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# Design and Research of Intelligent Video Room Monitoring System

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**Abstract.** With the advent of the cloud network era, the number of intelligent micro-data rooms has increased rapidly, and the requirements for the environment have become higher and higher. In order to solve the problem of massive computer room and equipment monitoring, this paper comprehensively uses Internet of Things technology, big data, artificial intelligence and other technologies to establish an intelligent video computer room monitoring system. Collect the online operation information of multi-source sensing equipment, realize data access through the Internet of Things gateway with multi-terminal adaptation, and realize online resource monitoring and fault analysis and early warning based on intelligent service model; The network fault detection and location algorithm is designed by detecting the congestion degree and packet loss rate of network equipment nodes; Realizing real-time monitoring of the computer room and ensuring the safe, stable and reliable operation of the data center infrastructure and IT equipment are of great significance for maintaining the stability of the computer room environment and ensuring the normal operation of the precision electronic equipment in the computer room.

**Keywords:** intelligent video monitoring, intelligence, rough set, fuzzy evaluation

## 1 Current Situation Analysis

With the vigorous development of Internet technology and communication technology, the amount of data that enterprises, universities, banks and other fields need to store is increasing. With the continuous development of cloud computing, various industries have begun to use high-performance, mass storage servers and high-speed data transmission network equipment to build data centers [1]. In the future, in the fields of finance, transportation, energy, medical treatment, education and other fields, we will increasingly rely on efficient and safe information technology, which also puts forward higher requirements for the safe and reliable operation of data centers. Therefore, how to maintain the stable operation of the data center has become the focus of attention. Efficient video monitoring is the premise and guarantee for the normal operation of the data center. However, the use of data center servers will inevitably encounter memory or hard disk failures; Precise electronic equipment also has high requirements for the operating environment. For example, abnormal environment will cause unstable equipment operation, equipment failure, data information loss, serious fire and other catastrophic accidents.

The general video monitoring system can only provide real-time viewing, recording, playback and other related functions of the monitored video. To make early warning and retrieval of abnormal behaviors in the video, the staff need to spend a lot of time viewing the video. When monitoring multiple videos for a long time, the monitoring personnel are easy to get tired, and may not be able to react immediately to the abnormal behaviors, or even prone to omission. Some video monitoring systems provide automatic functions such as detection line and dynamic and static image detection, which can automatically send out alarms and mark events based on images. However, these simple image algorithms cannot be further analyzed, and cannot effectively improve efficiency when it is necessary to monitor and search for specific targets. Therefore, there is an urgent need for intelligent

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video surveillance to assist the work of monitoring personnel.

With the continuous progress and development of the Internet of Things technology, the computer room environment monitoring system based on the Internet of Things, big data, visualization and other technologies came into being. These monitoring systems use sensors to identify the environmental information in the computer room, and use communication technology to integrate, upload and process the collected environmental information, thus forming a more comprehensive computer room environmental monitoring system. At present, large computer rooms used in banking, insurance, telecommunications and other fields have relatively mature monitoring system solutions. These systems achieve strict monitoring of computer rooms by providing professional supervision and maintenance personnel, data collectors and monitoring software, but the cost is high. However, small and medium-sized computer rooms used in universities, public institutions, small and medium-sized enterprises and other institutions are limited by operation and maintenance costs, and still lack a relatively complete computer room monitoring system scheme. Therefore, it is of great practical value to design an intelligent video monitoring system for small and medium-sized computer rooms and explore the integrated application of new technologies in the intelligent video room for the coordinated, high-speed and safe operation of computer room video monitoring.

## 2 System Architecture Design

The overall architecture of the intelligent video room monitoring system [2] is shown in Fig. 1. The system design is based on the three-layer architecture of the Internet of Things, which is divided into the computer room environment information perception layer, data remote transmission layer and system platform application layer. The system performs intelligent monitoring requirements for the computer room through environmental information perception and remote control, data collection and remote transmission, cloud data analysis and Web platform display.

