

Construction of Safety Management System of Instrument/Electrical Laboratory in Universities based on Artificial Intelligence Technology

Zhu Yu, Bian Jiang, Gao Zhe

College of Instrument Science and Electrical Engineering, Jilin University, Changchun 130026, China

Abstract: With the increasing importance of safety management of instrument and electrical laboratories in universities, the disadvantages of traditional management mode are becoming more and more obvious. This study aims to explore the construction of an efficient safety management system with the help of AI technology. Through literature research and theoretical analysis, this paper analyzes the application feasibility of AI related technologies such as machine learning, image recognition and sensor technology in laboratory safety management. In this paper, the system framework covering intelligent monitoring, risk assessment, emergency response and data management is constructed, and the functions and coordination mechanisms of each module are defined, and the implementation guarantee is put forward from three aspects: hardware facilities, operation management mechanism construction, data security and privacy protection. The research shows that the safety management system based on AI technology can realize all-round intelligent management of the laboratory. This provides a reliable guarantee for the safe operation of instrument and electrical laboratories in universities, and is of great significance to promote the intelligent transformation of laboratory safety management in universities.

Keywords: AI Technology, University Laboratory, Safety Management System, Instrument Laboratory, Electrical Laboratory.

1. Introduction

In the process of the continuous advancement of education and scientific research in universities, the laboratory of instruments and electrical appliances, as an important place, carries many key experiments and research tasks [1]. However, due to the complex equipment and strong professional operation, the safety management of such laboratories faces many challenges. When dealing with the increasingly complex experimental environment, the traditional safety management model gradually reveals the disadvantages of untimely monitoring and lagging risk assessment [2]. In recent years, with the rapid development of AI technology, its powerful data processing and intelligent analysis capabilities have brought new opportunities for the innovation of the safety management system of instrument and electrical laboratories in universities [3].

For instrument and electrical laboratories in universities, the occurrence of safety accidents may not only cause equipment damage and scientific research interruption, but also endanger the life safety of teachers and students [4]. Constructing a scientific and efficient safety management system is an inevitable requirement to ensure the stable operation of laboratories and the smooth development of education and scientific research in universities [5]. In this context, integrating AI technology into laboratory safety management is expected to achieve real-time accurate monitoring, intelligent risk assessment and rapid emergency response, and improve the overall safety management level.

Judging from the research status, some universities in the world have initially tried to introduce AI technology into laboratory safety management, and achieved certain results [6]. However, the related research in China is still in its infancy, mostly focusing on theoretical discussion and local application, lacking systematic research on system construction [7]. Therefore, it is of great significance to

deeply study the construction of safety management system of instrument and electrical laboratories in universities based on AI technology, which will fill the research gap and promote the intelligent transformation of laboratory safety management in universities. The purpose of this study is to explore a scientific and feasible safety management system through systematic analysis and theoretical construction, and to provide innovative ideas for the safety management of instrument and electrical laboratories in universities.

2. Safety Management of Instruments and Electrical Laboratories

AI technology covers many fields, among which machine learning, image recognition and sensor technology are the key technologies applied to the safety management of instrument and electrical laboratories in universities. Machine learning allows computers to learn rules from a large number of data through algorithms, and then make predictions or decisions on new data [8]. In laboratory safety management, machine learning algorithm can be used to analyze equipment operation data and predict equipment failures and potential safety hazards in advance. Image recognition technology uses computers to process, analyze and understand images, and identify illegal operations and dangerous goods in the laboratory. Sensor technology can collect laboratory environmental parameters in real time, such as temperature, humidity and harmful gas concentration, and provide basic data support for safety management.

The safety management of instrument and electrical laboratories in universities has the characteristics of strong professionalism, complex equipment and diverse risks. Its management content includes not only the correct use and maintenance of instruments and equipment, but also the safety guarantee of experimental environment and personnel operation norms [9]. Potential risks involve electrical safety risks, such as fire caused by short circuit and overload; The

risk of instrument failure may lead to deviation of experimental results and even safety accidents. It is highly feasible to apply AI technology to the safety management of such laboratories [10]. AI's intelligent analysis and real-time processing capabilities just meet the requirements of laboratory safety management for timeliness and accuracy.

