A Multifunctional Terminal Hardware Design for Teaching Assistant

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A Multifunctional Terminal Hardware Design for Teaching Assistant

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Abstract: An intelligent handheld terminal for campus was designed to meet the teaching management requirements under the new education situation. This system is composed of fingerprint identification module, wireless communication module, LCD touch screen module and embedded system. So, it can achieve multiple functions. Specifically, we design the hardware schematic diagram and PCB, then devise driver and transplant FreeRTOS operating system according to the working characteristic of each module. The communication protocol between the handheld terminal and the host computer is designed to complete the process of collecting fingerprint attendance and classroom test data and then transmitting those data wirelessly to the host computer. This system will be helpful to improve the campus service and teaching quality.

1.Introduction

Improving attendance in the university class is the basis of improving teaching quality. But for those courses with a large number of students, such as a class with about 100 people, it will take 7-10 minutes to record attendance. So the traditional methods to check on attendance will take up too much course time，especially in public elective course. Test in the classroom is an effective way to show learning situation of students. However, it takes up a lot of time for teachers to review and score. So, the teachers won't choose to test every class.

With the rapid development of network technology, information and digital applications in various fields are becoming more and more common. At present, the field involved in the digitization and information technology in higher education is mainly educational management [1]. For the teaching mode, especially for teaching and counseling, including attendance, class quizzes and review, there is a huge requirement.

In this paper, we study a teaching assistant system that includes multiple functions such as student attendance, teaching, quizzes and scoring. This device can be placed in the classroom for teachers and students to avoid negative impact on learning due to use of traditional mobile apps.

2.System design

The structure of the teaching assistant system is shown in Fig.1. The system includes a handheld terminal based on WiFi, a background computer, and a central database of the management department. The handheld terminal and the teacher background computer adopt a B-S network structure.

This paper designs a special handheld terminal based on WiFi with fingerprint checking function, which can be configured on the desk of teachers and students. Students can implement fingerprint attendance check and examination answer through the handheld terminal. Through the network transmission, the fingerprint information collected by the terminal matches the information of the student fingerprint database entered beforehand in the background database. Teachers can organize students to participate in the test through the background computer. Students answer questions by handheld terminals, and complete fingerprint attendance at the same time, so as to avoid wasting teaching time by repeating attendance.

Background computer is used in class teaching management. Teachers can employ this computer to teach, publish test questions, coring and manage information of students. In particular, we have developed a handwritten board to replace the traditional chalk writing. It not only avoids chalk dust, but also forms a teaching plan for blackboard writing. The computer can transmit relevant information to the data center through the network. The server of data center can realize school educational administration management. This paper mainly gives the design and implementation of the student handheld terminal in the teaching assistant system.

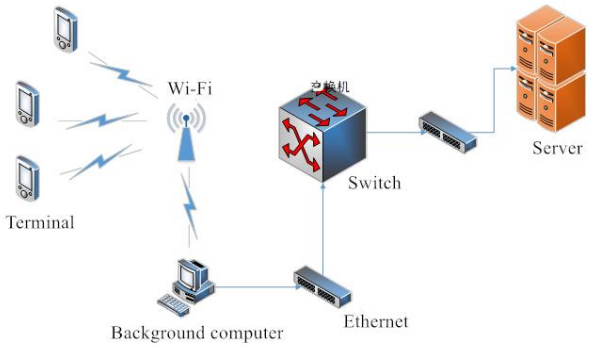

Figure. 1 Block diagram of system design.

3. Wireless handheld terminal system

3.1 Design of handheld terminal

In this paper, we employ ARM STM32F405 as the core processor, combined with fingerprint identification module, wireless communication module and LCD touch screen, to design a handheld terminal for students. Among them, fingerprint identification module is used to manage the attendance of students in class; touch screen module is used to answer questions and display the operations; wireless transmission module is used to transmit information with the background computer. Teachers can put questions randomly during the class through the background computer, and they can also conduct tests. The student answers through the handheld terminal. And the attendance information and answer information are automatically transmitted to the background computer. In addition, the system can also automatically review the test papers and statistical student scores, then analyse the learning effects of students through algorithms. According to the management rules set before, the system automatically counts the usual scores of students at the end of the semester and summarizes the teaching effects.

The wireless handheld terminal is a set of embedded wireless system with fingerprint identification. The design diagram is shown in Figure 2. The system has the functions of fingerprint image acquisition, processing and matching, data collection of touch screen, and wireless transmission.

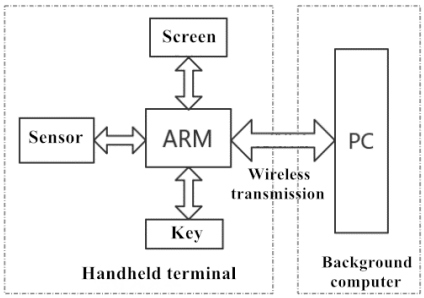

Figure. 2 Design block diagram of wireless handheld terminal.

