Scalable Computing: Practice and Experience, ISSN 1895-1767, http://www.scpe.org
© 2024 SCPE. Volume 25, Issues 4, pp. 2240–2249, DOI 10.12694/scpe.v25i4.2957

RESEARCH ON LABORATORY CONSTRUCTION AND MANAGEMENT BASED ON INTERNET OF THINGS AND DEEP LEARNING

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Abstract. A computer laboratory intelligent management and control system based on Internet of Things technology and deep learning is proposed to address the shortcomings of traditional university laboratory management.The system adopts the main embedded technology, mobile communication technology, wireless sensor technology and database storage technology in the Internet of Things technology, laboratory areas and equipment, identify and collect relevant data, monitor abnormal conditions in real time, and alarm. At the same time, the user is provided with a preview of the experimental content and a demonstration of the results through the handheld client APP. The experimental results show that: when the system is powered by 0.35A current, the total system power is about 3W. The NTC thermistor used has a B value of 3435. Under normal temperature, $T2 = 298.15K, R = 10K\Omega, R0 = 10K\Omega$. The current temperature value can be calculated according to the value obtained after the analog-to-digital conversion of the microcontroller. The output frequency of the humidity detection circuit is measured by the single-chip microcomputer, and the current ambient humidity can be obtained by substituting the result into the above formula, that is, when the output frequency dimension of the circuit is 6853Hz, the ambient humidity is 40%. Through the application of this system, the inefficient and extensive manual management method of the computer experimental teaching center is completely solved, so that it can bring more intelligent and efficient services to the teachers and students of the whole school, so as to comprehensively promote the experimental teaching of the school.

Key words: Internet of Things, laboratory management, environmental monitoring, deep integration, management research system

1. Introduction.

With the continuous improvement of university laboratory environment and hardware conditions, it is urgent to establish a more scientific and effective laboratory management and operation mode based on modern information technology. The Internet of Things management and control system will be cross-integrated with the existing laboratory management system to gradually improve the open and sharing rate of practical teaching resources of the center, effectively relieve the pressure of laboratory safety management, and effectively serve teachers and students. As the world ushered in a period of great development and great change in digital transformation, the new generation of information technology has accelerated to lead breakthroughs in technological applications, bringing about major changes in industrial forms, organizational management, social governance, etc, and the development of new generation technologies such as the Internet of Things, bringing new impetus and new opportunities to the development of the digital economy [1].

With the introduction of the new engineering concept, experimental teaching has become an important practice link for scientific development, knowledge innovation and talent training in colleges and universities, under the guidance of applied talent training, practical ability has become a rigid indicator, the result is to increase the proportion of experimental courses, improve the effective utilization of the laboratory, and increase the investment in laboratory construction to promote the self-improvement of students' practical ability [2]. As an important place to cultivate students' practical and innovative ability, university laboratories play a decisive role in the teaching process of universities. Under the new situation, the laboratory must gradually improve the utilization rate and sharing rate of open resources, and give full play to its important role in innovation and entrepreneurship education.

Internet of Things laboratory is an intelligent laboratory management system using Internet of Things technology. With the help of various sensors through the Internet and relays, the ubiquitous link between things and things and between things and people can be realized. Its technology can bring revolutionary

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changes to the entire laboratory environment. In contrast to this, the management and use of the laboratory still remain in the old mode of the original experimenter management, teacher's explanation and students' classroom operation [3]. Therefore, how to manage the laboratory scientifically and reasonably, it has become an urgent problem to make it serve the teachers and students of colleges and universities efficiently. Traditional laboratory management mostly adopts manual management mode, lacking systematic and scientific laboratory information management software, and the efficiency is low [4]. After class, the laboratory is closed, and it is difficult to meet the individual needs of students for experiments. The so-called open experiment means that from the selection of experimental time, experimental items, experimental instruments and equipment, in order to the formulation of the program and the implementation of the project, students can complete it independently.Open experiment breaks the various limitations of traditional experimental teaching and realizes the autonomy and diversity of experiments [5]. This kind of flexible teaching can fully mobilize students' enthusiasm for learning, and is conducive to cultivating students' innovation and entrepreneurship ability, cultivate more complex skilled talents needed by society [6]. The construction objectives of the training room in higher vocational colleges should be based on application-oriented infrastructure construction and curriculum construction, characterized by practical courses, and characterized by different industries, application examples and rich application scenarios. The room is committed to cultivating professional talents with certain electronic technology and information technology foundation, and cultivating professional talents with the application development ability of the Internet of Things.