3. Construction of Safety Management System Framework based on AI

In order to effectively improve the safety management level of instrument and electrical laboratories in universities and give full play to the advantages of AI technology, it is very important to build a scientific and reasonable safety management system framework. The framework is mainly composed of intelligent monitoring module, risk assessment module, emergency response module and data management module, which jointly ensure the safe operation of the laboratory.

(1) Intelligent monitoring module

Intelligent monitoring module is the front-end sensing part of the whole safety management system, which is responsible for collecting all kinds of laboratory information in real time. This module realizes all-round monitoring with the help of various sensors and image recognition technologies. In instrument laboratories, sensors can monitor the operating parameters of instruments and equipment in real time, such as voltage, current, temperature, etc., to ensure that instruments are in normal working condition. In the electrical laboratory, in addition to monitoring the operating parameters of electrical equipment, environmental conditions are also monitored by smoke sensors and harmful gas sensors to prevent fire and gas leakage accidents.

Image recognition technology is used to monitor the operation behavior of laboratory personnel and the placement of articles. It can identify whether the experimenter wears protective equipment correctly, whether the instruments and equipment are placed according to regulations, etc. Image data is collected by smart camera, and analyzed by deep learning algorithm. Once abnormal behavior or illegal placement is found, an early warning will be issued immediately. Intelligent monitoring module, like the "eyes" and "ears" of the laboratory, always pays attention to every move of the laboratory and provides basic data support for subsequent safety management decisions.

(2) Risk assessment module

Based on the data collected by the intelligent monitoring module, the risk assessment module uses machine learning algorithm and risk assessment model to scientifically assess the security risks faced by the laboratory. The module firstly cleans and preprocesses the collected data, removes noise and abnormal data, and ensures the accuracy and integrity of the data. Then, according to the laboratory type, equipment characteristics and historical accident data, a targeted risk assessment model is constructed. For high-precision instrument laboratories, the influence of aging degree and frequency of use of instruments and equipment on experimental results and equipment safety is emphasized; For high-voltage electrical laboratories, the risks such as electrical overload and short circuit are emphatically evaluated. Through model calculation, the current risk level of the laboratory is obtained, such as low risk, medium risk and high risk. In order to display the risk assessment results more intuitively, the risk assessment rating table is specially

formulated (see Table 1: Laboratory Risk Assessment Rating Table).

Table 1. Laboratory Risk Assessment Rating Table

Risk Level	Risk Description	Recommended Response Measures
Low Risk	The laboratory operates well overall, with a small number of general safety hazards present and a low likelihood of accidents occurring in the short term	Continuously monitor, conduct regular inspections, and address hazards in a timely manner
Medium Risk	Certain equipment or operations pose some safety risks that require attention, with the potential to trigger minor accidents	Increase monitoring frequency, develop targeted rectification plans, and implement rectifications within a specified timeframe
High Risk	Significant safety hazards exist in the laboratory, with the potential to trigger serious accidents at any time	Immediately halt relevant experimental activities, conduct a comprehensive hazard investigation, and take emergency measures to eliminate risks

(3) Emergency response module

The emergency response module is a response mechanism that is quickly started when the risk assessment module determines that there is a medium-high risk or a safety accident in the laboratory. The module has made a detailed emergency plan in advance, covering all kinds of possible safety accident scenarios such as fire, explosion, gas leakage, equipment failure and so on. Once the emergency response is triggered, the system will immediately notify the laboratory managers and relevant emergency rescue personnel through SMS, acousto-optic alarm, etc. At the same time, the emergency resources in the laboratory, such as fire extinguishers and protective equipment, are quickly deployed, and scientific coping strategies and operation guidelines are provided for rescuers according to the accident types and site conditions. When a fire accident occurs, the system can display the layout of the laboratory, the location of fire-fighting equipment and the information of evacuation passages in real time, and guide the personnel to evacuate and extinguish the fire quickly.