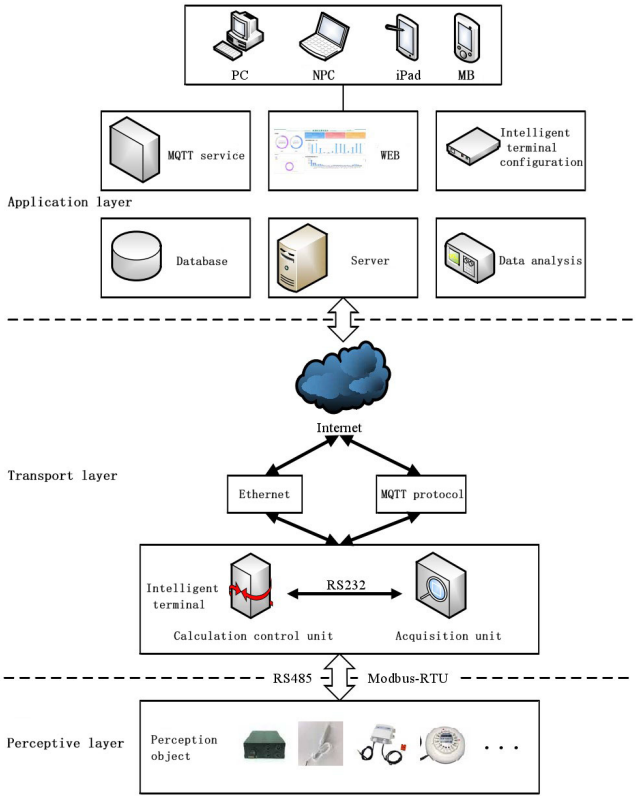


**Fig. 1.** Overall system architecture

### 2.1 Perceptive Layer

The sensing layer is mainly responsible for sensing the physical information of the monitored environment and executing the downlink command [3] of the network layer. It is composed of sensing units and executing agencies. The sensor unit mainly includes sensor equipment for monitoring the environmental information of the computer room, such as temperature and humidity sensor, smoke sensor, water immersion sensor, voltage and current sensor, and HD camera module.

### 2.2 Transport Layer

The authenticity and reliability of data collected in the process of computer room environmental monitoring is the basis of computer room environmental monitoring and subsequent data analysis and data mining, while the stability and real-time of data transmission is an important guarantee of data authenticity and reliability. The transmission layer in this system is composed of intelligent terminal with gateway function and data communication transmission network. The intelligent terminal is composed of two parts: acquisition unit and calculation control unit, which is responsible for the collection and transmission of environmental information in the computer room and the distribution of control instructions and acquisition parameter configuration instructions. The data communication transmission network consists of two parts: local data collection and transmission, wired communication, remote communication between intelligent terminal and cloud server, and data remote transmission. The local data acquisition, transmission and wired communication are connected with the intelligent terminal acquisition unit through RS485 bus, and the Modbus protocol commonly used in the industrial Internet of Things data acquisition is selected. The data transmission and remote communication between the intelligent terminal and the cloud server are realized using Ethernet or 4G network and Message Queuing Telemetry Transport (MQTT) protocol [4].

### 2.3 Application Management Layer

The object of the application layer is the computer room supervisor, so its design should be guided by the user's functional requirements and service requirements, and the main goal is to facilitate human-computer interaction with the computer room supervisor. In addition, the application layer should also be responsible for the analysis, storage and display of data, so as to facilitate the management of the computer room by the supervisor, and also provide basis and help for eliminating the hidden dangers of the computer room environment. The application layer is mainly divided into application support layer and application management layer.

1. Application support layer

The application support layer is mainly responsible for storing, analyzing, calculating and managing the data uploaded by the sensing layer and the transmission layer. The application support layer of the system is built on the basis of cloud server and its basic software and hardware. ECS includes MQTT server, database server, communication server and data analysis server. The basic hardware is mainly firewall to ensure the safe operation of the Internet of Things system. The basic software is mainly the operating system and application program interface, which is used to realize the query of the current and historical information of the computer room and the calculation model required in the process of running data analysis and processing. The application support layer does not directly interact with supervisors, but provides support and foreshadowing for human-computer interaction functions such as data query, management and user authority management and system management functions.

2. Application management layer

The application management layer is an important part of the human-computer interaction between the computer room supervisor and the monitoring system to achieve the monitoring and management of the computer room environment. The monitoring system provides the supervisor with functions such as real-time monitoring of the computer room environment information, abnormal information alarm, historical data query and user authority management through the Web terminal.

# 3 Research on Key Technologies of the System

## 3.1 Fire Detection and Early Warning based on GA-LSTM

In view of the problem that the Long Short-Term Memory (LSTM) neural network needs to spend a lot of time to manually adjust parameters and it is difficult to find the optimal parameter combination in the process of use, the Long Short-Term Memory based Genetic Algorithm (GA-LSTM) model of the LSTM neural network is designed and proposed to use the Genetic Algorithm (GA) to optimize the key parameter combination in the LSTM [5] neural network by using the global optimization ability of the GA algorithm, and then the LSTM neural network model is established by using the optimal parameter combination to detect and early warning the fire, While ensuring the accuracy and reliability of the fire type identification of the model, the tedious work of manually adjusting parameters for many times is avoided, and the fire prediction model has better performance in the early detection of fire.

In the GA-LSTM fire detection and early warning model, genetic algorithm is used to optimize the number of hidden layer units and the parameters of the Dropout layer in the LSTM neural network to determine the best combination. The GA-LSTM model establishment process is shown in Fig. 2.

