Construction of a Safety Management System for University Laboratories Based on Artificial Intelligence and IoT Technology

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Based on IoT technology, it can combine the actual needs of the university laboratory system to establish an equipment safety monitoring system, share data in real time, and monitor the operation equipment of university laboratories comprehensively. Through the collection of equipment-related data, we have a comprehensive analysis of data in order to have an accurate judgment of the state of the equipment, so that the chances of equipment failure can be gradually reduced. In this paper from the architectural point of view, IoT contains four layers: perception layer, network layer, platform layer, and application layer. The perception layer mainly solves the problem of data collection, the network layer mainly solves the problem of data transmission, the platform layer mainly solves the problem of data management, and the application layer mainly solves the problem of data value creation. From the technical point of view, the university laboratories’ Internet of Things (IoT) is to provide sufficient and effective information and technical support for planning and construction, production and operation, operation and management, integrated services, new business, new model development, enterprise ecosystem construction, and other aspects by bringing together resources from all aspects. The whole university laboratory system sustainability monitoring equipment maintains the continuity of monitoring and can be the first time to staff feedback fault information, to achieve the human-machine dialogue function; staff in the control of equipment safety monitoring system just enter the relevant instructions to fully achieve the purpose of control; staff can also print a certain period of time fault-related information, which will be properly stored in a reasonable location.

1. Introduction

1.1. Research Content. Artificial intelligence can scan relevant devices and objects to obtain various data information related to them, thus making it possible for information technology to connect with objects, which can further improve the efficiency of human-object and object-object interaction by means of data exchange and remote operation. At this stage, due to the high compatibility and development space of IoT technology, there is no clear definition of IoT, and people only call the product of combining information technology with other industrial technology as IoT in general, but the actual integration of technical resources and corresponding industrial categories are very different. University laboratories’ IoT is the application of IoT in the smart grid, which is the result of the development of information and communication technology to a certain stage [1]. It will effectively integrate communication infrastructure resources and university laboratory system infrastructure resources, improve the level of information of the university laboratory system, and improve the utilization efficiency of the existing infrastructure of the university laboratory system.

1.2. Theoretical Research Direction. The theoretical research is oriented around the management layer and the management model. The main functions realized by the management layer mainly include the backup of important data and other functions. During the operation of the university...
laboratory system, data loss or leakage occurs due to various reasons. On the one hand, the data loss or leakage caused by a virus, Trojan horse invasion, and hacker attack can be effectively protected by the security protection layer; on the other hand, the timely backup of data is also crucial. Once data loss occurs, the data can be quickly recovered to minimize the impact of data loss on the normal operation and management of university laboratories.

The management model starts from risk control, aims at continuous improvement, and puts forward a set of concepts and methods suitable for university laboratories’ safety management with systematic and standardized management ideas. Risk-based is the starting and ending point of this system construction work, emphasizing prior analysis and control. The risks related to the university laboratory system and environment involved in the daily production process need to be analyzed and evaluated beforehand in order to implement safety control measures and safety management measures in the course of events and to provide the most basic original data comparison for the summary review and rectification afterward, so as to finally realize the safety and stability of university laboratories. Systematization is a way of thinking that emphasizes a holistic view and a global view [2]. Systematization means that in the process of daily safety of university laboratories, we take the goal we want to achieve, the factors to be considered to achieve the goal, the optimization of the implementation process, and the consideration of the possible impact on the future, etc. as a whole to study, taking into account both the comprehensiveness of management and the organic connection between the elements that make up the system. The scientific and effective combination of management concepts, system knowledge, system elements, and management nodes forms a closed-loop management system mechanism for continuous operation. Standardization is a working method that emphasizes the unification of a standard system and personnel values. Standardized management is ultimately implemented through rules and regulations, but the system is only the form of definition and implementation. The system is not simply to develop specific standard behaviors for daily work and processes but to unify management standards and management behaviors on the basis of scientific human nature, and standardization is an important basis for the effective implementation of the system construction work. Continuous improvement is a cyclic activity that emphasizes data analysis and correction and prevention. By reviewing and analyzing the performance of each element in the planning, execution, compliance, and performance aspects, improvement opportunities are proposed for the root causes of the system or management.