3.2 Hardware design

The hardware part includes the processor, battery and external equipment, etc. It is the basis of the whole terminal system and directly affects the system performance of the handheld terminal. The hardware system includes ARM Cortex-M processor, fingerprint identification module, wireless signal transmission module, LCD touch screen, WiFi wireless transmission module, etc. Each module performs different functions respectively. The hardware platform of wireless handheld terminal is based on ARM Cortex-M processor. The peripheral of the chip expands power supply, clock, reset circuit, reserved debugging serial ports circuit, fingerprint identification module, LCD touch screen, wireless communication module and so on. FreeRTOS is used as the operating system of the terminal development platform.

1. STM32F405 microcontroller was selected as the core processor. STM32F405 embedded microprocessor is the processor of CortexTM-M4 core [2,3]. It is a 32bit-based ARM processor and available in 64~144-pin package with a size as 4 * 4.2 mm. The processor can operate at frequencies below 168MHz, and it is always designed for embedded applications requiring low power, high performance, and low cost. At the same frequency, the program can provide 210 DMIPS/ 566 CoreMark performance when executed from Flash memory, and it can also implement Flash zero wait state.

2. Compared with the current fingerprint acquisition technology, the optical technology acquisition can keep stable and reliable state in long application time, and suitable for the influence of temperature variation, and it can achieve a higher resolution of 500 DPI at a low cost. Therefore, the system selects UART Fingerprint Reader as the system fingerprint identification module. The module is based on STM32F205ARM processor, which embeds advanced fingerprint algorithm and configures high-precision commercial optical sensor. It has functions such as fingerprint collection, fingerprint image optimization processing, feature value extraction, fingerprint storage, comparison and search. It provides both serial ports and communication protocol for easy development and integration. The device provides 6 pins, and the function and name of each pin are shown in Table 1.

Table.1 UART Fingerprint Reader pin.

Pin Name	Pin Description
VCC	Power Input
GND	Ground
TXD（Fingerprint serial ports transmission）	Connect MCU serial ports 2 receive pin
RXD（Fingerprint serial ports receiving）	Connect MCU serial ports 2 send pin
BL（Backlight）	Connect the MCU control pin
RES（Reset）	Connect the MCU control pin

3、Embedded system of fingerprint identification needs wireless communication transmission between handheld terminal and background computer. WiFi technology can meet the above

requirements. We choose USR-WIFI232-T module as wireless transmission module, which is a highly integrated Embedded WiFi module with Low-Power supporting 802.11 b/g/n WiFi protocol [4]. And the device can access wireless network and provide corresponding serial ports to achieve data transmission. USR-WIFI232-T adopts the minimum power embedded structure, which is small in size so that we can choose the built-in and external antennas freely. The module interface pins are defined as shown in Table 2.

Table.2 USR-WIFI232-T pin.

Pin	Description	Network Name	Signal Type	Remarks
1	Ground	GND	Power	
2	+3.3V power	DVDD	Power	3.3V@250mA
3	Restore factory configuration	nReload	I	Low effective import pin
4	Reset	nReset	I	Low effective import pin
5	Serial ports receiving	UART_RX	I	
6	serial ports transmission	UART_TX	O	
7	Power switch	PWR_SW	I,PU	
8	PWM/WPS	PWM_3	I/O	Default WPS
9	PWM/nReady	PWM_2	I/O	Default nReady
10	PWM/nLink	PWM_1	I/O	Default nLink

4. The color touch screen in the system includes a touch screen controller and touch detection. Touch detection can effectively detect the position and area operated by the finger of users and transmit this position to a touch controller which can convert this position into point coordinates. This controller transmits the point coordinates to the processor, which also accepts instructions from the processor and executes them. The users can touch the menu location or icon to complete this operation. The touch screen is 2.8-inch TFT color LCD screen which uses SPI communication [5]. The LCD driver chip model is ILI9341; the touch chip model is XPT2046; the module resolution is 240*320;

The hardware platform of the terminal is based on the STM32 processor. In addition to extending those peripheral interface circuit above, it also includes a reserved debug serial ports circuit and a button portion. This mode can be easily debugged when the touch screen is abnormal. The circuit schematic is shown in Fig.3.

