Design of Multimedia Intelligent Classroom Interactive Teaching System Based on Internet of Things Technology

Wei He[1(✉)], Cheng-hui Zhang[2], and Yang-bo Wu[1]

[1] College of Mathematics and Computer, Xinyu University, Xinyu 338031, China
[2] Xinyu University, Xinyu 338004, China

Abstract. At present, smart teaching system has the problem of poor contact point tracking effect, so we design a multimedia smart classroom interactive teaching system based on Internet of things technology. According to the requirements of software module development, the system hardware optimization is divided into two parts: the core circuit design and the system memory expansion chip design. The optimized system hardware is used as the basis of software development, and classroom resource management module, classroom teaching action collection module and teaching gesture recognition module are designed. The system hardware and software are combined to complete the design process of multimedia intelligent classroom interactive teaching system based on Internet of things technology. According to the results of the system test, the auxiliary teaching effect of this system is better than that of the traditional system. In the future teaching process, this system can be used to complete the teaching process.

Keywords: Internet of things technology · Multimedia smart classroom · Interactive platform · Teaching system

1 Introduction

With the development and popularization of network technology, especially Internet technology, network teaching using the Internet has become an important and development direction of teaching. Network teaching is the product of the application of computer and network communication technology to the teaching field. This teaching mode is completely realized through the network, which can give full play to the advantages of network in teaching. It is a new educational mode to build people's lifelong learning in the era of knowledge economy and a trend of future education development [1, 2]. Since the 1960s, the application of information technology in teaching has roughly experienced three education modes: Cai, computer-aided learning, information technology and curriculum integration. Facing the new century, educational theories and methods have been deeply explored in colleges and universities and social education, and a modern teaching mode in multi-disciplinary fields has been formed. Combined with

W. Fu et al. (Eds.): eLEOT 2021, LNICST 389, pp. 442–452, 2021.
https://doi.org/10.1007/978-3-030-84383-0_38

the application of computer system and projection display system, the network teaching, which is based on the advanced technology of informatization, digitization and networking, has been widely used. Under the influence of the network teaching system, daily teaching from the traditional blackboard, projector and other conventional teaching methods. The development of multimedia teaching methods based on computers and networks has a great influence on the teaching method of knowledge.

Nowadays, the research and application of multimedia intelligent classroom interactive teaching system in China mainly focus on the application level of classroom teaching. Students carry out self-study through multimedia terminals, and get help from teachers through online communication and other methods when they encounter problems in learning [3, 4]. At the same time, a large number of multimedia intelligent classroom interactive teaching systems provide the functions of course selection, grade examination registration, score query, exchange forum, etc., which realize the communication between teachers and students.

On the basis of the actual teaching situation, according to the guidance of Internet of things technology, this research carried out the demand analysis of multimedia intelligent classroom interactive teaching system. According to the conclusion of the demand analysis, the overall design of the system and the design of database and table are planned reasonably. According to the functional characteristics of interactive teaching, the system modules are divided. And innovative design of classroom teaching action acquisition and teaching gesture recognition module, not only improves the interaction between teachers and students in teaching, but also use the image frame difference method to reduce the amount of calculation of the system, improve the quality of interactive teaching. Finally, through the research of the Internet of things technology, combined with its specification and architecture, the paper attempts to use the Internet of things technology to carry out the realization principle and method of data transmission, which has a certain reference value.

2 Hardware Design of Multimedia Intelligent Classroom Interactive Teaching System

2.1 Core Circuit Design

Through the analysis of the original system, the main control module needs to complete the network communication function with the server layer, the serial communication function of wireless sensor network and the display function of multimedia devices. In order to achieve these functional requirements, the processor chooses S3C2440 chip from SamSung company as the main control chip of the system [5]. The chip adopts 32-bit RISC instruction set, which has the advantages of low price, low power consumption and high performance. The chip has an arm core based on 32 KB instruction cache and 32 KB data cache, which reduces the cost of the system and the number of useless components. It is especially suitable for low-power applications. The data processing module is composed of processor, ram and ROM, which is set as the core controller of the system. In order to ensure the normal operation of the controller, the core circuit is set as 4 MB Nor Flash, 164 MB NandFlash on-board ROM, 32 MB SDRAM, 15 MHz

crystal oscillator circuit and other circuits. The block diagram of hardware composition is shown in Fig. 1.