(4) Data management module

The data management module is the "data hub" of the whole safety management system, which is responsible for storing, managing, analyzing and mining all kinds of data collected by the intelligent monitoring module. The module adopts distributed database technology to ensure large-capacity storage and efficient access of data. At the same time, establish a strict data security management mechanism to ensure the confidentiality, integrity and availability of data and prevent data leakage and tampering.

Through the analysis and mining of historical data, the data management module can find the potential laws and trends in laboratory safety management. In addition, it can provide data support for the optimization of risk assessment model and continuously improve the accuracy of risk assessment. The data management module provides strong support for the continuous improvement of laboratory safety management through the in-depth use of data.

4. Safety Management System Implementation Guarantee

The effective implementation of the safety management system of instruments and electrical appliances laboratories in universities based on AI can not be separated from various safeguard measures. These measures cover key areas such as hardware facilities, operation management mechanism construction, data security and privacy protection, and they cooperate with each other to provide solid support for the stable operation of the system.

(1) Hardware facilities

Advanced and adaptive hardware facilities are the basis for

the operation of safety management system. In the intelligent monitoring link, various types of sensors need to be deployed. The temperature and humidity sensor monitors the temperature and humidity of the laboratory environment to ensure that the instruments and equipment operate under suitable conditions; Smoke sensor and combustible gas sensor are used to discover fire hazards and gas leakage risks in time. At the same time, it is equipped with a high-definition smart camera for image recognition and monitoring. For instrument laboratories, it is also necessary to install monitoring sensors for equipment operation parameters to grasp the working state of instruments in real time. The following is the layout of some key hardware facilities (see Figure 1):