1.3. Technical Research Direction. The technical research direction revolves around the physical layer, application layer, and protection layer. The physical layer mainly contains hardware facilities such as computers and disks and is an important physical foundation of the security system of the university laboratory system network. In the process of building the physical layer, the key elements to be considered are the avoidance of damage to hardware facilities and the establishment of emergency handling mechanisms. On the one hand, if the quality of computer hardware has problems, it will make the important role of the university laboratory system, and network security system is not fully played and displayed. In addition, some hardware facilities are also susceptible to external environmental factors or human factors and damage, and this damage also has the characteristics of irreversibility.

Application layer construction focuses on the issuance and management of security certificates and the establishment of a perfect authentication system. In this process, the identification of risky sites is particularly important, and security certificates can be issued for safe and reliable sites to ensure normal access for employees in university laboratories. For insecure sites, the security certificate will not be issued and access is prohibited. This can not only effectively avoid the leakage and loss of university laboratory system data and from the propagation path to interrupt the link between the insecure site and the university laboratory system.

The role of the protection layer is to deal with network security issues. At the current stage, there are many products that deal with network security issues, such as firewalls, intrusion detection systems, and intrusion prevention systems. These products can not only effectively achieve isolation between the trusted network and the untrusted network but also effectively detect and deal with the university laboratory system in case of intrusion or threat, providing a reliable barrier to the network security of the university laboratory system [3]. In addition, there are many types of antivirus software in the market; they can not only effectively monitor and deal with viruses but also have the function of security vulnerability scanning and patch installation. At the current stage, the types of Trojan viruses are also diverse and are constantly mutating and upgrading; a slight inadvertence may lead to a large area of the entire system infected with viruses, resulting in data loss and leakage, which will have a great impact on the normal operation of the university laboratory system.

2. University Laboratories’ Safety Management System

2.1. Safety Management Drawbacks. In addition to being the cradle of high-tech talent training, laboratories have also turned out to be accident-prone. In recent years, laboratory explosions have been frequent; for example, in December 2018, students at Beijing Jiaotong University were doing research experiments when they caused an explosion in the laboratory and three students were unfortunately killed. Scientific research laboratories have more advanced equipment and instruments, hazardous chemicals, especially some special laboratories, chemical laboratories, and laboratories with higher danger, which, once problems occur, not only cause property and personnel losses but also concern the stability of the school and society. 2019 China’s General Office of the Ministry of Education issued document No. 1” Notice of the General Office of the Ministry of
Education on Further Strengthening the Safety Work of Teaching Laboratories in Universities. In 2019, the General Office of the Ministry of Education of China issued a document entitled “Notice of the General Office of the Ministry of Education on Further Strengthening the Safety Work of Teaching Laboratories in Colleges and Universities,” which states that it is necessary to learn from the lessons of accidents, strengthen laboratory safety work, and establish the concept of “hidden danger is accident” [4]. At present, in response to the national policy on laboratory safety, universities have been strengthening their laboratory safety systems, safety systems, and facilities and investing more in various aspects of laboratories, so that the software and hardware conditions for safe laboratory operation have been greatly improved.

(1) The safety management model cannot adapt to the current situation of highly complex laboratory operations. At present, there is a wide variety of laboratory management, and most laboratories still rely mainly on manual management, with manual monitoring and recording of laboratory equipment operation, and in the event of safety problems, they can only rely on managers to troubleshoot afterward. Some special laboratories, which require managers to be on duty to guard or manually patrol the lab, have high labor costs, subjective variability, and fatigue-related errors are common.

(2) Relatively independent monitoring systems do not form an effective codefense mechanism. Most of the current laboratories are installed with access control, cameras, temperature, humidity monitoring, and smoke alarms, but each system operates independently and cannot be managed simultaneously in one system, making it more difficult for the management staff and causing waste of resources at the same time.

(3) Basically, there is no real-time warning and proactive barrier elimination capability. Some laboratories have gas alarms installed, but they do not have remote warning and door and window controller linkage and cannot be remotely warned and prompted in case of emergency. At the same time, the equipment cannot be linked to eliminate hidden dangers immediately, and the real-time nature of the problem cannot meet the needs.