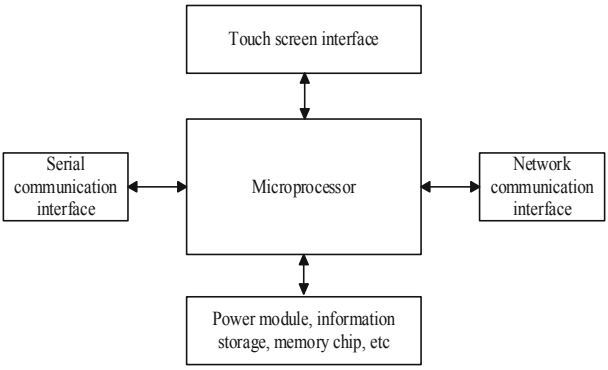

Fig. 1. Framework of gateway main control module

The power supply of system gateway is mainly responsible for the power supply of S3C2440, CC2530, MAX3232, DM9000 and network transformer. S3C2440 needs three kinds of voltage: 1.5 V, 1.8 V and 3.7 V. Among them, 1.5 V is replaced by a similar 1.3 V power supply, while other chips are 3.7 V.

2.2 Design of System Memory Expansion Chip

According to the design results of the central controller, the system expansion module is embedded in the controller to improve the use effect of the central controller. This module and the core module of the system constitute a super compact embedded PC system. These modules have the characteristics of rich functions, complete, standard size, and can face a variety of users. SysExpanModuleTM/CSD is designed according to PC/104 bus standard. Its core functions are CAN controller, serial communication port and digital IO. The main technical performances are summarized as follows.

Four independent can bus controllers which conform to CAN protocol 4.0B. Six independent serial communication ports, each of which can be set to RS232C, RS485, RS422 working mode. CAN communicates with host in memory mapping mode, and serial port communicates with host in I/O mode. The transmitting and receiving rate of CAN bus is programmable, and the rate range is 10 kb/S-500 kb/s, which is divided into 10 levels. The serial communication rate can be set by programming, and the rate range is 5 kb/s-50 kb/s, which is divided into 15 levels. With the functions of WATCHDOG and EEPROM, important field data can be saved automatically. Multiple software selectable interrupt request lines and port read/write base addresses (BA). PC/104 standard size (50 * 55 mm), directly connected with PC/104 TMCPU and expansion board. DC + 5 V operation voltage, low power CMOS circuit design. Working environment temperature range: 0C – 50C, humidity range: 0–90% RH. CSD is configured with four independent CAN controllers. The CAN controller (SJA1000) is accessed through memory mapping

mode, and A2 connector is the two connecting terminals. The function definition of each pin of A2 connector is shown in Table 1.

Table 1. Function interface design of system memory expansion chip

Function serial number	Chip pins	Function
1	1	CANL
2	2	CANH
3	3	Isolated place
4	6	Isolation + 3V
5	7	Isolated place
6	8	Isolation + 3V
7	9	CANL
8	10	CANH
9	4, 5	None

In the long-distance communication, the common mode voltage of the isolated ground node of each CAN node is limited within 3 V to ensure the normal communication. The CAN bus transmits differential signal through twisted pair. The 110 Ω terminal matching resistance between the two twisted pair must be connected by wire. A1/A2 is the setting end of resistance jumper. The nodes at both ends of the bus shall be set with CAN 1/CAN2 terminal matching.

The above hardware part is combined with the original system hardware to complete the system hardware optimization design part. At the same time, this part is used as the system software development environment.

3 Software Design of Multimedia Intelligent Classroom Interactive Teaching System

In this design, the composition of the software module is optimized, and the optimized software module architecture is shown in Fig. 2.

According to the above setting results, the software optimization process of the design system is completed. In order to reflect the software optimization results more concretely, it is divided into three modules for analysis.