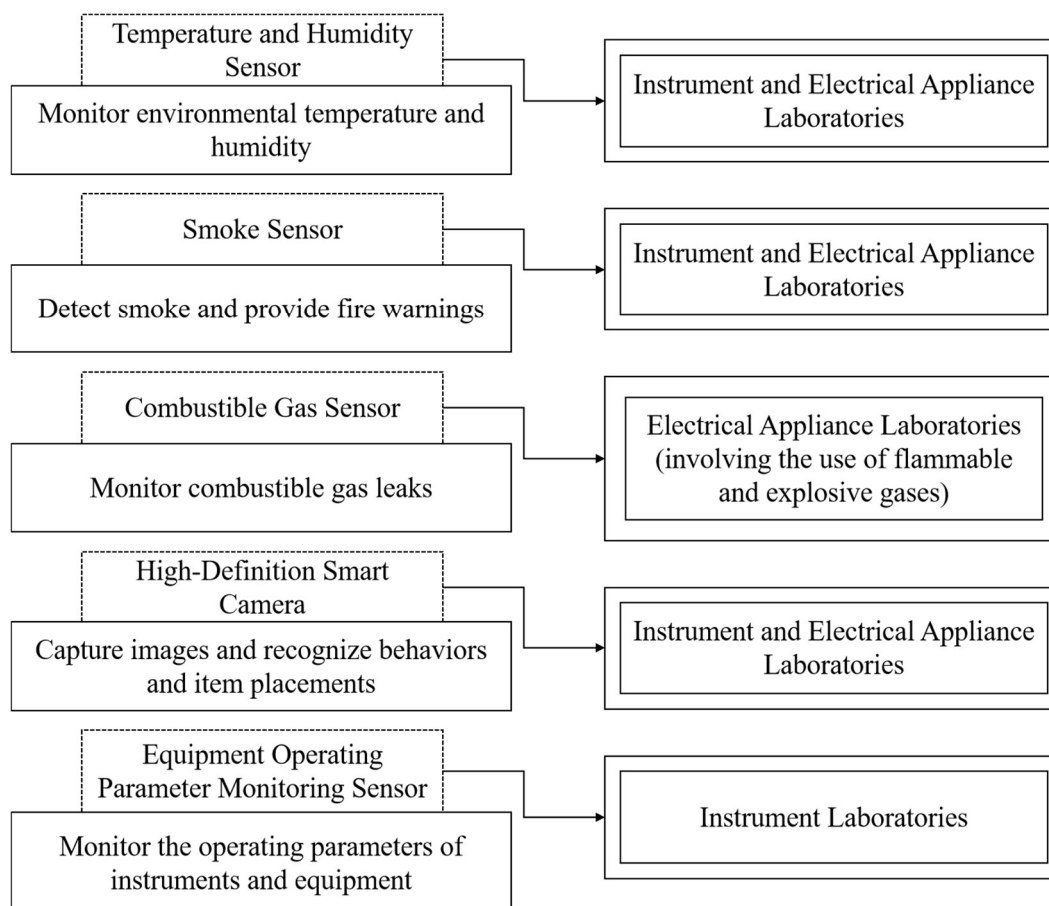


Figure 1. Key hardware facilities for laboratory safety management

(2) Construction of operation management mechanism

The operation management mechanism is like the baton of the safety management system to ensure the orderly operation of the system. First, establish a data update mechanism. The real-time data collected by sensors and cameras need to be updated regularly to ensure the timeliness and accuracy of the data. The temperature and humidity data are updated every 5 minutes, and the operation parameters of the equipment are dynamically updated according to the operation state of the instrument. Secondly, the personnel training mechanism is indispensable. Conduct regular training for laboratory managers and operators. The training content includes the basic knowledge of AI technology, the operation process of safety management system and emergency treatment methods. Through the combination of theoretical teaching and practical exercise, the cognition and operational ability of personnel on safety management system are improved. Furthermore, set up inspection and maintenance mechanism. Regular inspection of hardware facilities, timely find and deal with equipment

failures and damage.

(3) Data security and privacy protection

During the operation of the security management system, data security and privacy protection are very important. Laboratory data includes information of instruments and equipment, experimental data and personnel, etc. Once leaked or tampered with, it may cause serious consequences. In order to ensure data security, encryption technology is used to encrypt the transmitted and stored data. AES encryption algorithm can be used to encrypt key data to ensure the confidentiality of data during transmission and storage. Establish strict access control mechanism, and only authorized personnel can access specific data.

For data involving personal privacy, such as identity information and health status of experimenters, strict privacy protection principles are followed. When collecting data, clearly inform the purpose and scope of data use and obtain the consent of relevant personnel. In the process of data processing, anonymization and de-identification technology

are adopted to reduce the risk of privacy disclosure.

5. Conclusion

This study focuses on the construction of the safety management system of instruments and electrical appliances laboratories in universities, and deeply integrates AI technology into it, forming a complete and scientific system. In the aspect of system framework construction, the intelligent monitoring module uses sensors and image recognition technology to collect laboratory information in real time, just like a keen perception antenna. Based on the monitoring data, the risk assessment module uses machine learning algorithm and targeted model to accurately assess risks, and provides a basis for management decisions through an intuitive risk assessment hierarchy. The emergency response module starts quickly when the risk is triggered, allocates resources according to the preset emergency plan and guides the response. As the data hub, data management module not only ensures data storage and security, but also provides support for system optimization through analysis and mining.

At the level of implementation guarantee, perfect hardware facilities lay a solid foundation for the system operation, the operation management mechanism is like a command system to ensure the orderly operation of the system, and strict data security and privacy protection escort the system operation. The safety management system of instrument and electrical laboratory in universities based on AI technology effectively makes up for the deficiency of traditional management mode, and realizes the transformation from passive prevention to active early warning, from extensive management to precise control. This system is of great value for improving the safety management level of laboratories in universities, ensuring the safety of teachers and students' lives and property, and promoting the stable development of education and scientific research in universities.

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