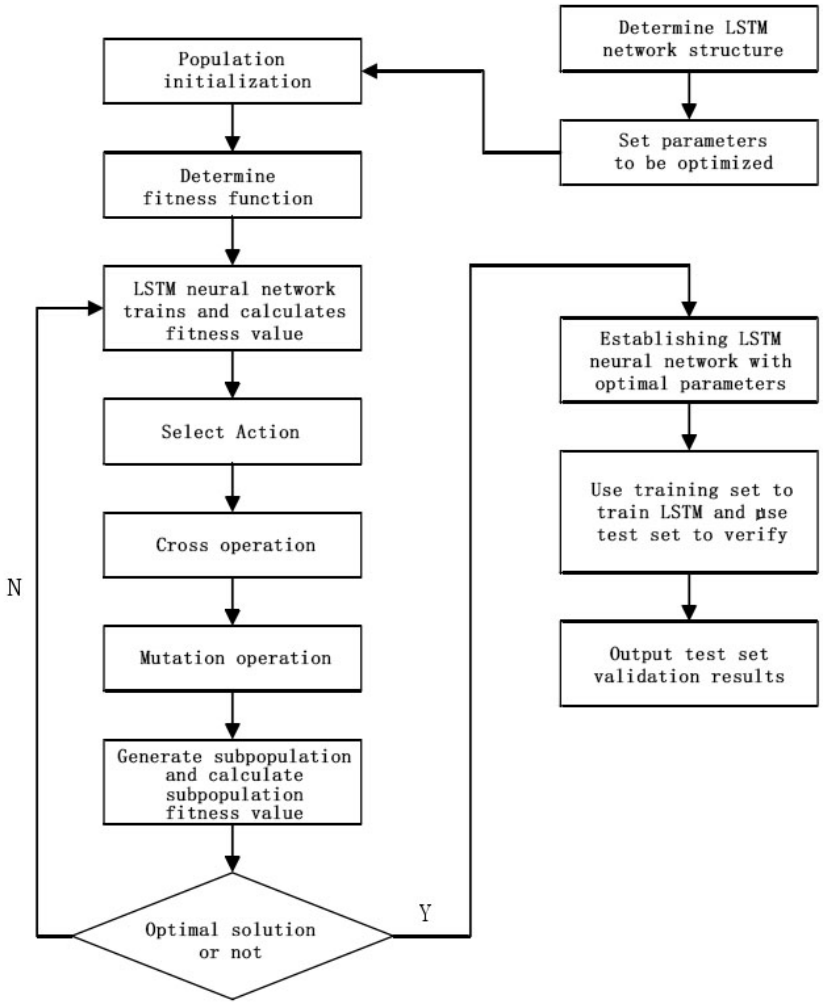


**Fig. 2.** GA-LSTM algorithm flow

The steps of GA-LSTM model establishment are as follows:

1. The genetic algorithm population is initialized with the number of units in the two hidden layers and the parameters of the Dropout layer in the LSTM neural network as the optimization objects of the genetic algorithm. Set the population size to 30, the maximum number of iterations to 100, the coding method to select binary coding, the solution range of the number of units in the two hidden layers is [40, 90], and the solution range of the probability of the Dropout layer is [0.2, 0.51].

2. The LSTM model is established with the corresponding parameters of individuals in the population, and the model is trained with training sets, and the neural network model is verified with test sets. The mean square error between the actual output value of the LSTM neural network and the expected output value of the test set is taken as the fitness function solved by the genetic algorithm, and the fitness function value of each individual in the population is calculated.

3. The individuals in the population are selected, crossed and mutated to generate a new generation of population. Among them, the selection operation selects the championship selection algorithm, the crossover probability is set to 0.8, and the mutation probability is set to 0.1. In addition, in order to improve the convergence speed of the genetic algorithm, the elitist retention strategy is set, that is, the individuals with the largest fitness function value in the current population do not carry out crossover and mutation operations, and directly enter the next generation.

4. Evaluate the fitness of individuals in the new population generated by the genetic algorithm. If the fitness function value reaches the best, proceed to the next step, otherwise return to step (3).

5. The LSTM neural network is established with the optimal parameters obtained by genetic algorithm, and then the model is trained with training set, and the trained model is verified with test set, and the training results and prediction results are output.

Use MATLAB 2018a to simulate the GA-LSTM fire detection and early warning model. The comparison between the training results and the LSTM model is shown in Fig. 3. It can be seen from the figure that the convergence speed of the GA-LSTM model is faster, and it has basically stabilized when the number of training times is 200, and the accuracy fluctuation gradually decreases during the training process, and the final training accuracy is also higher than the ordinary LSTM neural network model [6].

