Embedded Wireless Fingerprint Exam Affair Management

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Abstract

This thesis studies the design method of fingerprint identification module based on embedded system, which can realize the design of wireless fingerprint examination management system.This method reduces the hardware cost by building hardware environment whose platform is ARM9 microprocessor and MBF200 fingerprint sensor-integrated module. And, under the enviroment of Linux, adopting framework for embedded fingerprint identification system and introducing relevant technology about fingerprint identification, the design of distributed fingerprint identification system could be realized, which is low-cost and reliable. Meanwhile, by combining wireless network communication with Ethernet communication, it can maintain real time data exchanege with central data bank. This system adopts SQL Server database to manage usres' baisc information and information data of their fingerprints' characteristics and runs reliably. Comprehensive tests and practical application proved that fingerprint images collected by this system are more clear and less fuzzy. After being processed, the outlines of images are clear and have outstanding features, so that it is easy to classify and identify fingerprints. This system could be applied in the management of large-scale examinations and remote network examination. It also improves traditional checking way which identifies person by his holdings, and is the future direction of examination management.

Keywords: *exam affair management; fingerprint identification system; embedded system; wireless communication; Hardware Design.*

1. Forward

With the high development of computer and Internet, there is a higher demand of the veracity, safety and practicability of the human identification. Intelligence authentication technology based on biometrics. In many biometric identification technology, fingerprint is one of the earliest and most widely used[1]. As fingerprint has the characteristics of universality, uniqueness, and fixity, fingerprint identification technology has gradually replaced traditional identification methods based on marks and numbers, and now is widely applied in many business, such as Internet, banks, finance, medical treatment and security check. So we are considering to apply fingerprints identification into current exam system.Currently, in examinations we primarily use admission ticket, student's identity card or ID card to inspect examinees' identity. However, misconducts, such as forging admission tickets or ID cards to hire someone to take exams for her or him, happen all the time. In order to eliminate such cheating activities, we need to approve the real identity of examinees, which is an urgent problem that needs to be solved in exam management[2]. Because human bodies cannot be copied, people resort to biological identification technology, and hope we could use this technology to deal with challenges current exam system are facing. And fingerprints are the most obvious external characteristic and they are universal, unique and easy to get.

2. Principle of Fingerprint Identification System

Major headings are to be column centered in a bold font without underline. They need be numbered. "2. Headings and Footnotes" at the top of this paragraph is a major heading. The center of this system is fingerprint identification system. Fingerprint identification technology is a kind of biometrics that reads fingerprint images from image acquisition equipment, extracts feature data from fingerprint images obtained by identification software, and then identifies all people's identity according to the results got from matching algorithms[3]. Fingerprint identification system mostly concerns three steps: preprocess, minutiae extraction, and feature match.

The principle of fingerprint identification system is as Chart 1:

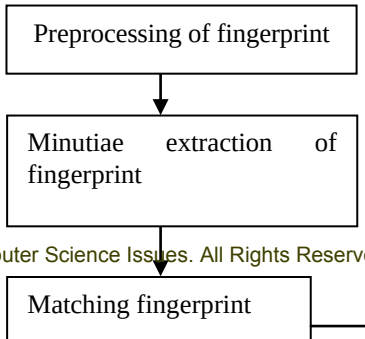


Fig. 1 Fingerprint identification system

Actually the process of fingerprint identification is rather complicated. The whole process includes acquisition of fingerprint image, preprocessing of fingerprint image, calculating fingerprint direction and filtering, binary image, thinning fingerprint threads, picking-up characteristic, and fingerprint match[4]. Considering requirements in practical application, this process would also include processing and transporting data and controlling external equipments so that a series of jobs can be done, such as human-computer dialogue, reading data in fingerprint database, and outputting matching results.

2.1 Preprocessing of fingerprint image

We need to enhance the images of fingerprint that we read from fingerprint read equipment. The key problem we need to deal with is preprocessing fingerprint image whose purpose is to gain images that fit characteristic from inputted gray image. This is the first step of fingerprint identification processing. Generally, those images gained from sensor would contain noises and distortions in fingerprint images because of various reasons[5]. So it is an important content in fingerprint identification that we should eliminate those noises and distortions by preprocessing and turn them into some standard forms, which would make the characteristic acquisition and identification more easier.

The main steps of preprocessing images including: gray-value normalization, image segmentation, filter, image enhancement, binaryzation, thinning etc. The purpose of preprocessing is to improve the quality of input fingerprint image so as to increase accuracy of minutiae extraction[6]. Original fingerprint images usually would have problems, such as noise pollution, disconnection or ambiguity of ridge line, so we need to enhance images (by using filter technology) to improve quality. Because the characteristics of fingerprint only consists in the form of ridge line, and ridge lines have different darkness and width, we could turn them into thin ridge lines that have the same gray-value and are one pixel width by using normalization, binaryzation, and thinning, thus we can perform minutiae extraction.