2. Literature review. In recent years, the construction of laboratory management system has attracted great attention from related industries at home and abroad [7]. The construction of Internet of Things laboratory is of great significance for improving students' comprehensive quality, promoting students' employment, improving the Internet of Things research environment and enhancing scientific research strength. The Internet of Things laboratory is divided into two areas: the Internet of Things application display area and the student experiment area. Relevant practical training resources and experimental operation guidance are managed uniformly through the Internet of Things practical training management system. Teaching and practical training, application and innovation will be better integrated. However, most of these systems are aimed at the management and monitoring of biochemical laboratories, with low comprehensiveness, relatively single functions, and high prices. In traditional laboratories, equipment management has always been managed by laboratory administrators on the spot, regularly checking the safety hazards such as water and electricity consumption in the laboratory, only a small number of scientific research institutes have joined the assistance of information technology, temperature, humidity, light and smoke are monitored [8]. With the rapid development of Internet of Things technology, the real-time collection of laboratory environmental information and equipment information can be realized by sensors, which can greatly facilitate the effective management of experimental equipment [9]. In experimental teaching, most colleges and universities still use the traditional face-to-face teaching method, that is, teachers teach and students do the same, this form of teaching has certain unfavorable factors for students' thinking and exploration and after-class review, and cannot form a systematic system. In recent years, with the development of network technology, remote video teaching methods have sprung up and have been widely used, the distance teaching technology realizes the centralized utilization of teaching resources such as excellent teachers and advanced teaching methods, and meets the various needs of users at different levels [10]. Applying this concept, efficient and rich experimental equipment and experimental resources can be effectively used in experimental practice teaching, and audio and video teaching and operation demonstrations can be used to explain experimental tutorials and experiments, so that students can flexibly learn experimental knowledge from various aspects and improve their practical ability. Some enterprises and scientific research institutions in my country have also begun to pay attention to the informatization construction of laboratory management [11].

Umashankar, M. L. et al. launched Bio-LIMSV1.0 for biological research and development, pharmaceutical manufacturing and chemical enterprise management, to a certain extent, the laboratory management system realizes the main functions of biochemical laboratories in daily life, project topics, inventory, material consumption and ordering [12]. In addition, it can intelligently allocate the inventory and usage of chemical reagents in the laboratory, a customized management plan is designed for some special chemical reagents [13]. In addition, some laboratory management systems have emerged in the industry to meet the needs of specific fields. Zhang,

Y. et al. developed a laboratory energy consumption management control system, which senses the working conditions of electrical equipment in the laboratory through sensor detection technology, and conducts differential management, greatly reduces the loss of laboratory electricity [14]. Zheng, X. et al. developed a set of commercial laboratory management system, which is mainly used for course scheduling management and charging management of teaching units and teaching institutions. In foreign countries, StarLIMS has been committed to the research and development of laboratory management and solutions for public health and environmental monitoring for several years, and has occupied a large market share in Europe and North America [15].

Internet of Things application and practical training scene construction: On the basis of the experimental teaching platform of basic courses, an exhibition environment covering intelligent home, intelligent building, robot control, industrial monitoring and other Internet of Things application scenes is built. Enable students to intuitively understand the specific application of the Internet of Things industry, and make use of the open interface to carry out the actual development of the Internet of Things engineering, cultivate the students' application level of comprehensive knowledge, improve their comprehensive skills of the Internet of Things.

On the basis of the above research, the author proposes a laboratory construction and management research system based on the Internet of Things and deep integration, through the experimental observation of the circuit current, temperature, humidity and other parameters in the laboratory, in order to carry out the daily management and environmental monitoring of the laboratory.

3. Research methods.

3.1. IoT-based laboratory management system. The daily safety management of the laboratory is faced with some safety risks, such as water and electricity safety, hazardous chemicals management, the use of instruments and equipment, open use, etc. The traditional surveillance system has many loopholes, and the camera equipment usually leaves many blind spots. Moreover, the surveillance video cannot deal with the abnormal situation in real time, so it needs to be judged by human afterwards. In addition, the collection of information is single, the provision of effective information is not comprehensive, and there is no effective analysis tools, can not be remote monitoring.