2.2. Management Perspective. University laboratories’ safety management system is a complex system involving power supply enterprises, users, related departments, etc. At present, there are still many problems in this field in China: firstly, there is a lack of scientific and reasonable effective methods to analyze the management mode; secondly, there is no sound supervision mechanism and responsibility system; thirdly, the supervisors are not competent. This series of factors lead to the frequent occurrence of university laboratories’ accidents. University laboratories’ safety management is a product of development under China’s socialist market economy system. With the progress of the times, the state has put forward new requirements for university laboratories, which has made universities start to pay more attention to safety management [5]. At present, many universities in China have established relatively perfect and stable as well as relatively independent safety management systems. Laboratories’ safety management is a professional work, which requires the relevant staff to have rich knowledge reserve and strong technical ability.

Open experiments are an extension of traditional experimental teaching and an effective way for universities to cultivate practical and innovative talents. Open experimental teaching helps to improve teaching quality and gives full play to the efficiency of laboratory use to cultivate students’ practical ability and innovation spirit. The establishment of open laboratories is conducive to making full use of experimental resources, improving the usage rate of instruments and equipment and experimental sites, and effectively alleviating the outstanding contradictions such as the expanding scale of university enrollment and small experimental sites [6]. The management mode of open laboratories can effectively integrate the experimental teaching resources within the university, fully improve the utilization rate of the equipment within its limited life cycle, and maximize its use value.

Laboratory safety management has always been a key focus of school safety management, and a veto system has been adopted to emphasize the importance of safe laboratory operations. However, in the actual operation of laboratory safety management, the funding and staffing problems of individual schools have led to uneven laboratory safety management conditions [7]. Some school laboratories have installed camera probes in key parts of key laboratories for security reasons; individual laboratory centers attach importance to security management and have built access control systems for laboratory centers; fire and other types of alarm system equipment in buildings are old or even partially removed due to the need for environmental aesthetics; various security protection systems are in different periods and under different management network environments. The various safety protection systems are in different periods and under different management network environments, resulting in the inability of each system to coordinate and link up, thus failing to accurately and effectively improve the efficiency of safety warnings when the laboratory is open and shared.

3. Data and Analytical Methods

Motion target detection in laboratory video means separating the foreground motion target from the background in a continuous video sequence and obtaining the location of the motion target area, motion target information, etc. It is the basis for image recognition, motion target tracking, and other processing. In recent years, many experts have conducted more research on target detection and tracking and proposed many effective methods, but in the actual application scenario, the environment, lighting, shadows, and occlusion factors increase the difficulty of target detection, while the generality and robustness of some algorithms are
lacking [8]. The following is a detailed theoretical study of the three main detection methods: interframe differencing, optical flow, and background subtraction.

3.1. Interframe Differential Method. Video sequence data has the characteristic of continuity; if there is an active target, there is an obvious change between two frames of sequence data; otherwise, the change in data information between frames is not obvious. Interframe differencing refers to whether there is variation between two adjacent frames of data in a continuous piece of video information. The interframe difference algorithm performs a difference operation on two or three adjacent frames of data, the pixel point information of two different frames of data is calculated, and then the absolute value of the grey scale difference is judged, and when the resulting absolute value exceeds a threshold, the presence of a moving target can be judged and the function of intrusion target detection is achieved. As the interframe difference method takes the previous frame of the current frame as the background reference, it has less influence on the change of the background and has strong environmental adaptability, the data does not need to be stored, and the calculation is fast. The disadvantage is that only the boundaries of the moving target can be extracted, and the selection of the time between two frames also has a huge impact on the detection results. Depending on the selection of adjacent video data frames, there are two-frame differencing and three-frame differencing methods [9].

3.1.1. Two-Frame Differential Method. A frame of data is got from the video, the image data of the current frame is recorded as \( f_n \), the image data of the previous frame adjacent to the current frame is recorded as \( f_{n-1} \), and then the grey value of the pixel points of the two frames of image data is recorded as \( f_n(x, y) \) and \( f_{n-1}(x, y) \). Then, the grey value of the pixel points of the image data of the current frame and the previous frame will be differenced; further, we get the absolute value of the difference and get the result as differential image data \( D_n \), as in

\[
D_n(x, y) = |f_n(x, y) - f_{n-1}(x, y)|. \tag{1}
\]

Then, we set the threshold value \( T \). The differential image data obtained from equation (1) is binarized according to equation (2) to obtain \( R_n \). When the differential image data is greater than or equal to the threshold value \( T \), the value is 1; otherwise, the value is 0. The values 1 and 0 are distinguished according to the obtained \( R_n \) value, the value 1 is the motion target point, and the value 0 is the background point.

\[
R_n(x, y) = \begin{cases} 
1, & D_n(x, y) \geq T, \\
0, & D_n(x, y) < T. 
\end{cases} \tag{2}
\]

The detailed processing flow of the two-frame differential method is shown in Figure 1.