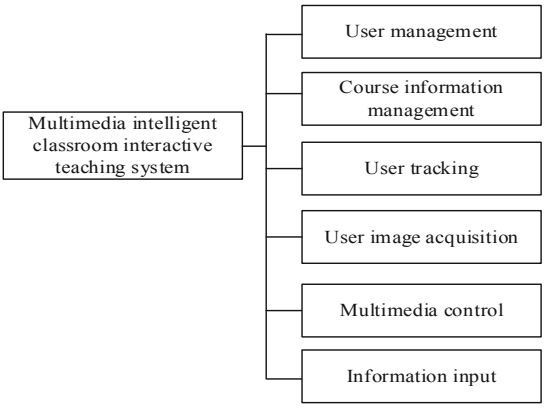

Fig. 2. Software module optimization results

3.1 Design of Classroom Resource Management Module

In this design, the content of curriculum management module is set as curriculum design, curriculum display, curriculum design, and other sub modules. Curriculum design mainly refers to curriculum design, curriculum arrangement, curriculum input and other operations [6]. The course display mainly uses 3D technology, animation effect and artistic way to show the course content more vividly. Curriculum design is mainly for the corresponding curriculum design. Course management module is the basis of teaching. A good and orderly management module can make students study and live well. Therefore, the module is very worthy of attention. The course management module is shown in Fig. 3.

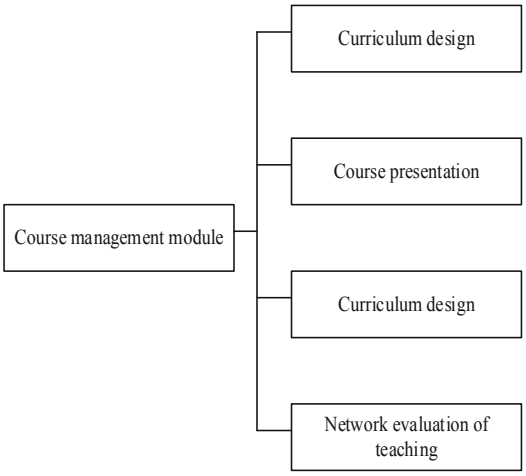

Fig. 3. Schematic diagram of course information management module

In addition to the basic course management, this module also includes three sub modules: course input, course modification and course query. Curriculum input refers to the administrative teacher according to the teaching plan arrangement to the students to input courses, so that students can choose. Curriculum modification is the teacher will not meet the course content to modify, as well as students' own classroom Q & A on the way to chooseing the wrong modification. Course query mainly refers to the statistical analysis of the selected courses by the academic affairs office or administrative teachers.

3.2 Design of Action Collection Module in Classroom Teaching

The first calculation step in the process of classroom teaching action collection is the feature extraction calculation process of digital image, that is to say, the first step of processing a frame of digital image is to extract the graphic feature points in the image. Each pixel value in the image is detected to determine whether the pixel has certain characteristics. If the detected image contains a lot of data information, the feature extraction method is used to extract the needed useful image information. As the original data of the follow-up research, the workload and difficulty of the research are greatly reduced, and the accuracy of the research results is improved.

The system designed in this study mainly uses infrared camera to collect user gesture information. According to the distance of the user's gesture, the brightness of the infrared reflection in the camera is also different. When the user's finger touches the screen, the contact will prevent a large number of infrared rays from penetrating the screen and will produce reflection. Thus, the brightness of the contact in the infrared camera is higher, and it can be distinguished from other objects obviously. According to the difference of contact brightness and background brightness, the system extracts the contact, and then through a series of image processing, so as to recognize the user's operation gestures and instructions on the display screen.

In the operation gesture video of this system, the main research object is the moving contact, and the contact object background separation is to extract these moving objects from the video frame sequence in real time [7, 8]. Background separation is the basis of image processing technology in this paper. Only after the contact target is detected and separated from the background, can the follow-up work such as target contact recognition, contact tracking and gesture analysis be carried out. Firstly, this paper studies the background separation technology, and the contact detection is mainly divided into two steps. The first step is to extract the contact area from the background image of the video frame sequence. Then the contact foreground image is processed to obtain the contact target. Then, the collected image is processed by background separation.

