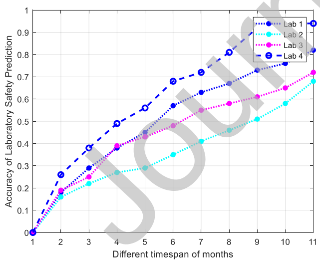
(a) Data from 2013 year



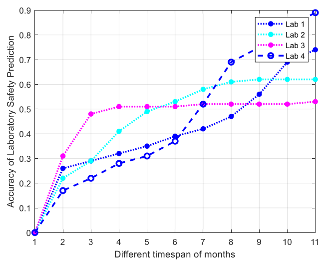
(b) Data from 2014 year



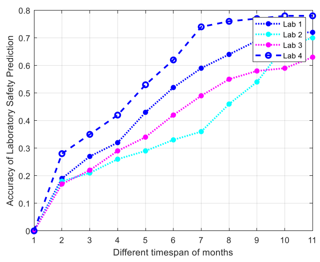
(c) Data from 2015 year



(d) Data from 2016 year



(e) Data from 2017 year



(f) Data from 2018 year

Figure 9 Laboratory management and Maintenance Forecast

From the results illustrated in Figure 9, we have suggested that there is a similar trend for the prediction of lab1, lab2, lab3, and lab4 with the time from year 2013 to year 2018. That is to say, for the January of each year, the accident is the least to be approached to zero. With the time passed, the accident will be added, and the largest number of accidents is in December. The prediction results are accord with the variations of the accidents. Therefore, our proposed accident prediction algorithm will be fully used in the real-world laboratory management and maintenance.

In addition, the efficiency is also another index for measuring the proposed intelligent algorithm for the management of laboratory. For the selected dataset from 2013-2018 of four different labs, we used the same computing platform of one Intel i7-9700K CPU with 16GB memory two measure the time complexity of the proposed algorithm. Table 5 illustrates the proposed intelligent accident prediction algorithm time complexities compared in different lab.

Table 5 Time complexity comparison of different labs and years by intelligent accident prediction

Laboratory	2013	2014	2015	2016	2017	2018
Lab 1	2384.32 ms	2837.38 ms	2736.46 ms	2637.33 ms	2938.39 ms	2737.67 ms
Lab 2	7463.23 ms	6365.32 ms	6645.56 ms	6736.73 ms	6476.38 ms	7362.27 ms
Lab 3	3183.28 ms	3026.83 ms	2937.73 ms	3173.78 ms	3387.29 ms	3126.81 ms
Lab 4	2583.41 ms	2653.43 ms	2736.82 ms	2557.38 ms	2587.98 ms	2555.76 ms

From the results in Table 2, we have found that the accident prediction of Lab 2 shows a little bit slower than the other labs. This is because the data from Lab 2 contained more dimensions of sensors that needs more time to combine all data for the following indexes computation. However, for the all years from different four labs, the prediction time complexity trends have the same changing rules for the accident prediction. The proposed accident prediction algorithms will be fully used for the real-world labs running application scenarios.

7 Conclusion

The management and maintenance of university laboratory is an important part of university work. With the rapid development of computer technology, computer-aided technology is widely used in the management and maintenance of university laboratories. This paper designs and implements a laboratory management system based on the Internet of things. Through the optical fiber ring network, the information such as RFID, infrared alarm video, laboratory water and electricity consumption is uploaded to the central server, forming a client and server architecture, forming a centralized control mode. The experimental results show that the model constructed in this paper can evaluate the security situation of university laboratory management well. Through the use of the management framework and safety assessment and maintenance model, colleges and universities can ensure the orderly operation of the laboratory, through effective management and data analysis, reduce the potential safety hazards in the laboratory, and avoid unnecessary security problems.

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Research on university laboratory management and maintenance framework based on computer aided technology

Conflict of interest

None to disclose.

Research on university laboratory management and maintenance framework based on computer aided technology

Brief introduction to the author

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