From equation (1), it can be seen that after the two adjacent frames of video data information are differenced, the background part common to both frames is removed and only the moving target part is retained. The speed of the moving target has a large impact on the detection results of the frame difference algorithm. When the monitored target is moving slowly, the extracted target may be incomplete or may have a “hole” in it. In addition, the choice of the threshold will also have a direct impact on the detection of the target and is generally based on previous experience.

3.1.2. Three-Frame Differential Method. The image information for each frame of the \( n + 1 \)st, \( n \)th, and \( n - 1 \)st frames of the recorded camera video sequence is \( f_{n+1}, f_n \), and \( f_{n-1} \) respectively, and the grey scale values of the corresponding pixel points of the three frames are noted as \( f_{n+1}(x, y), f_n(x, y) \), and \( f_{n-1}(x, y) \), respectively, and the differential images \( D_{n+1} \) and \( D_n \) of the absolute value of the difference are obtained, respectively, according to equation (1).

\[
\begin{align*}
D_{n+1}(x, y) &= |f_{n+1}(x, y) - f_n(x, y)|, \\
D_n(x, y) &= |f_n(x, y) - f_{n-1}(x, y)|. 
\end{align*} \tag{3}
\]

Then, the threshold \( T \) is set empirically, and the two binarized images \( R_{n+1}(x, y) \) and \( R_n(x, y) \) are obtained from the differential image data obtained in equation (3) according to equations (4) and (5). Then, the logical sum operation is performed on the two images to obtain the image \( R(x, y) \) containing only the motion target, as shown in equation (6).

\[
\begin{align*}
R_{n+1}(x, y) &= \begin{cases} 
1, & D_{n+1}(x, y) \geq T, \\
0, & D_{n+1}(x, y) < T. 
\end{cases} \tag{4}
\end{align*}
\]

\[
\begin{align*}
R_n(x, y) &= \begin{cases} 
1, & D_n(x, y) \geq T, \\
0, & D_n(x, y) < T. 
\end{cases} \tag{5}
\end{align*}
\]

\[
\begin{align*}
R(x, y) &= \begin{cases} 
1, & R_{n+1}(x, y) \cap R_n(x, y) = 1, \\
0, & R_{n+1}(x, y) \cap R_n(x, y) = 0. 
\end{cases} \tag{6}
\end{align*}
\]

A detailed flow chart of the three-frame differential method is shown in Figure 2.

The logic principle of the frame difference method is relatively simple, comparing the previous frame with the current frame of image data, which is less computationally intensive and does not require the storage of large amounts of data, thus taking up less memory and providing faster detection. The two-frame difference method gives a more complete part of the moving target than the three-frame difference method and achieves better results but still does not overcome the problems inherent in the interframe difference method.

3.2. Optical Flow Method. Optical flow is the instantaneous speed of pixel movement of an object moving in space on a two-dimensional planar image. The optical flow method is a way of calculating the motion of an object between adjacent image data frames. The method takes advantage of the continuity of the image, the change in the time domain of the pixels in the image sequence, or the correlation between adjacent frames to find the correspondence between the previous frame and the current frame [10]. The main task of
the optical flow method is to obtain the optical flow field of the image. It is a two-dimensional vector field, which is expressed as a trend in the movement of each pixel in the image or as the instantaneous velocity field generated by the movement of a pixel with a grey scale on a two-dimensional vector image, which reflects the instantaneous velocity vector information of the image pixels. Detection and segmentation of moving targets and scenes are performed by analyzing the changes in the motion field on the image [11].

The application of the optical flow method has the following three assumptions.