Background separation is the basis of contact tracking process, and the effect of separation determines the effect of contact tracking. Therefore, it is necessary to study the method of contact target background separation. In order to make the edge of the image more prominent, the image needs to show obvious black-and-white contrast effect. But at the same time, the characteristic region of the image should be preserved. The system performs binary processing on the sharpened image. The result of image binarization will further reduce the calculation of the system and the gray level of the image. At the same time, the edge information of the image is clearer, which provides technical support for the subsequent edge extraction and ensures the accuracy of the whole system.

3.3 Design of Teaching Gesture Recognition Module

The images collected by the system are continuous video images. When the user carries out a series of operations on the screen, the system needs to detect the target contact and recognize the target gesture for each frame image. According to the needs of the system, this paper needs to carry out contact detection for each frame image in the video, involving a large number of frame difference detection technology [9, 10].

According to the extracted contact a edge, there are a total of pixels, which are respectively recorded as $S_1(x_1, y_1)$,$S_2(x_2, y_2)$,$S_i(x_i, y_i)$,...,$S_n(x_n, y_n)$ and the geometric center of the pixel a is calculated. According to the coordinate average of geometric principle, the area center of the contact in the image is calculated. The calculation formula is shown in formula (1) and formula (2), and the coordinate $J(x, y)$ of the central point of the contact area is obtained.

$$x = \frac{x_1 + x_2 + x_3 + \ldots + x_n}{n} \tag{1}$$

$$y = \frac{y_1 + y_2 + y_3 + \ldots + y_n}{n} \tag{2}$$

According to formula (1)– (2), the coordinates of the central point of the contact area $J(x, y)$. At the same time, in order to facilitate the identification and ensure the accuracy of the system, take $J(x, y)$ as the center of the circle and 3 mm as the radius to mark the circular area, so as to facilitate the follow-up frame difference contact real-time tracking.

The contact area center of each frame image in the video has been identified. Combined with the image frame difference method, the real-time tracking of contact trajectory is carried out [11–13]. The basic principle of image frame difference method is to arrange the video frames in time order and extract three consecutive frames for corresponding processing. The three frames are represented as $B_{k-1}(x_{k-1}, y_{k-1})$, $B_{k-1}(x_{k-1}, y_{k-1})$ and $B_{k+1}(x_{k+1}, y_{k+1})$, and the difference between B_{k-1}, B_k and B_{k+1} is calculated, as shown in formula (3) – (4).

$$B_u(x, y) = B_k(x_k, y_k) - B_{k-1}(x_{k-1}, y_{k-1}) \tag{3}$$

$$B_v(x, y) = B_{k+1}(x_{k+1}, y_{k+1}) - B_k(x_k, y_k) \tag{4}$$

In formula (3)– (4), $B_v(x, y)$ and $B_u(x, y)$ are the difference between B_{k-1}, B_k and B_{k+1} respectively. The intersection of $B_v(x, y)$ and $B_u(x, y)$ is processed. Formula (5) is as follows, and the trajectory $R(x, y)$ of the target object can be obtained.

$$R(x, y) = B_u(x, y) \cap B_v(x, y) \tag{5}$$

According to the characteristics of the target object processed by the system, the above calculation method is improved to make it more suitable for the processing requirements of the system [14, 15]. Since the system has calculated the area center of the contact in each frame of the video so far, in order to improve the response speed of the system, we need to reduce the amount of calculation as much as possible. Only the center point $R(x, y)$ of the contact area is tracked. According to the position change of the center of

the contact area, the movement track and gesture command of the contact can be judged to realize the interactive process in the teaching process.

By combining the above system hardware and software, the design of multimedia intelligent classroom interactive teaching system based on Internet of things technology is completed.

4 System Test Analysis

4.1 System Test Environment Design

In order to verify the performance difference between the designed system and the original system, the corresponding system test link is set to analyze its use effect. The specific system test platform parameters are as follows.