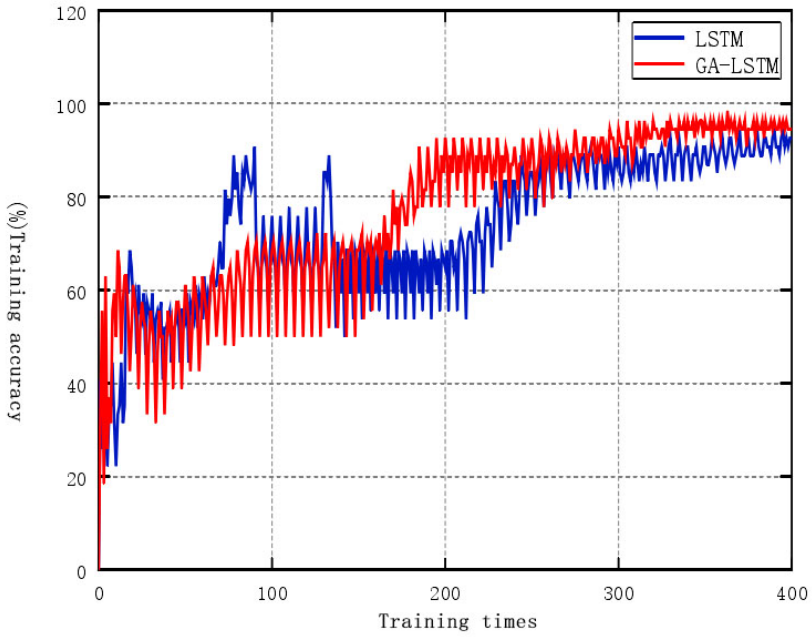


**Fig. 3.** Training process of GA-LSTM fire detection and early warning model

### 3.2 Online Status Analysis and Fault Warning of Server Equipment

The system adopts the combination of rough set theory and fuzzy comprehensive evaluation method. First, it collects the historical data of the online operation of the server equipment, extracts the status characteristic data of the server equipment at different stages, and carries out attribute reduction on its characteristic data to find out the rule of fault occurrence. In the process of fuzzy comprehensive evaluation, rough set is introduced to determine the weight of the indicators that affect the operation of the server, and a comprehensive evaluation model of the online status of the server equipment is established, and the alarm is given when some main indicators are poor.

The weight of each factor is taken as the weight of the fuzzy evaluation index through the attribute importance of rough set [7], and the attribute weight is completely determined by the data itself, which makes the attribute weight of each factor may have certain one-sidedness. Therefore, the system combines the objective attribute weight determined by historical data with the subjective attribute weight of experts to determine the weight of indicators based on expert knowledge and experience.

The server device status analysis steps are as follows:

1. Establish factor set

Factor set P is a collection of factors that affect the evaluation of server status, including CPU temperature, CPU usage, system average load, memory usage, disk usage, disk read/write rate, I/O read/write time, database access, etc.

$$P = \{p_1, p_2, \ldots, p_n\}, i = 1, 2, \ldots, n. \quad (1)$$

Where: $p_i$ represents the ith influencing factor in the factor set p.

2. Create comment set

Build information system $S=(U, A, V, f)$. Where U represents a non-empty finite set of server objects; $A$ represents the non-empty finite set of evaluation indicators; $A=C \cup U$, $C$ is the condition attribute set, $D$ is the decision attribute set, normalize the data, and establish the indicator decision table; The comment set is a collection of evaluation results made by the server status attribute. This paper measures it by four levels: “good”, “normal”, “poor” and “serious”.

$$V = \{v_1, v_2, \ldots, v_n\}, j = 1, 2, \ldots, m. \quad (2)$$

Where: $v_j$ represents the $j$th possible evaluation in the comment set $V$.

3. Simplify attributes, determine indicator weights and establish weight sets according to attribute importance

The weight set is a set reflecting the importance of each state in the server state factor set, namely

$$A = \{a_1, a_2, \ldots, a_n\}, a_i = 1, a_i \geq 0. \quad (3)$$

Where: $a_i$ is the importance of the $i$th factor in the factor set, then the weight of attribute $p_i$ is normalized as objective weight $W_{pi}$ . The weight of attribute $p_1$ is its importance in the decision set.

$$lmp = 1 - card(posc(D))/card(U). \quad (4)$$

Where, $card$ represents the cardinality of the set, and $posc(D)$ represents the C-positive domain of $D$ .

The attribute weight based on rough set is only driven by data, which requires the selected data to be universal, representative and one-sided. Therefore, different types of servers can be classified, and the subjective weight of indicators and the comprehensive weight can be determined for servers with different requirements according to different server types and actual needs.

$$W_{pi}=W_{pi}^{'}\times(1-a)+W_{pi}^{''}\times a. \quad (5)$$

Among them, the experience factor is set as $a(0 \leq a \leq 1)$. The larger the value of the experience factor, the more important the comprehensive weight is to subjective opinions.

4. Single factor fuzzy matrix

The subordinate degree of the second single factor to the level status evaluation is established by using the real-time online data of the server equipment through the statistical method. Form a single factor fuzzy evaluation matrix [13], which is recorded as

$$R = \begin{pmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ r_{m1} & r_{m2} & \cdots & r_{mm} \end{pmatrix}. \tag{6}$$

5. Fuzzy comprehensive evaluation

The single factor evaluation matrix is fuzzy transformed with the weight set, and finally the multi-factor fuzzy evaluation is formed, which is recorded as

$$B = A \circ R = (a_1, a_2, \cdots, a_n) \begin{pmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ r_{m1} & r_{m2} & \cdots & r_{mm} \end{pmatrix} = (b_1', b_2', \cdots, b_m'). \tag{7}$$

Among them, the fuzzy operator uses $M(\cdot, \oplus)$, that is, $b_k = \min(\Sigma_{i=1}^{n} a_i r_{ij})$, to obtain the evaluation value of the online status of different servers at a certain time. This paper selects different membership degrees to evaluate the status level of the equipment.

## 4 Module Design

### 4.1 IT Equipment Monitoring Module

The design of IT equipment monitoring platform [8] includes server equipment system, storage equipment system, database system, middleware system, etc. for real-time monitoring and management. The above subsystems are integrated on an IT equipment monitoring platform for centralized control and management, meeting the requirements of "centralized monitoring, centralized maintenance and centralized management", and providing users with the ability, means and tools of centralized monitoring related to the application directly.