There are many kinds of instruments and equipment in the laboratory, with different functional components and different requirements for the environment, and even some instruments and equipment have very strict requirements on the environment. According to this characteristic, the management work of the laboratory is mainly the management and maintenance of the experimental equipment and the monitoring and control of the laboratory environment. In addition, the opening of experimental activities is limited by time and place, which cannot meet the students' follow-up exercises and summaries, repeated experiments in batches increase the workload of teachers. In response to this problem, if you integrate excellent experimental content and methods and other resources, and store them on the central control server in the form of documents or videos, students can access them remotely through handheld terminals, which can facilitate review, summary and self-learning thinking, the workload of experimental teachers.

The application of Internet of Things technology can strengthen laboratory security management, and effectively improve the timeliness and efficiency of security control. Through the Internet of Things perception system, environmental monitoring system, power safety system, smoke alarm system, real-time monitoring of hazardous chemical cabinets, air conditioners, projectors, light incubators, ultra-low temperature refrigerators, access control and other equipment safety and environmental safety, in case of abnormal conditions, can immediately start the automatic alarm function, real-time information feedback to the laboratory manager.

The overall structure of the laboratory management system is shown in Figure 3.1. In this system, the administrator can monitor the laboratory information in real time through the PC client or the mobile phone, so as to realize the effective management of the management laboratory equipment. Students can also learn teaching resources such as experimental content and experimental instrument usage instructions through the terminal [16].

Combined with the three-tier architecture of the Internet of Things and the actual construction requirements, the system is divided into layers. The perception layer mainly acquires information, and uses the wireless sensor network to monitor the natural information such as temperature and humidity, illuminance, and smoke and dust concentration in the laboratory in real time [17]. Through the scanning equipment, the experimental

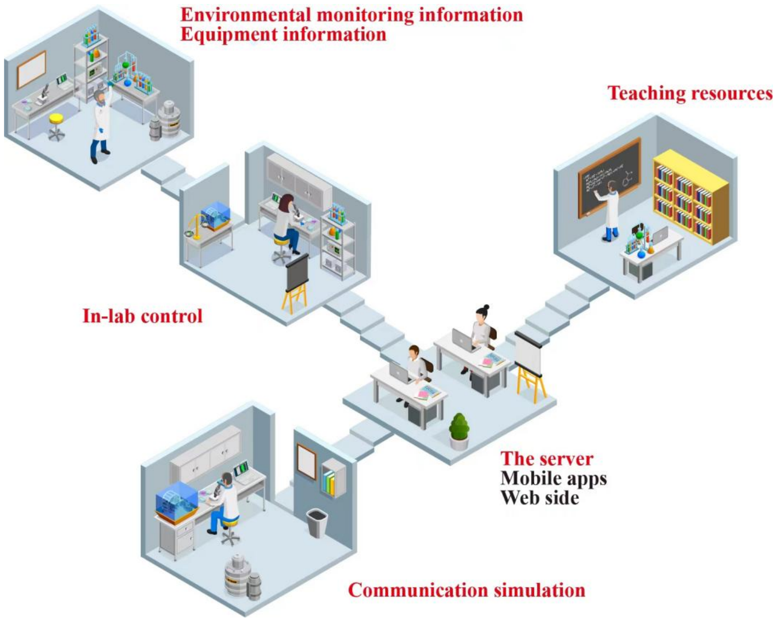

Fig. 3.1: Overall structure of the system

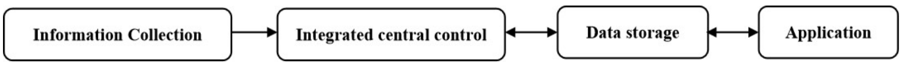

Fig. 3.2: System function structure diagram

equipment, experimental equipment and other information can be quickly and accurately identified and obtained. The collected information is transmitted to the central control storage unit using wireless transmission technology.

The large instrument room of the center is used as a pilot to introduce the Internet of Things technology and connect things Network management and control system and large instrument platform existing management system cross integration, real Instrument and equipment reservation, access control authorization, remote monitoring, equipment status tube Management, environmental monitoring, data reporting and other functions of intensive, intelligent management.

The network layer mainly completes the network transmission design according to the actual needs, in order to realize the fast and accurate data transmission to the central control unit, an embedded system needs to be constructed to complete the relay transmission of the perception layer information.