PAD client: using modern Play X900 Android Pad, operating system is Android 4.1, processor is Ruixin micro 3066 (dual core CortexA9, main frequency is 1.6 GHz), 1 GB DDR3 RAM, 16 GB Flash, screen resolution is 2048 * 1536, supporting front and rear 200 J7 pixel cameras.

Teacher's PC workstation: DELL 990M is used as the carrier of the workstation, the operating system is Windows 2010, the processor is I5–2400, and the memory is 4G DDR3.

Network environment: the wireless network supports IEEE 802.11n.11n, and the maximum network speed is 300 Mbps; the LAN is 802.3 Ethernet, and the network speed is 100 Mbps.

According to the parameters, the performance comparison between the designed system and the original system is completed.

4.2 System Test Plan

Through literature research, it can be seen that system testing is a necessary and very important testing process to comprehensively test the primary products of the system to the realization of system design ideas and script design requirements. After the development of the design system is completed, before it is put into use, it is necessary to conduct a reasonable and comprehensive test and evaluation. In the process of testing, the problems found should be modified in time to reproduce the design requirements of the script as much as possible, so as to achieve the goal of system design.

In this system test, we will mainly test the touch screen tracking of teachers in the design system and the traditional system. Therefore, the indicators are set to the touch screen tracking accuracy and the number of touch screen tracking points. In the preset test cycle, the above contents are taken as the basic performance analysis contents of the design system and the traditional system.

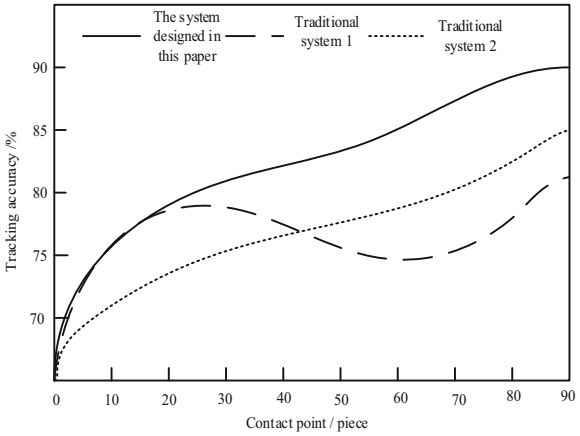

Fig. 4. Touch screen tracking accuracy test results

4.3 Analysis of System Test Results

The test results of touch screen tracking accuracy are shown in Fig. 4.

From the above test results, it can be seen that the touch screen tracking effect of the system designed in this paper is good, and the tracking accuracy is stable and the fluctuation is small in the process of multiple tests. Compared with the system designed in this paper, the tracking effect of the system in use is obviously poor. When the teacher's gesture moves too fast, the tracking effect decreases obviously, which shows that the performance stability of the system is poor. At the same time, through the analysis of the tracking reaction degree of the system, we can see that the tracking reaction effect of the system designed in this paper is better, because this method innovatively designs the classroom action collection module and teaching gesture recognition, which improves the accuracy of touch screen tracking (Fig. 5).

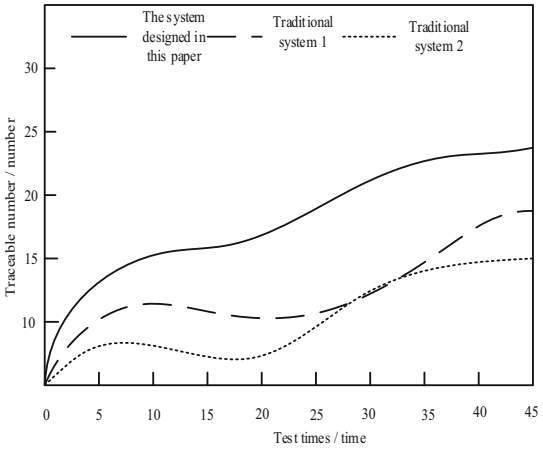

Fig. 5. Test results of the number of touch screen tracking points

From the above test results, we can see that the designed system can track a large number of contact points, realize the interaction between teachers and students in the process of classroom teaching, and increase the communication between teachers and students. In the process of traditional system testing, the test results are poor and the number of traceable contact points is small. In the process of daily use, it is limited for teachers' teaching activities, and can not achieve daily interaction between teachers and students. Because the method of this paper simplifies the calculation of action recognition by using the image frame difference method, the effect of the design system is better than that of the traditional system.