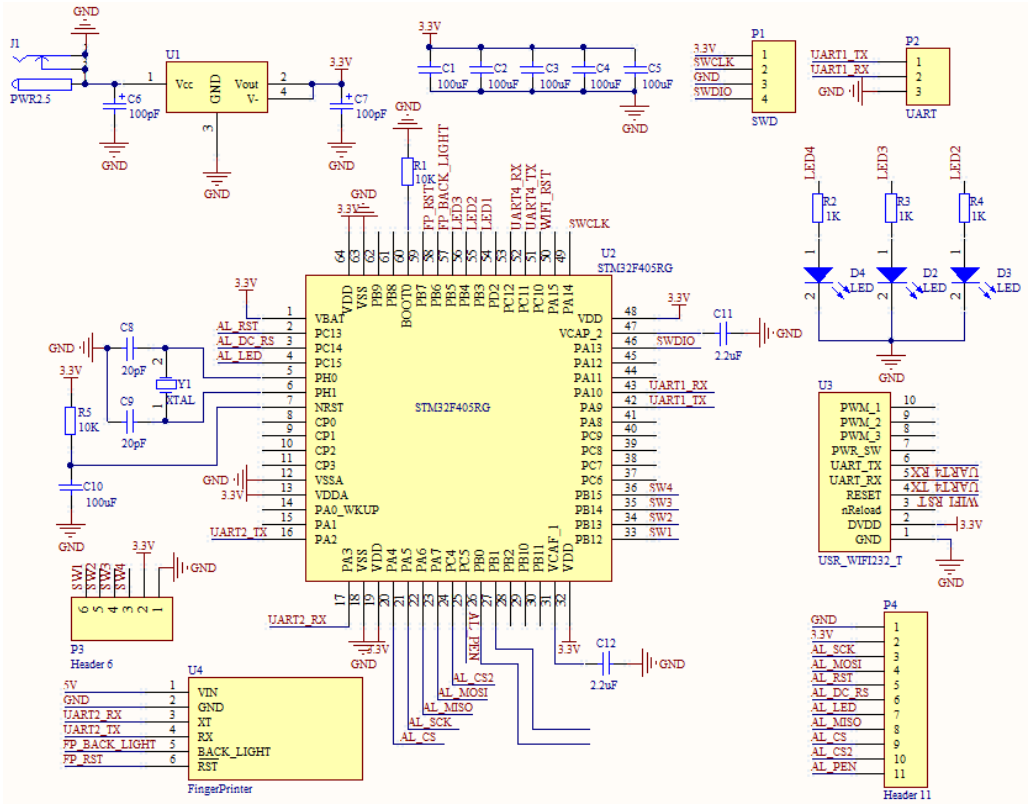

Figure. 3 circuit schematic.

An embedded system should be designed to minimize the size of the board, as well as electromagnetic compatibility and anti-interference. Handheld terminals are designed under the Altium designer 2016.

3.3 Software part

The FreeRTOS operating system is used as the operating system of the handheld terminal, which can meet the requirements of smaller systems and can implement multiple functions [6,7]. The kernel of the FreeRTOS operating system has an efficient priority scheduling algorithm that enables relatively important tasks to be executed before the next most important tasks [8]. The CPU will also give priority to running high-priority tasks when it is working. Kernel of FreeRTOS operating system also has a better rotation scheduling algorithm [9]. The FreeRTOS kernel can be set to a deprivable or non-disintegrable kernel, and the working mode can be selected according to the usage requirements. FreeRTOS is a free operating system that can reduce costs in the development of smaller systems. The terminal constructed by FreeRTOS operating system and STM32F405 single-chip computer has the characteristics of high reliability and good stability, which achieves better control effect.

The software design of the wireless handheld terminal mainly includes seven parts, as shown in Figure 4. These seven parts are independent of each other, but there is a certain connection in the data sharing of attendance records and answering information. Specifically, we use C language (MDK ARM) to program in the Keil Microcontroller Development Kit.

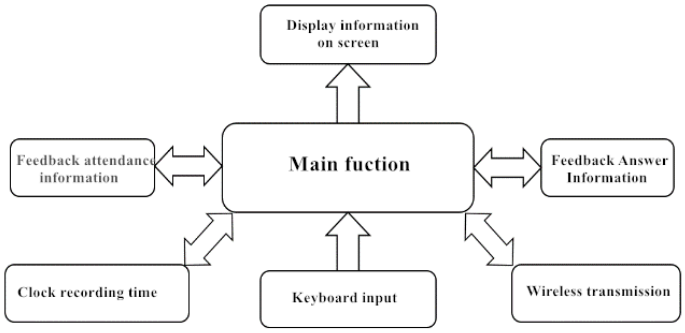

Figure. 4 control software function diagram.

The handheld terminal connects to the background computer using the TCP/IP (Transmission Control Protocol/Internet Protocol) protocol [10], which is the most basic protocol of the Internet.

4. Results and Analysis

For testing purposes, we employed VisioStudio2010 to produce a simple background computer simulation program. Specifically, we have established a class management database of 30 students, including fingerprint information for each person, and we set up a test bank for automatic test questions. After the background computer issued the attendance request, the students started fingerprint check through the handheld terminal. The information was transmitted to the background computer to match the fingerprint information stored in the database, and the attendance information had been recorded. After receiving the "query test" command of the background computer, the terminal entered the "schedule test" mode. The computer automatically issued the test questions and displayed them on the terminal screen. After the students answering, those answers were uploaded to the background computer. The computer automatically reviewed the scores and analysed the statistics. In this process, the terminal operated simultaneously with the background computer. Currently, during the period of continuous operation for eight hours, the timing operation haven't occurred error.

5. Conclusion

In this paper we employed ARM processor, WiFi wireless communication module, touch screen module to develop a handheld terminal for recording attendance and testing in the class. Specially, the device connects with a background computer through WiFi, so it can access the system server and database. During a specific time, the user can activate the attendance function to ensure the accuracy of student attendance. The system can also realize recording attendance data automatically, and then combine the online answering function to achieve classroom learning detection, which will help to improve classroom efficiency.

Acknowledgments

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