The IT equipment monitoring platform realizes the monitoring and management of servers, storage devices, network systems, equipment and security systems running in each computer room. It can remotely configure the network nodes of the IT operation and maintenance system, and monitor the performance status of each node in real time. Once there is a fault, it can automatically and timely alarm; Be able to carry out highly automated management, minimize human intervention, and avoid system failure caused by improper operation of personnel; Help IT operation and maintenance system management personnel to grasp the operation situation of IT equipment in real time and comprehensively; Statistics and analysis of alarm information and fault information from all aspects of the network, and timely prediction, response and handling of IT resource failures; It provides strong technical support for business maintenance work by monitoring and alarming the health status of equipment components, estimating the service life of SSD, and automatic electronic inspection of hardware equipment failures.

### 4.2 Intelligent Terminal Module

The overall function structure of the intelligent terminal module is shown in Fig. 4, which mainly includes two main tasks. The first main line is that the intelligent terminal acquisition unit collects the environmental information of the computer room, and then transmits it to the computing control unit. The computing control unit analyzes the environmental information data of the computer room, distinguishes the outliers and converts the protocol, and then packages and uploads it to the cloud server; The second main line is that the cloud server sends the collection parameter configuration information, control instructions or fire warning information to the intelligent terminal. If the collection parameters are configured, they will be synchronized to the collection unit through the calculation control unit to configure the collection parameters; If it is a control command, it will be sent to the computer room precision air conditioner through the calculation control unit of the intelligent terminal to realize

the remote control of the air conditioner; In case of fire warning information, audible and visual alarm will be conducted through the alarm module connected to the calculation unit.

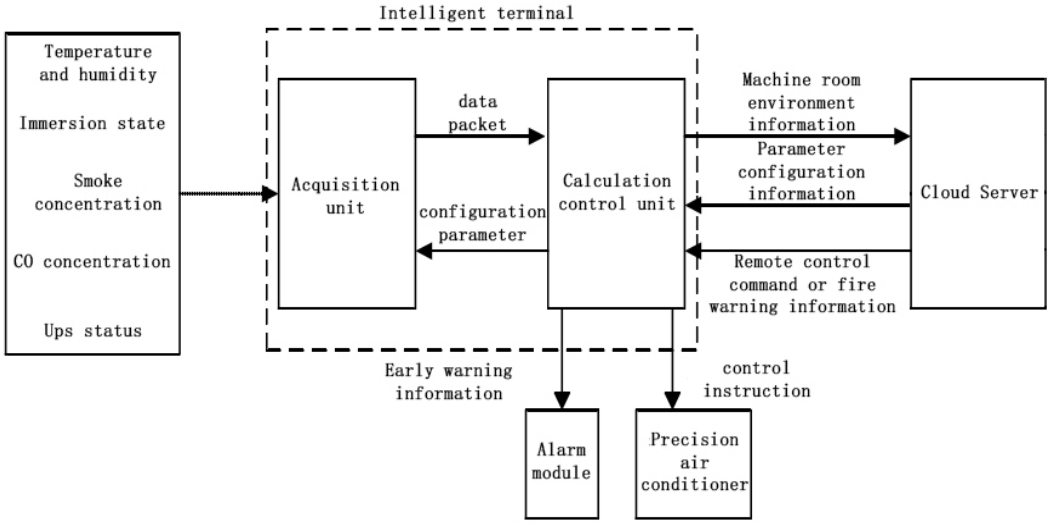


**Fig. 4.** Overall design of intelligent terminal module

1. Design of acquisition unit

The main task of the acquisition unit is to connect with each sensor to collect the environmental data of the computer room, so as to realize the perception of the environmental information of the computer room. At the same time, the collected environmental information data of the computer room is initially organized and synchronized to the computer control unit for further data processing and remote transmission.

The software flow [9] of the acquisition unit is shown in Fig. 5. First, initialize the hardware system, including configuring the input and output modes, baud rate, priority and other hardware parameters of the communication serial port, and then configure the receiving interrupt and interrupt processing function of the serial port to complete the interrupt initialization. The acquisition unit communicates with the computing control unit through RS232 bus. After connecting the computing unit successfully, the computer room environment information collection begins. The machine room environment information collection adopts the polling mechanism, and the data transmission protocol selects the Modbus-RTU protocol commonly used in the industrial Internet of Things data collection. The collection unit queries the sensors mounted on the RS485 bus, and analyzes the data after receiving the response frame returned by the sensor to obtain the machine room environment information data. After the collection of the environmental information parameters of the computer room is completed, the data will be uniformly converted into JSON format, packaged and transmitted to the computing control unit, and whether the transmission is successful will be detected. If the transmission is successful, the next round of collection will be started, and if not, the data will be uploaded again.

2. Calculation control unit design

As the most core part of the environment detection module [10], the main tasks of the computing control unit are:

(1). Connect with the acquisition unit, receive the data packet transmitted by the acquisition unit, analyze the data, and then judge the abnormal value of the obtained computer room environment information data, and give an alarm in time in case of any abnormality;

(2). An MQTT connection is established with the ECS to package and publish the collected machine room environment information data to the ECS. At the same time, you can subscribe to the configuration instructions issued by the server to configure the collection unit and intelligent air conditioner accordingly.