1. **Constant Brightness.** The luminance of the same moving target does not change when it moves between frames. This is the basic assumption of the optical flow method and is used to obtain the basic equations of the method [12].

2. **Small Movement.** No large changes in the position of the moving target occur over time, and small displacement changes occur in adjacent frames in the image. This assumption is also integral to the optical flow method.

3. **Spatial Consistency.** Adjacent pixel points on the image are in close proximity.

The basic constraint equation is given below. Let a pixel \((x, y)\) be the light intensity of the first frame at the moment \(I(x, y, t)\) at \(t\), and \(t\) is the time dimension in which it is located. The pixel moves \((d_x, d_y)\) distance to the next frame, and the time used to move this distance is \(d_t\). From the first assumption, we know that the light intensity of the pixel does not change before and after the movement during this time; i.e., we obtain equation (7) and carry out the Taylor expansion equation (8).

\[
I(x, y, t) = I(x + d_x, y + d_y, t + d_t),
\]

\[
I(x, y, t) = I(x, y, t) + I_x d_x + I_y d_y + I_t d_t + o(d_t^2).
\]

\(I_x, I_y, \) and \(I_t\) are the partial derivatives of the grayscale functions in the \(x, y\), and \(t\) directions, respectively. Let \(u\) and \(v\) be the velocity vectors of the optical flow in the \(X\) and \(Y\) axes; then, \(u = d_x/d_t, v = d_y/d_t\), which are brought into the above equation to obtain

\[
I_x u + I_y v + I_t = 0,
\]

where \(I_x, I_y, \) and \(I_t\) can be obtained from the image data, and \((u, v)\) is the desired optical flow vector.

The optical flow method is based on two methods: the global optical flow field and the characteristic point optical flow field. The most classical global optical flow field calculation methods are the L-K (Lueas & Kanada) and H-S (Hom & Schunck) methods, in which the global optical flow field is obtained, the difference between the moving target and the background is compared, and then the optical flow is segmented for the moving target [13]. The feature point optical flow method is to find the flow velocity at the feature point by feature matching, it has the advantage of being computationally small, fast, and flexible, but the disadvantage is also more obvious, and the sparse optical flow field is difficult to extract the shape of the moving target accurately.

The optical flow method can be used for foreground detection of images without acquiring any information about the scene in advance to detect moving targets. The method is also suitable for situations where the background is in motion, but it is susceptible to image noise, illumination, shadows, and occlusions, which not only affect the distribution of the optical flow field but also have a serious impact on the calculation results; moreover, the calculation of the optical flow method is also complex and the detection accuracy is not high, making it difficult to achieve real-time image processing.

3.3. **Background Subtraction Method.** The background subtraction method is now widely used in motion target detection. The basic idea is to use video correlation algorithms to obtain a background image and then achieve the
detection of motion regions. First, the current video image data frame and the background image will be differential processing, where the pixel difference in a relatively large range is considered to be the motion target area, while the pixel difference in a smaller range is considered to be the background area [14], determining that the background image is the key to the background subtraction method. As the environment of the monitored video area changes, the background image should be able to be updated in real time, so the good or bad algorithm model of the background image directly affects the detection effect of the motion target. The operation process of the background subtraction method is as follows. First, the background image frame \( B \) is established using the background model, the current frame of image data is recorded as \( f_n \), the grey value of the current frame and the background frame are recorded as \( f_n(x, y) \) and \( B(x, y) \), respectively, and then the two frames are subtracted and their absolute values are recorded as \( D_n(x, y) \), which is the difference image, as shown in

\[
D_n(x, y) = |f_n(x, y) - B(x, y)|.
\]

Set the threshold value to \( T \), and then binarize each pixel point of the image to obtain the binarized image \( R_n(x, y) \).

The point with value 1 is the motion target point, and the grayscale value 0 is the background point, as shown in

\[
R_n(x, y) = \begin{cases} 
1, & D_n(x, y) \geq T, \\
0, & D_n(x, y) < T.
\end{cases}
\]

In the background subtraction method, the background image does not contain the motion target, and the current image containing the motion target is subtracted from the background image to obtain the complete motion target. A diagram of the background subtraction method is shown in Figure 3.