The application layer mainly completes the establishment of the database and the design of the application program, which is used to store the data collected by the sensing device, process different data separately, and make corresponding responses to different applications.

System specific design. Apply IoT-related technologies to design the laboratory management system, referring to the IoT hierarchy model, combined with the specific application space, the functions of laboratory environment data acquisition, system integration central control, sensing data storage, and interactive application are realized [18]. The laboratory environment data collection is realized by the perception layer function, the system integration central control is guaranteed by the network layer transmission protocol, and the perception data storage and interactive application are realized by the application layer function.The functional division of the system is shown in Figure 3.2.

The data acquisition function module is mainly used to acquire the environmental information inside the

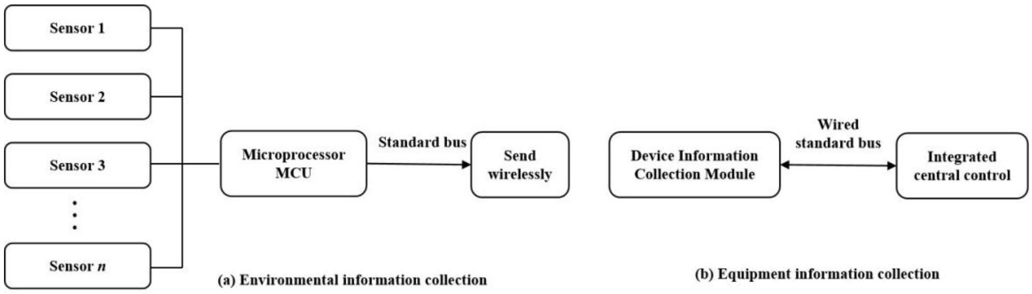

Fig. 3.3: Schematic diagram of the data acquisition part

Table 3.1: Barcode Encoding Rules

information bits	illustrate
1	Floor
2	
3	Laboratory number
4	
5	Equipment type
6	
7	
8	Serial number
9	
10	

laboratory and the status information of the experimental equipment, collect the laboratory environmental data in real time and input the information of the experimental equipment, finally, the acquired information is transmitted to the system integration central control through the network protocol [19]. The data collection process is shown in Figure 3.3.

The collection of indoor environmental data mainly applies wireless sensor network technology and sensor technology, real-time monitoring of laboratory temperature, humidity, light, smoke and other data information [20,21]. As a component, sensors must be used in conjunction with microcontrollers to detect environmental data information. The system uses ARM Cortex-M3 as the microcontroller, uses ZigBee module for wireless transmission, and completes the perception of laboratory environmental data in combination with sensors. The hardware part of the microcontroller is composed of power supply, signal amplification circuit, crystal oscillator and wireless transmission module to transfer serial port. The signal collected by the sensor is transmitted to the microcontroller through the amplifier, and then the data is converted by the microcontroller, finally, it is sent to the server via ZigBee for use and processing by the application [22].

The experimental equipment information coding is carried out according to certain rules, and the building number, laboratory number, equipment type and equipment serial number to which the equipment belongs are combined in order to form a bar code in a unified format. The specific rules of barcode coding are shown in Table 1, with the help of barcode generation tools, printing barcodes can be generated. Enter or view the information of the experimental equipment by scanning the barcode with a USB scanner or manually entering the coded information [23].

The integrated central control part plays the role of data transfer and transmission in the whole system, and completes the storage and forwarding of data information, which is the specific embodiment of the network layer function in the Internet of Things system. After the sensor receives the monitoring data and device data, it sends the data to the service central control terminal using standard network protocols [24]. Considering the future upgrade and function expansion of the system, enough interfaces are reserved in the hardware structure