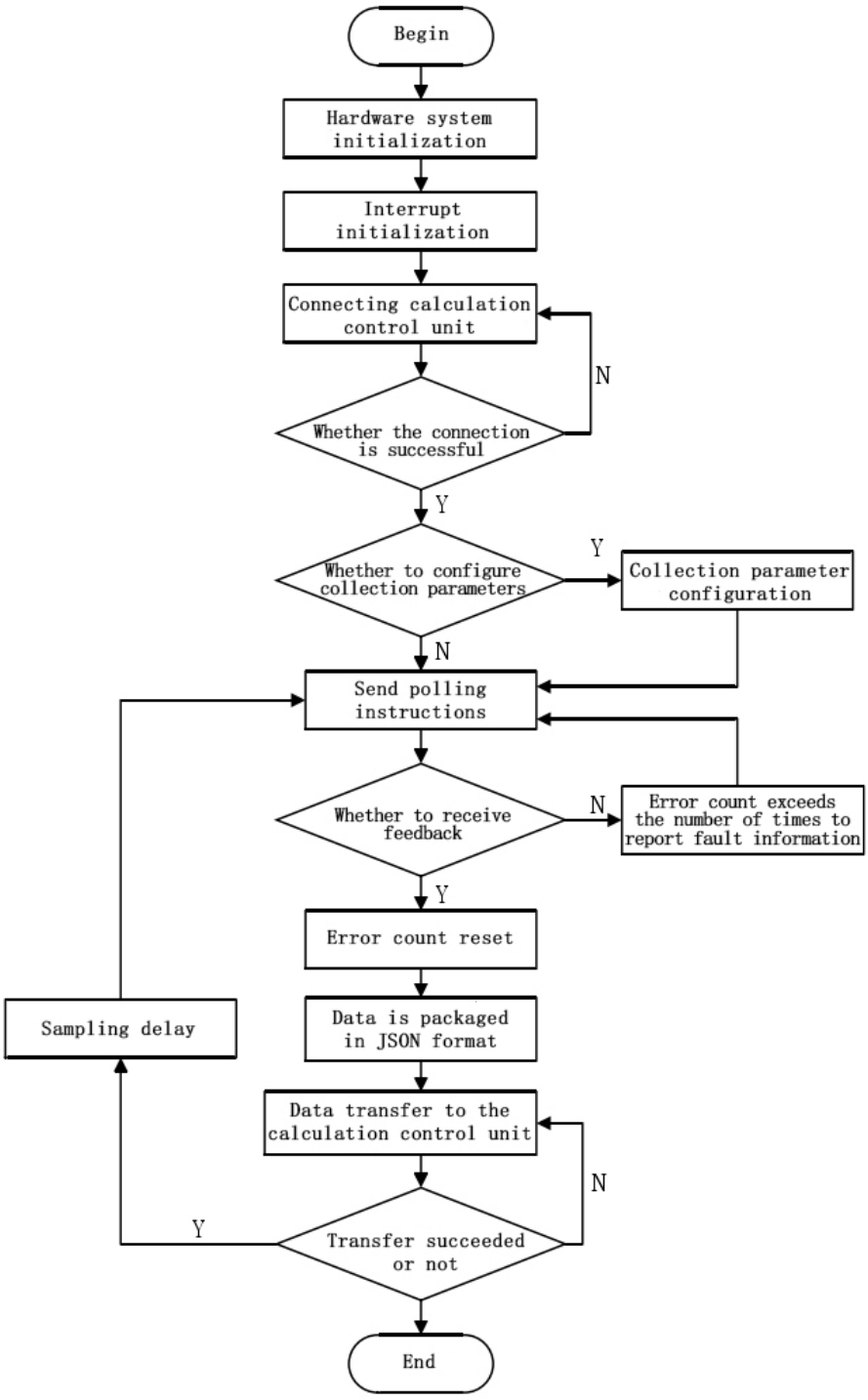


**Fig. 5.** Process of acquisition unit

The calculation control unit software operation process is shown in Fig. 6. After the system starts, first load the Linux kernel and initialize the hardware and peripheral interfaces. After initialization, start the acquisition unit connection process and network connection process. During the connection process of the acquisition unit, after the connection with the acquisition unit is successful, it receives the computer room environment information data transmitted by the acquisition unit and analyzes the data. The parsed data is used to distinguish the abnormal value. In case of any abnormality, it will start the alarm and send a short message to the supervisor via the 4G module; If there is no exception, the data will be stored locally and published to the cloud server through the network connection process. At the same time, the collection parameter configuration information subscribed from the ECS is synchronized to the collection unit through RS232 bus to realize the collection parameter configuration. During the network connection process, first check whether the network connection is normal. If it is normal, establish an MQTT connection with the server according to the server IP address, port number and the account password of the MQTT server. After the connection is successful, the calculation control unit can use mqtt_ The publish() function publishes data to the server, or mqtt can be used_ The subscribe() function subscribes the collection parameter configuration command, alarm command and air conditioning parameter configuration command from the server to configure and control the collection unit, alarm and intelligent air conditioning.