The background subtraction method requires the following four steps: background modeling, background update, target detection, and postprocessing. The difficult part is the background modeling, where a good or bad background model directly affects the detection of moving targets. Currently, widely used background modeling algorithms are a time-averaged model, median filter model, hybrid Gaussian model, etc.

4. Experiment and Discussion

4.1. Experiment. In the current situation of various institutions to speed up the pace of open laboratory construction, open laboratory safety supervision issues are increasingly becoming a problem that school managers have to consider. On the one hand, laboratories continue to increase investment and experimental equipment to the trend of high precision, the total value of equipment in various laboratories continues to increase, and many types of equipment of fire, water, theft, and other property safety issues gradually appear; on the other hand, experimental projects often involve the use of gas, toxic, and harmful gases and other experimental materials; due to the leakage of gas, harmful gases and other substances caused by casualties have been commonplace. On the other hand, experimental projects often involve the use of gas, toxic gases, and other experimental materials. Through in-depth automated analysis of a large amount of data, the potential patterns and data value of the data are explored. The main analytical methods of big data technology are cluster analysis, regression analysis, classification analysis, neural network methods, and web data mining. The most commonly used method for laboratory management is cluster analysis, and the most commonly used cluster analysis method is the \( K \)-means algorithm. \( K \)-means algorithm is currently the most commonly used type of cluster analysis algorithm. \( K \)-means algorithm has certain scalability and high efficiency, and the analysis results are sensitive to the initial value setting. Depending on different initial values, different results may be analyzed, and if the initial values are not chosen properly, the final analysis results will deviate to a certain extent.

Flow chart of laboratory safety management with \( K \)-means algorithm in Figure 4. Based on the large and complex characteristics of the data, we kept increasing the number of reference samples, so the target detector had more references to the same target to be detected and therefore added a test of the target detector to analyze the detection performance of the target detector. The target detector is still grouped according to the grouping method used in the training of the target detector, but unlike before, for the improved target detector, each group of data from split1-split4 is rotated as the test set, and the other three groups are used as training for training and testing, the measurement criterion is AP50%, and AP refers to average precision; i.e., the average precision of each class for multiclass prediction. AP is the average precision, i.e., the average of the precisions of each class in multiclass prediction, and 50% is a detector with an IoU threshold greater than 0.5.

As can be seen from Table 1, by adding additional sample images for the model to reference, the performance of the improved target detector is significantly improved; in particular, the recognition of out-of-set objects is improved by 4.5% on the AP 50% criterion.

4.2. Discussion. Through the university laboratory system, parallel structure of the equipment for the unified number can provide convenience for abnormal situation processing, so that the relevant personnel combined with the collected data can be clear fault generation causes and targeted inspection and repair failure, but also according to the actual need to switch the monitoring mode, so that manual monitoring can be closely integrated with the automatic monitoring mode and play the advantages and role of different monitoring mode.

The strategic goal of university laboratories' IoT is to establish a multidimensional energy ecology, which requires comprehensive cooperation among terminal sensing, edge computing, communication network, cloud platform, and application layer. Among them, intelligent terminal to achieve accurate data collection and millisecond information feedback is the basis of university laboratories' IoT, and processing redundant data through edge computing is the
key to improve information processing efficiency. In terms of relationship, the strong smart grid and the university laboratories’ Internet of Things are complementary and integrated to form a powerful value creation platform, which together constitutes a “multistream” energy Internet with energy, business, and data flows.

Based on the Internet of Things technology, a perfect safety monitoring system can be established, which can comprehensively monitor the operation of the relevant equipment of the university laboratories, connect the safety monitoring system with the sensor network, etc., and realize the human-computer interaction function by the special personnel comparing the data collected by the equipment. When the university laboratory system is in the process of operating device operation problems, a safety monitoring system will be used for the first time by the staff of the mobile terminal transmission of information and there is a timely alarm; the staff want to understand the fault information, which through the mobile terminal can be viewed, and the mobile terminal content as the basis for the targeted handling of fault problems. In addition, the staff through the mobile terminal can target the control of the site equipment to ensure that the site equipment is in good running condition, while there is real-time monitoring of data and security conditions and reasonable use of data to ensure the safety of the operation, according to the need to view the detailed alarm records and fault content, so as to make the right decision. By building a safety monitoring system based on IoT technology, the production efficiency of the university laboratory system can be further improved, the safety of staff can be effectively ensured, and the work efficiency can be improved comprehensively.