5 Conclusion

This system is supported by campus network. Firstly, the existing classroom interactive teaching system is deeply analyzed. Then from the basic theory of software development, software architecture research, development platform related technical characteristics, the design and development of classroom interactive teaching system are fully analyzed and discussed. According to the theory of software engineering, the project management is developed and tested. Through the system test, we can see that the design system in this paper is scientific and can be applied to daily teaching. Education has always been a great cause in human history. With the progress of science and the development of educational learning theory, the design system can make full use of modern information technology to integrate excellent educational resources. Due to the limitation of research time and experimental conditions, only the touch screen tracking accuracy and the number of tracking points were tested. Therefore, the next step will be to take more indicators for research.

References

1. Huang, Z., Zhou, R., Wan, L.: Design and empirical research on interactive classroom ecosystem in blended learning environment. E-educ. Res. **41**(04), 78–85 (2020)
2. Wu, Y.: Design of data analysis and processing system for teaching quality evaluation of interactive electronic whiteboard classroom. Mod. Electron. Tech. **43**(10), 89–91+96 (2020)
3. Zhao, M., Fan, Z., Wang, R.: Design of synchronous teaching system for hydraulic component theory and experiment based on interconnection. Mach. Tool Hydraulics **48**(02), 106–109+113 (2020)
4. Yao, L., Zhang, L.: Design and implementation of Chinese architecture history teaching system based on mixed reality technology. J. Comput. Appl. **39**(09), 2689–2694 (2019)
5. Liu, S., Li, Z., Zhang, Y., et al.: Introduction of key problems in long-distance learning and training. Mobile Netw. Appl. **24**(1), 1–4 (2019)
6. Fu, W., Liu, S., Srivastava, G.: Optimization of big data scheduling in social networks. Entropy **21**(9), 902 (2019)
7. Liu, S., Glowatz, M., Zappatore, M., et al. (eds.): E-Learning, E-Education, and Online Training, pp. 1–374. Springer International Publishing, (2018)
8. Lv, B., Wang, D.: Multi path intelligent recognition algorithm of face identity in the environment of Internet of Things. Comput. Simul. **37**(07), 436–439+484 (2020)
9. Zhao, M., Chen, H., Zhang, G., et al.: Design and application of optical laboratory system based on Internet of Things. J. Daqing Normal Univ. **39**(06), 32–36 (2019)

10. Cao, S., Li, C., Li, X., et al.: Design of experimental curriculum evaluation system for educational technology specialty based on SSM framework. J. Hubei Normal Univ. (Nat. Sci.) **39**(01), 30–34 (2019)
11. Xu, Q., Xiong, X., Feng, G.L, et al.: Design of intelligent campus multimedia interactive system based on Internet of Things technology. In: 2019 International Conference on Virtual Reality and Intelligent Systems (ICVRIS), pp. 223–226. IEEE (2019)
12. Cai, J.Y., Zhang, P.P., Tan, X.: A novel physical education environment platform using Internet of Things and multimedia technology. Int. J. Electr. Eng. Educ. 0020720919879390 (2019)
13. Dong, H.J., Abdulla, R., Selvaperumal, S.K., et al.: Interactive on smart classroom system using beacon technology. Int. J. Electr. Comput. Eng. **9**(5), 2088–8708 (2019)
14. Liang, W.: Scene art design based on human-computer interaction and multimedia information system: an interactive perspective. Multimedia Tools Appl. **78**(4), 4767–4785 (2019)
15. Bai, H., Zhang, Q.: English smart classroom teaching system based on 5 network and Internet of Things. Microprocess. Microsyst. 103421 (2020)