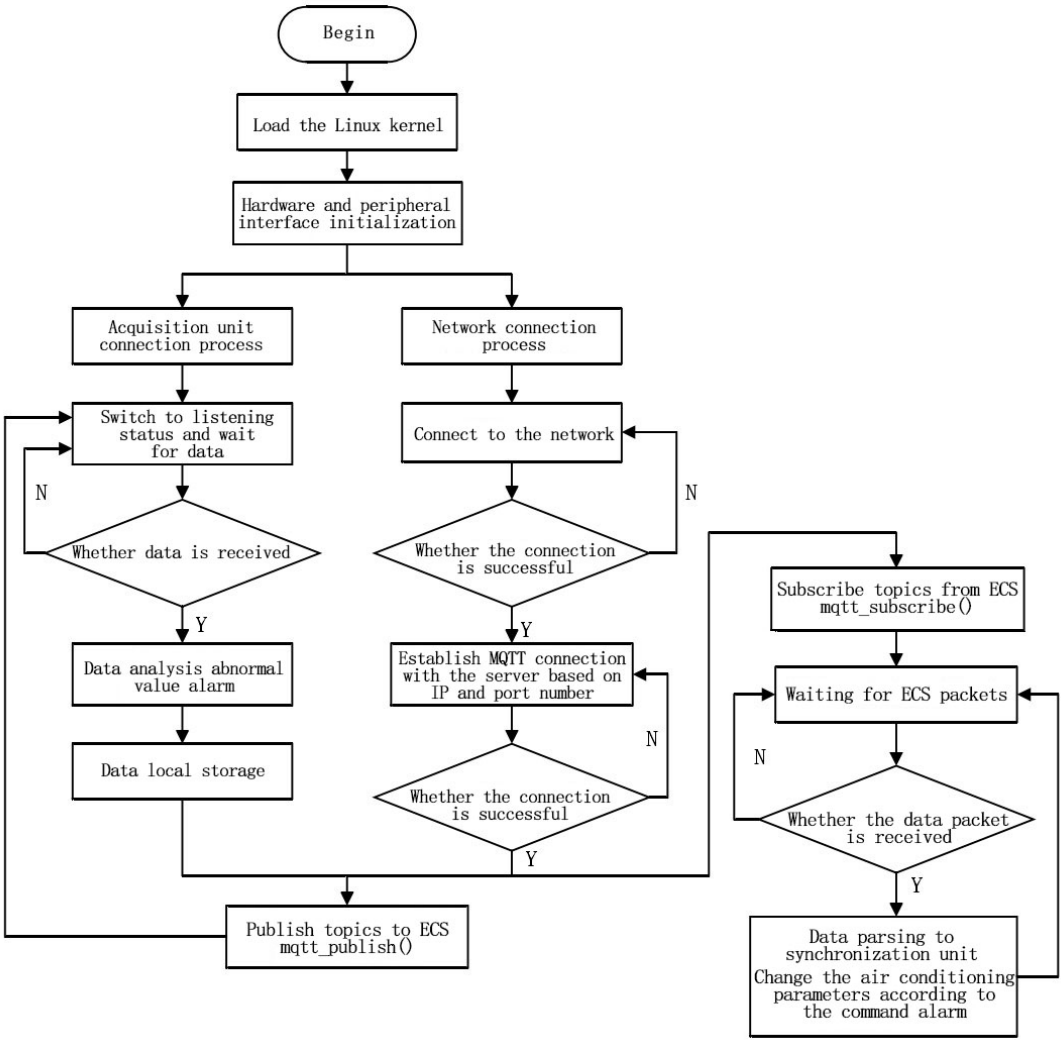


**Fig. 6.** Calculation control unit flow

### 4.3 Security Monitoring Module

Computer room video monitoring is not only the monitoring of environmental data, but also the security video monitoring of the computer room. Security video monitoring can well realize remote supervision and is an important guarantee for the safety of the computer room. In addition to the access control system, infrared anti-theft can prevent unauthorized personnel from entering the computer room and damaging the equipment in the computer room.

The front end completes the functions of video shooting, detector alarm signal generation, alarm output, etc. It mainly includes camera, electric zoom lens, outdoor infrared radiation detector and dual monitor detector. The camera captures the on-site situation through the built-in CCD and auxiliary circuit into an analog video electrical signal, which is transmitted through the coaxial cable. The electric zoom lens will pull the scene closer and farther, and realize optical adjustment such as aperture and focusing. The transmission part is mainly composed of coaxial cables. The transmission part requires real-time transmission of the images recorded by the front-end camera. At the same time, the transmission is required to have low loss and reliable transmission quality, and the images can be clearly restored and displayed in the video control center. The control part is the core of the security monitoring system, which completes the digital acquisition of analog video monitoring signals, MPEG-1 compression, monitoring data recording and retrieval, hard disk video recording and other functions.

This module uses personnel re recognition technology to obtain the number of personnel inside the computer room and the physical attribute characteristics of different personnel, and compares the obtained characteristics with the characteristics and number of personnel stored in the cache that should appear in the computer room, generating corresponding personnel abnormality events based on the comparison results. According to the system defined abnormal behavior, the personnel abnormal event detection algorithm can be divided into the following two steps.

(1) Machine room unauthorized intrusion detection

The surveillance video frame detected by the target recognition algorithm [11-14] is used as the input of the algorithm, and submitted to the personnel attribute recognition algorithm for personnel re identification to obtain the number of personnel and personnel characteristic data existing under the corresponding video frame. Due to the significant adverse effects of lighting, deformation, and other factors on the personnel re recognition algorithm, we simultaneously detect the human body information of the target personnel and send the detected human body information to the background service through the http request service for processing. The background service compares the personnel information stored in the cache for the current effective application with the personnel information existing under the received current video frame.