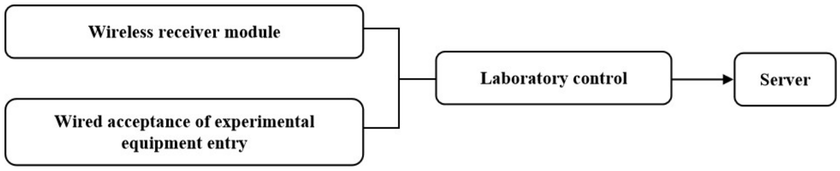

Fig. 3.4: Structure diagram of transit storage unit

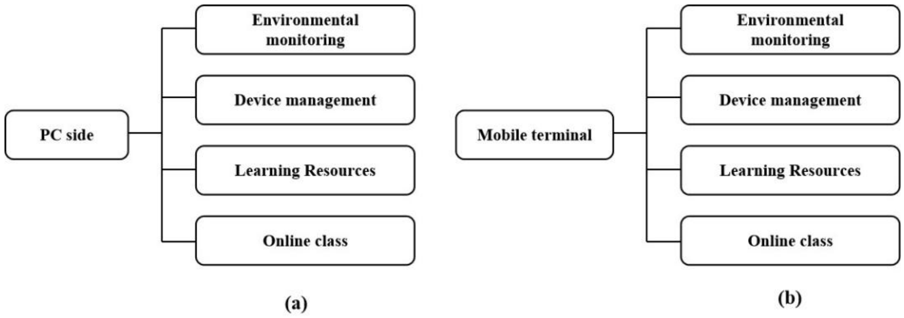

Fig. 3.5: Application unit structure diagram

of the integrated central control for future expansion of the system. The memory cell structure is shown in Figure 3.4.

The wireless monitoring module uses the ZigBee protocol standard to transmit the environmental perception information to the central control unit, ZigBee is a highly reliable wireless data transmission network, similar to CDMA and GSM networks. The ZigBee data transmission module is similar to the mobile network base station, and the communication distance ranges from the standard 75m to several hundred meters and several kilometers, and supports unlimited expansion. It is based on the IEEE802.15.4 standard and has the characteristics of high reliability, high cost performance, and low power consumption [25].

The design of the integrated central control system needs to build an embedded system, including embedded hardware and embedded software. The embedded hardware part adopts the integrated development board, which mainly includes the design of the core processor and its peripheral circuits. This system chooses ARM9 of ARMV5TE architecture as the core processor of the system. In the embedded software design, it is necessary to build an embedded operating system, and design applications based on the operating system, mainly based on the Linux system and build a cross-compilation environment arm-linux-gcc. In this environment, the input environmental information is processed, and the output data is transmitted via the ZigBee wireless network.

The storage application part needs to complete two aspects of work, namely: Parsing the data transmitted by the central control unit and saving it to the database; All kinds of teaching resources required for the experimental course are entered and accessed by visitors. The system uses SQL Server database to store and manage data. Considering the practical application, when designing the database, it is necessary to set a threshold value for each monitoring data, when a certain value exceeds the threshold value, an alarm message must be generated to prompt the administrator. At the same time, it is necessary to set user classification information, and set different operation access rights for different users.

The application part realizes the interaction between users and the system, and presents environmental monitoring data and experimental resources to different users according to different application needs. Application functions include mobile phone applications and PC applications, allowing users to view information in real time through the terminal. The application part mainly realizes functions such as environmental monitoring, equipment management, and experimental teaching. Figure 5 shows the functional block diagram of the application part of the system.

Both the web application and the mobile application include four functional applications of environmental monitoring, equipment management, learning resources, and online classroom. Environmental monitoring mainly displays the monitored laboratory environment information to administrators; Equipment management can facilitate administrators and teachers to view experimental equipment information; Learning resources provide teachers and students with teaching resources such as experimental teaching documents and videos; The online class is for teachers and students to exchange and discuss experiment-related techniques, experiences and questions.

3.2. Analysis of brightness, temperature and humidity.

(1) Design analysis of LED brightness adjustment circuit. PT4115 is a step-down constant current source chip, which is in continuous inductor current conduction mode and can drive one or more LEDs in series. The input voltage is 6∼30V, and the output current can be adjusted up to 1.2A. The pull tab can drive up to tens of watts of LED lights, depending on the input electrode and external devices. The chip has a built-in power switch, and the average LED drive current is selected through an external sampling resistor, in addition, PWM is input through the DIM pin to achieve dimming. When the voltage of the DIM pin is lower than 3V, the power switch is turned off, the PT4115 enters the standby state, and the working current is extremely low. The output current of PT4115 is set by R3 and R4 in the schematic diagram, and the relationship is shown in the following formula:

$$I = \frac{0.1 \times (R_3 + R_4)}{R_3 \times R_4} \tag{3.1}$$

when $R_3 = 1\Omega, R_4 = 0.4\Omega, I = 0.35A$. The single LED used by the author is 0.5W, so two LEDs are connected in parallel to form a group, and then three groups of LEDs are used in series, when using 0.35A current to supply power, the total power is about 3W.