2.2 Minutiae extraction of fingerprint image

The most frequently used way of minutiae extraction is feature extraction, because it is the most widely applied matching method which is based on position, type and direction of feature characteristics. Minutiae extraction which we use in reality is also based on feature characteristics. Fingerprint minutiae include endpoint, bifurcation, center-point, triangulation point etc. The endpoint and bifurcation are the most common features in fingerprint and they are relatively stable, so in this essay we also adopt the two features[7]. Fingerprint is composed by the crisscross of ridges and valleys. After fingerprint images' binaryzation, we can see this structure clearly. After analysis, we can find out that endpoints of fingerprint ridges are corresponding with same bifurcations of fingerprint valleys and bifurcations of fingerprint ridges are corresponding with same endpoints of fingerprint valleys[8]. Thus we only need to extract endpoints of two thinning images to extract all endpoints and bifurcations of fingerprint.

2.3 Minutiae extraction of fingerprint image

Feature matching of fingerprint is the last step of fingerprint identification system, and is also the most important foundation to evaluate the function of the whole system. Compare newly input minutiae eigenvalue with minutiae eigenvalue in fingerprint database, find the most similar fingerprint as the result and output it[9]. This is the process of fingerprint validating identification and it is also the ultimate propose of fingerprint identification system. Because of the influence of various factors, it is very likely that minutiae module might be different when the same fingerprint are put in. So, as long as the minutiae module of input fingerprint is similar with the one in database, we think they are a match[10]. Then comes to the problem of measures. Usually, we describe the matching result as match measure. When match measure is greater than a certain threshold, we think the two fingerprints match; otherwise, when match measure is lesser than this threshold, we think they don't match. The number of threshold is usually set based on some factors, such as experience, by man.

3. Hardware Design Of Exam Affair Mangement

This system could read human fingerprints' image from fingerprint reader equipment, initially process original

images to make them clearer, and build fingerprints' characteristic data by fingerprint identification software. Then the software could find data point that we called nodes from fingerprints. These data are usually called templates[11]. With computers' vague comparison, we could compare the templates of two fingerprints, calculate their similarities, and finally get a match result of two fingerprints.

The design of hardware is centered with microprocessor UP-NETARM 2410-S that includes ARM core. The server hardware of fingerprint identification are made up with Ex-patulous memory Flash, SDRAM, and external expansion fingerprint sensor MBF200. And we could use wireless Internet technique and Ethernet to build system hardware.
The design of system hardware is as follows in Chart 2.

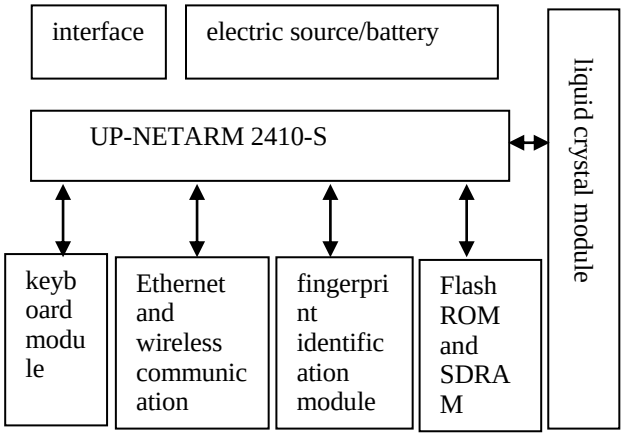


Fig. 2 System Hardware Structure

3.1 Fingerprint Identification Module

Ordinary fingerprint identification module is usually composed of fingerprint acquisition module, system center module, data storage module and output display module. The hardware circuit of this module is centered with ARM9 microprocessor, while peripheral circuit primarily includes fingerprint identification module, data storage module Flash, hardware calendar& clock equipment DS1320, power supply/circuit, reset circuit and clock circuit.
The structure of the system hardware is as Chart 3:

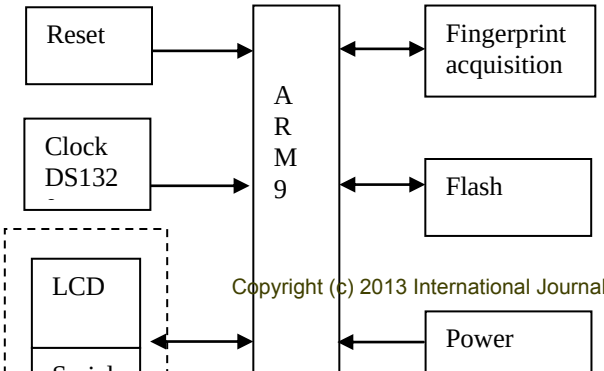


Fig. 3 Hardware Design Of Fingerprint Identification Module

ARM9E is a kind of integrated processor including micro-controller, DSP, Java function. It intensifies the ability of digital processing processing, and applies to conditions that should combine DSP and micro-controller[12]. Meanwhile, it extends Thumb signal and DSP into ARM instruction, and possesses EmbededICE-RT logic which fits the need of time system in a better way. ARM9 is a high-performance and low-power consumption microprocessor that is widely used in embedded system.
We take MBF200 fingerprint sensor chip, produced by Fujitsu Ltd, as the acquisition module to perform acquisition of fingerprint images. This fingerprint sensor adopts standard CMOS technology, contains eight A/D converter, works with wide range voltage input between 3.3V to 5V, can automatically check whether fingerprint has reached sensor, and realizes online acquisition.
Data storage module includes a SRAM of 512KB and a FLASH of 4MB. SRAM is used to store acquired data of fingerprint images and temporary data when program is running; the FLASH of 4MB is used to store system applications and minutiae database. The identification results would be output through LCD.

3.2 Analysis on Other Related Technology

3.2.1 Analysis on Ethernet and Wireless Communication

There is a key USB at the port of ARM development board, which could insert WLAN cards that follow 802.1l WLAN protocol. When relevant equipment Drives are loaded in Linux, the data transportation of wireless fidelity could be completed. After the WLAN card that connects to ARM development board registered to AP access point, the WLAN cards between AP and ARM port could form wireless fidelity. In order to obtain more resources, we can get access from wireless to wire LAN and Internet.

3.2.2 LCD Display Module

The LCD display screen in UP-NETARM 2410-S development platform could be compatible with many

kinds of LCD[13]. We could use a five-inch 256 color screen or an eight-inch 16bit true color screen, and at the same time provide a 24bit port.

3.2.3 Keyboard Module

The keypad in UP-NETARM 2410-S development platform uses ATMEGA8 single chip to control two PS2 ports and keypad on board, and the two PS2 could connect to PC keyboard and mouse.

3.2.4 FLASH ROM and SDRAM

FLASH ROM : the chip of FLASH ROM is CMOS FLASH of 16Mb, which is used to store applications, such as the kernel of Linux operating system, fingerprint acquisition & identification, and communication, and file system that is used to support all kinds of service[14].

SDRAM : the existence of embedded operating system needs some dynamic RAM. Operating system, after being decompressed, would bootstrap from FLASH ROM to SDRAM[15], resident memory; simulate memory to hard disk space, so that we could save files on it like the way we did on hard disk; meanwhile, users' stack and service data are also put in SDROM.

4. Design of System Software

Normally, when the system is electrified, we should perform an initialization operation to the whole acquisition system, including the initialization operation of microprocessor and the peripheral on target board, so that we could perform configuration parameter[16]. After initialization operation, we could start to test if there is any finger on sensor. If there is, we begin to acquire fingerprint images. When build fingerprint database, acquired data would be stored in image SDRAM. System pulls out data from SDRAM. If the quality of acquired images is bad, new fingerprint data would be acquired. Because processing fingerprint data concerns much algorism and high computation, ARM9E system adds some enhanced processors to perform attached instructions of typical DSP algorism conducting ability. After a fingerprint image is required, inform DSP to perform data processing[17]. In this phase, data in image RAM would first be partitioned, and imaged would go through some operations, such as preprocessing, and minutiae extraction. Fingerprint data information which has been processed would be stored in fingerprint database constructed by FLASH team, and finally results would be output through USB[18]. When comparison is needed, fingerprint could be taken out from database, and the software can compare the extracted result and acquired fingerprint data to determine whether they are match and draw a conclusion.

Software of this system are consisted of two parts mainly: PC server software and clients software. The flow chart is under below:

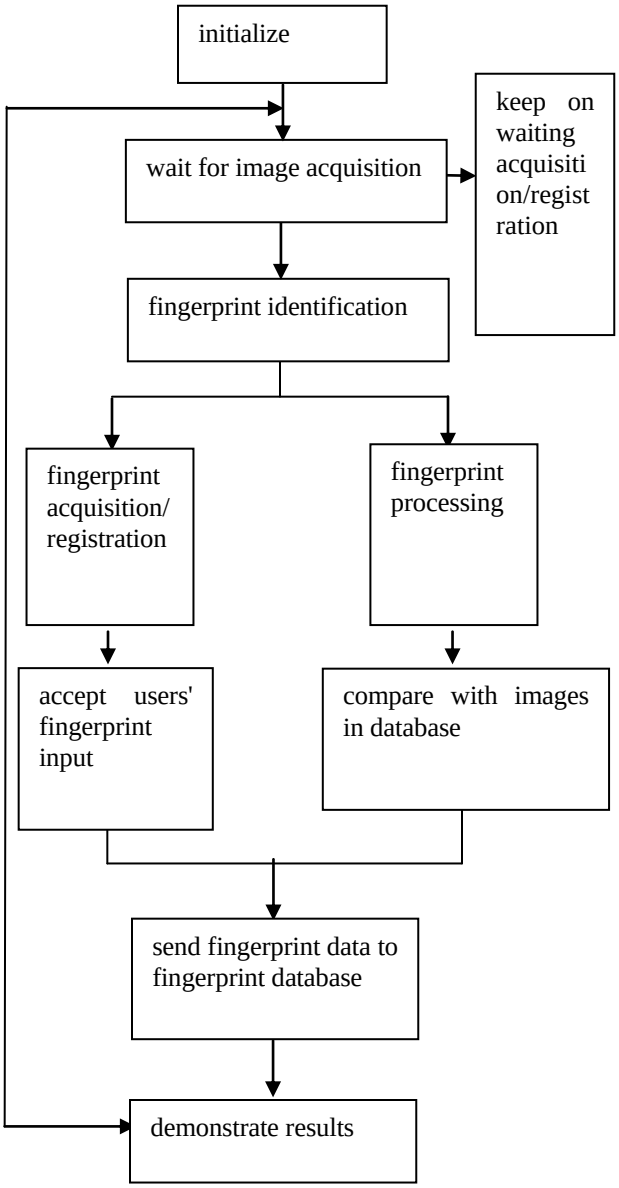


Fig. 4 Flow Chart of Software Module

Server runs on PC host, chooses Windows XP operating system, and adopts ACCESS database at server. When client sends fingerprint data, asking to register, fingerprint data from client would be saved in database. When client asks to identify fingerprint, compare fingerprints that need to be compared with fingerprints in database, and then send the result back to client.

Client runs on development board, adopts Linux operating system which has been clipped. And it keeps running since the system starts. First, client would connect to PC host through wireless or wire network. After this connection, wait for users to choose operation[19]. If users want register fingerprint, then ask them to input fingerprint. If users want to identify fingerprint, also ask them to input fingerprint; after input, data, if legitimate, would be transported to server to deal with through wireless or wire network. Client would only need to wait. Finally, this program would show the received results on the liquid crystal display of the development board.

5 Test and Running

We use two classrooms, one as exam-room and another one as control center. Including: fingerprint acquisition module, UP-NETARM2410-S development board, PC host (with Windows XP system and Access database), and WLAN card.

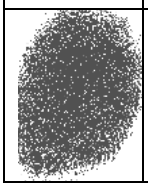
5.1 Testing Data and Analysis

Having finished the circuit of control board hardware ARM9, we embed Linux operating system, and then compile applications under operating system[20]. The main functions include: connect Internet, transport fingerprint information to Internet to realize network function, initialize and reset the equipment, register fingerprint information, manage fingerprint information database, match fingerprint information and other managing functions.

Start PC server and then client to see if two ports can be connected; operate program, transport data, and observe whether or not server and client can correctly send and receive data.

Follow testing procedure and data to run the test. The results are in Table 1:

Table 1:Testing Data and Analysis

testing fingerprint	***expected registration result***	***expected reaction time***	***expected checking time***	***expected reaction time***
	succeed	<1S	succeed	<1S
	succeed	<1S	succeed	<1S
	succeed	<1S	fail	<1S
	fail	<1S		

Testing results show that our equipment and program have basically achieved predesigned standards.

When acquired fingerprints are a bit obscure, normal registration could be performed. But these fingerprints could fail in checking because of deviation. If acquired fingerprints are really obscure and the program cannot even identify, registration would fain because system would deny registration. But these incidents rarely happen, only when fingers are covered with mud while fingerprints are being acquired.

6 Conclusions

To adapt the need that fingerprint acquisition sensor and fingerprint identification system are developing towards being small and embedded, this essay put forward a design plan about embedded fingerprint identification system based on ARM9 processor, and also introduces basic methods of acquisition, processing, extraction, and matching of fingerprint. At the same time, this essay illustrates the hardware structure and software flow of this fingerprint identification system[21]. Judging from final fingerprint identification results, we can tell this set of design plan is efficient and has reached our expectations.

Embedded wireless fingerprint exam affair management system is suitable for current exam information management system. When it's being used, users can independently complete the comparison of fingerprint and information inquiry without connecting to other equipments and computers[22]. Examinees only need to sweep fingerprint acquisition equipment with his or her

fingers, then identities could be confirmed. They do not need to show a lot of credentials which is convenient for both invigilators and examinees. Real running results demonstrate this system of great practical value.

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