5. Conclusion

Laboratory as scientific research, training high-tech talent base, let the country have great importance; in recent years, with increasing China’s economic strength, domestic institutions began to continuously increase investment in the laboratory and purchase a large number of foreign instruments and equipment; in 2019, many domestic enterprises and schools purchase a number of instruments and equipment which have been caught up with the number of developed countries in Europe and the United States laboratory, and in the advanced degree there is not much difference with the advanced laboratory instruments [15]. On the other hand, with the continuous investment in research funding and the increase in projects, research institutions, schools, and other research activities have become frequent, making the current number of research-type laboratories increasing, which makes it more difficult to manage the scientific operation and safety of laboratories.
The safety management mode of open laboratories differs from that of traditional laboratories in that it places higher demands on laboratory safety management. With the same staffing level, only by using modern computer information technology to build a systematic, comprehensive, and highly implementable safety management system can we provide strong security guarantees for the effective management of open laboratories, enhance the effect of openness, and bring the effectiveness of open experiments into play [16]. Therefore, the comprehensive use of modern Internet of Things technology, communication technology, and embedded system control technology lets us achieve open laboratory personnel, facilities, environment, and other comprehensive intelligent safety management.

First is the research on load balancing technology in university laboratories’ IoT terminal access. Based on the inherent demand for assessing and analyzing the voltage quality of low-voltage distribution networks and scientific governance, the low-voltage distribution network voltage monitoring system is built by combining with IoT technology to collect and monitor the voltage data of low-voltage distribution network lines in real time. The main functions cover various modules such as data collection, storage, analysis, and report. It quickly provides information such as minute voltage average value, daily voltage data statistical value, monthly voltage data statistical value, etc.; it issues alarm events for abnormalities of voltage not conforming to the supply voltage regulations, which plays a good supporting role for intelligent analysis of voltage data [17]. At the same time, the system integrates excellent technology and management methods and concepts with the development of voltage reactive profession in China and is ahead of its time.

Second is the research on edge computing technologies to alleviate data transmission pressure. IoT requires collaboration between endpoints, edge computing nodes, and cloud data sharing and applications in a high-bandwidth, low-latency, and high-concurrency environment. Existing security systems using network isolation and defense-in-depth cannot meet the defense requirements of the university laboratories’ IoT. Therefore, it is necessary to break down the boundaries of physical networks and establish a new cybersecurity framework based on services and applications to achieve fine-grained security awareness and protection. The current zero-trust security architecture is expected to meet the security requirements of university laboratories’ IoT.

Third is the research on the application layer of university laboratories’ IoT platforms. On the one hand, we study the application solution of “zero-trust” typical business scenarios of university laboratories’ IoT with “risk assessment, scenario awareness, access control, and trust assessment” as the core and design the security protection architecture of university laboratories’ IoT based on zero-trust. The solution focuses on subjects and objects. A new protection architecture is built based on services and applications to achieve fine-grained security awareness and protection capabilities. On the other hand, it is the network access behavior characteristics by experimentally analyzing the data of network traffic of IoT devices, comparing the differences between benign and attack data, and identifying the behavior characteristics that can represent the security baseline of device network access. Finally, according to the external characteristics of network flow, protocol keyword characteristics, and network access behavior characteristics of terminal devices, the device portrait is constructed to determine the baseline of device security operation. Through the device portrait, the health status of the device is monitored in real time, and intrusive behaviors and malicious or false end devices are detected to achieve the security monitoring of university laboratories’ IoT terminals.

Facing the future, we gave a zero-trust-based security protection architecture for university laboratories’ IoT devices, which focuses on subjects and objects. A dynamic access control module is employed, which continuously updates authorization at runtime to enable real-time security awareness, continuous authentication, behavior monitoring analysis, and fine-grained control of access behavior. Access control policies are determined based on security and trust levels from multiple sources, while the trust assessment process performs continuous assessment from four dimensions and inferential reporting from a risk determination mechanism.

Data Availability
The data of this paper can be obtained from the corresponding author upon request.

Conflicts of Interest
The authors declare that there are no conflicts of interest regarding the publication of this work.

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