(2) Design and Analysis of Temperature Detection Circuit. The temperature sensor used by the author is an NTC thermistor with a nominal resistance of 10K ohms and has a negative temperature coefficient. The thermistor is mainly composed of metal oxide materials, and the conduction mode is similar to that of semiconductor materials such as germanium and silicon. When the temperature decreases, the number of carriers in the material decreases, and the resistance value increases; On the contrary, the resistance value decreases. At room temperature, the resistance value varies in the range of 100-1000000 ohms, and the temperature coefficient is about $-2\% \sim -6.5\%$. In addition, NTC thermistors are widely used in temperature measurement, temperature control and temperature compensation.

The author connected a 10K ohm NTC thermistor in series with a 10K ohm fixed value resistor and connected it to a 3.3V power supply. Detecting the voltage value on the thermistor can be converted to obtain the resistance value of the thermistor at the current temperature. The specific calculation process is as follows:

If the voltage value across the thermistor is X after analog-to-digital conversion, and the on-chip ADC of the MSP430G2553 has 10-bit resolution, the voltage across the thermistor is as follows:

$$V = \frac{x \times 3.3}{1023} \tag{3.2}$$

If the resistance value of the fixed value resistor connected in series with it is R_0, the current resistance value of the thermistor is

$$R_t = \frac{R_0 \times X}{1023 - X} \tag{3.3}$$

Thermistor resistance meets

$$R_t = R \times e^{B \times (\frac{1}{T_1} - \frac{1}{T_2})} \tag{3.4}$$

In the formula, R_t is the resistance value of the thermistor at the temperature of T_1, R is the nominal resistance value of the thermistor at the normal temperature of T2, and B is the parameter of the thermistor itself. In addition, T_1 and T_2 are both Kelvin temperatures.

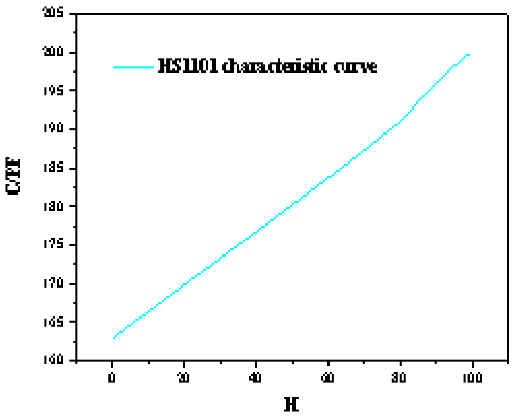

Fig. 3.6: HS1101 characteristic curve

It can be obtained from the above formula that the current temperature and the resistance of the thermistor have the following relationship:

$$T_1 = \frac{1}{ln\frac{R_t}{R}/B + \frac{1}{T_2}} \tag{3.5}$$

Substitute $R_t = \frac{R_0 \times x}{1023-x}$ to generated

$$T_1 \frac{1}{ln\frac{R_0 \times x}{R \times (1023-x)}/B + \frac{1}{T_2}} \tag{3.6}$$

The NTC thermistor used in this paper has a B value of 3435, when $T_2 = 298.15K$ at normal temperature, $R = 10K\Omega, R_0 = 10K\Omega$. The current temperature value can be calculated according to the value obtained after the analog-to-digital conversion of the microcontroller.

(3) Design and Analysis of Humidity Detection Circuit. HS1101 is a kind of humidity sensor based on capacitance principle, which is widely used in various fields, such as home, automobile, office and engineering control system. Compared with other sensing products, it has the following advantages: (1) Unique solid polymer structure; (2) No calibration required; (3) Fast response time; (4) Instant dehumidification; (5) Adapt to automatic assembly; (6) Suitable for linear voltage output, linear frequency output; (7) High reliability and stability.

With the change of relative humidity, the capacitance value of HS1100 changes nearly linearly, as shown in Figure 6. In the monitoring system, the change of the capacitance value is equivalent to the change of the voltage value or the frequency value, in order to carry out effective data collection, the oscillating circuit is composed of 555 integrated circuits, and the HS1100 humidity sensor acts as an oscillating capacitor, thus, the conversion of humidity to frequency is completed.