The specific process of comparison is as follows: Compare the number of personnel. If the number of personnel detected in the current monitoring video frame is greater than the currently effective number of applications, this module will consider that an abnormal intrusion event has occurred in the computer room, and generate an ultra vires intrusion alarm for the computer room. Comparing the human body attribute characteristics of personnel, if it is detected that there is personnel data in the current monitoring video frame that is inconsistent with the currently effective application, this module will also consider an abnormal intrusion event in the computer room and generate an alarm. The process of detecting intrusion exceptions is shown in Fig. 7.

(2) Timeout exception detection

In view of the situation where an abnormal alarm is not generated after the unauthorized intrusion detection in the computer room, the system believes that the personnel detected in the input video frame data are all personnel who have applied to enter the computer room. For these personnel, this module needs to determine whether the personnel have entered the computer room within the requested time period. Therefore, it is necessary to compare the current time with the requested time. The comparison process is as follows:

Match the personnel characteristics of the current video frame with the personnel characteristics of the effective application, read the entry time and departure time of the application stored in the database based on the matching results, and compare the current time with the entry time and departure time of the matched application to determine whether it is within the time period of the application. If it is found that it is not within the requested time period, this module will consider that a timeout exception has occurred in the computer room and generate a timeout exception alarm. The timeout exception detection process is shown in Fig. 8.

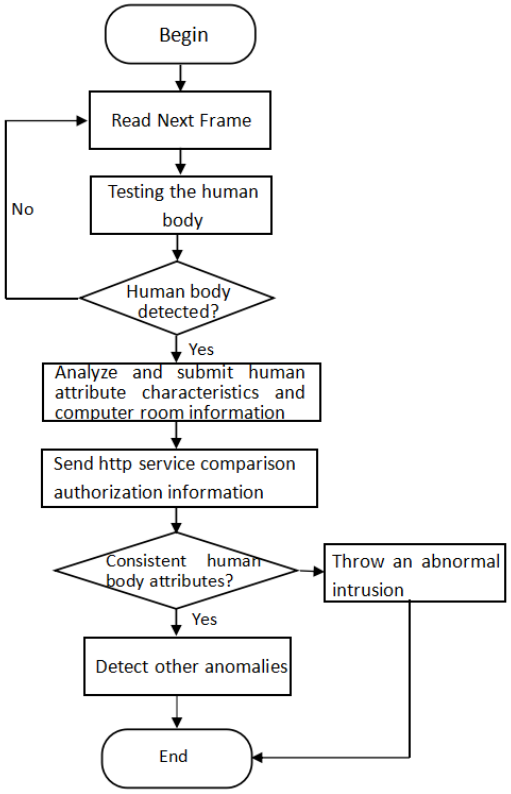


**Fig. 7.** Abnormal intrusion process

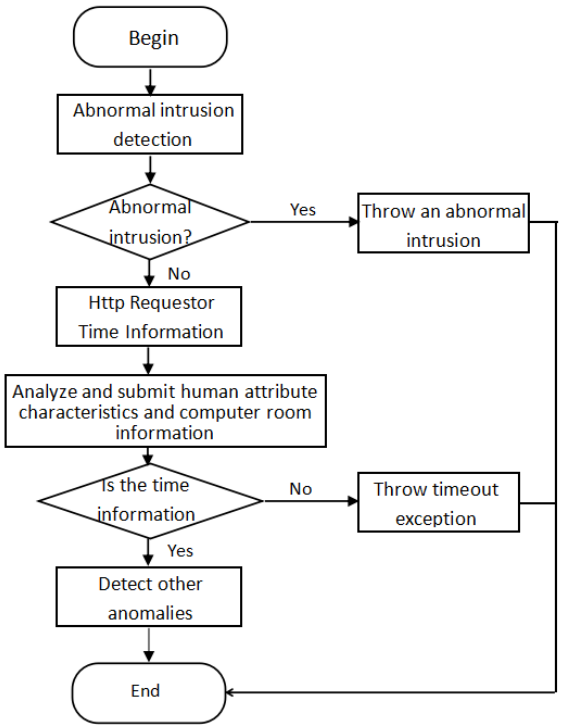


**Fig. 8.** Timeout exception flowchart

## 5 Conclusion

The intelligent video room monitoring system is an application system based on advanced computer vision and artificial intelligence technology, which can achieve automated analysis and processing of monitored videos. With the continuous progress of technology, intelligent video room monitoring systems will be widely used in the field of security and gradually demonstrate strong potential and market value. According to relevant technologies, this paper makes comprehensive use of sensor equipment, cloud computing, big data and other technologies to intelligently perceive, identify, locate and track the status of equipment, equipment and personnel through the Internet and other communication networks to achieve real-time, dynamic, interactive and integrated information collection, transmission and processing. Through information processing, data mining and situation analysis, it can predict whether the operating environment of the equipment is normal. It not only meets the centralized control and operation and maintenance service requirements of the distributed intelligent video machine room, but also has the intelligent linkage processing capability of machine room abnormalities, meets the unattended demand of the machine room, reduces the operation and maintenance management costs, and ensures the safe and stable operation of the machine room.

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