$R_8 + R_9 = R_a, R_3 + R_4 = R_b$ in the circuit schematic diagram of the temperature and humidity monitoring node, the output frequency f of the humidity detection circuit satisfies the following formula:

$$f = \frac{1}{C \times (2 \times R_S + R_b) \times ln2} \tag{3.7}$$

Combined with the HS1101 characteristic curve, the relationship between the output frequency of the humidity detection circuit and the humidity can be obtained. As shown in Table 3.2.

Therefore, the output frequency of the humidity detection circuit is measured by the single-chip microcomputer, and the result can be substituted into the above formula to obtain the current environmental humidity.

Table 3.2: The relationship between the output frequency of the humidity detection circuit and the humidity

humidity (%)	0	10	20	30	40	50	60	70	80	90	100
frequency (Hz)	7351	7224	7100	6976	6853	6728	6600	6468	6330	6186	6033

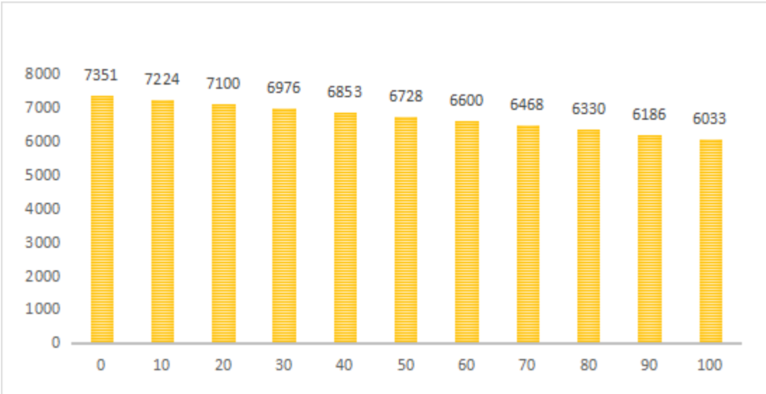

Fig. 4.1: The relationship between the output frequency of the circuit and the humidity

4. Result Analysis. According to the above calculation results, the following relationship can be obtained: When the system uses 0.35A current to supply power, the total system power is about 3W. The NTC thermistor used has a B value of 3435. At normal temperature $T_2 = 298.15K, R = 10K\Omega, R_0 = 10K\Omega$. According to the above calculation results, the following relationship can be obtained: When the system uses 0.35A current to supply power, the total system power is about 3W. The NTC thermistor used has a B value of 3435. At normal temperature Equation 3.7, the output frequency of the humidity detection circuit is measured by the single-chip microcomputer, and the result is substituted into the above formula to obtain the current ambient humidity, thus obtaining the relationship diagram as shown in Figure 4.1.

That is, when the circuit output frequency dimension is 6853Hz, the ambient humidity is 40%, and when the circuit output frequency dimension is 6600Hz, the ambient humidity is 60%.

5. Conclusion. The construction of the Internet of Things laboratory focuses on both theoretical learning and the improvement of practical innovation ability, allowing students to have access to as many technologies and products as possible on the open platform of the laboratory, stimulating students' awareness of independent learning, and completing practice and innovation in their spare time. The author proposes a system for laboratory construction and management research based on the Internet of Things and deep integration. The laboratory management system is designed by applying the related technologies of the Internet of Things, so that the management of the laboratory can integrate environmental monitoring, equipment management and experimental teaching. Administrators, teachers and students can view laboratory conditions and learning resources anytime and anywhere through wireless and wired methods, which greatly facilitates administrators' control of the laboratory, it also increases the initiative and flexibility of students' learning. After testing, the system has fast transmission speed and high accuracy, and can respond to various needs of users in real time, which greatly improves the efficiency of laboratory management, enhance students' practical ability and thinking ability.

The Internet of Things is not a new technology, but the integration of embedded systems, wireless sensor networks and other technologies and innovation. Based on the engineering application of the Internet of Things, the advantages of the school's own industrial application background should also be considered in the construction process of the laboratory, so as to cultivate professionals with certain industrial application background of the Internet of things.

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Edited by: B Nagaraj M.E.
Special issue on: Deep Learning-Based Advanced Research Trends in Scalable Computing
Received: Dec 1, 2023
Accepted: Jan 23, 2024