Advances in Computer Science Research, volume 89
2019 International Conference on Wireless Communication, Network and Multimedia Engineering (WCNME 2019)

Individual Design and Rapid 3D Printing of an Intelligent Fingerprint Identification Drawer

Weizhen Li and Qiyuan Fan
School of Mechanical Engineering, Guangzhou College of South China University of Technology, Guangzhou, 510800, China

Abstract—With the development of biometric identification technology, fingerprint identification technology was used widely in the fields of attendance, entrance guard and mobile payment due to its advantages of security and reliability. Now Fingerprint locking technology has also been developed rapidly in intelligent home, more and more users began to try to accept the fingerprint lock products. In this paper, an intelligent fingerprint identification drawer was designed with Arduino UNO R3 development board as the main body and an auxiliary control electric control circuit to realize the function of "cabinet locked if hand out and unlocked if hand in". After designed the lock structure of the fingerprint drawer and then rapid prototyped the main components with 3D printing, then assembled and debugged. An individual fingerprint identification drawer was finished. And it's meaningful for the promotion in the individual design in the smart home area in future.

Keywords—biometric identification; fingerprint identification; smart home; individual design; 3D printing; assembly debugging

I. INTRODUCTION

The fingerprint identification technology (Automatic Fingerprint Identification Technology) is abbreviated as AFID, which mainly works for the unique of the skin pattern of each person's fingerprint. Because the break point and crossing point of each person's fingerprint pattern are different, and they never change all life. Therefore, fingerprint can be used as the basis of personal identification. Its development also benefits from modern electronic integrated manufacturing technology and the fast & reliable algorithm research. Common keys, smart cards, passwords, etc may be in danger of being stolen, copied, forgotten, lost, and so on. But human biometrics cannot be forgotten, stolen and copied. The fingerprint recognition belongs to biometrics, and it is more accurate than other biometrics such as vein recognition, face recognition and pupil for iris recognition, and so on. The fingerprint recognition has much advantage for it's safe, reliable, difficult to forge, and especially the low cost, high practicability. So fingerprint identification technology in the meeting attendance, entrance guard, mobile payment and other industries has been applied widely. Therefore, fingerprint identification was becoming one of the potentially developed technologies [1]. According to the survey results, Prospective Industrial Research Institute released the 2014-2018 market prospect and investment of biometric technology industry in China. As showed in Figure 1 According to the Strategic Planning Analysis report, the global biometric market reached $9.8 billion in 2013, with fingerprint identification accounting for 91.0% of consumption at a 10.4% growth rate. It is expected to increase to about $30 billion by 2020[2].

In recent years, China promoted the standardization of biometric identification in the fields of information technology, information security, financial transactions, social security, and so on. From 2002 to 2015, the market for biometric identification had been continued to grow at a high rate. The annual compound growth rate of domestic biometrics market reached 50%, and the scale of biometric market reached about 12 billion yuan in 2016. By 2020 it was expected that, the market scale of biometric industry in China would exceed 34 billion yuan [2], and the global fingerprint recognition market would be expected to reach $13.0 billion, face recognition $2.4 billion and iris recognition $1.6 billion, as shown in Figure 2.

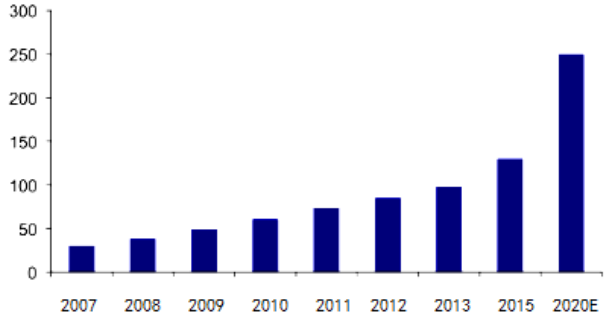


FIGURE I. INDUSTRY MARKET DATA AND FORECAST OF GLOBAL BIOMETRIC IN 2007-2020 (UNIT: US $100 MILLION)

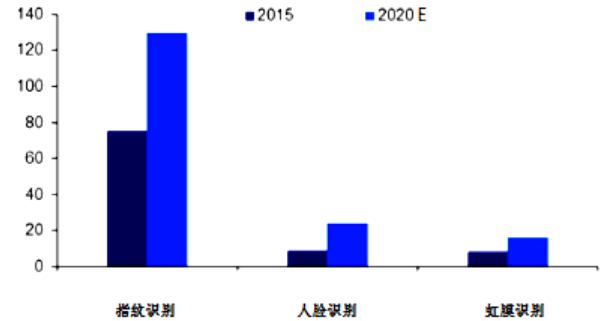


FIGURE II. MARKET DATA OF GLOBAL BIOMETRIC SUBDIVISION (UNIT: US $100 MILLION)

Fingerprint lock, as a branch of fingerprint identification technology, its security and anti-counterfeiting performance was very prominent. It had been widely developed and applied in recent years [3], and lots of fingerprint extraction accuracy matching algorithm had been explored to some degrees [4,5,6,7]. Intelligent fingerprint identification drawers were also accompanied by high-quality "intelligent residence" applications, it not only met with people's needs for daily use,

also improved the security of storage items greatly for the drawers.

There were two kind of fingerprint lock modules on the market at present: one was optical fingerprint head, the characteristic of this fingerprint module was its lower price, but the recognition errors often occurred. It needed the user to re-press the finger to identify, and it needed more power consumption; The other was capacitive fingerprint head, which was more expensive than optical fingerprint head, but it had high recognition rate, low power consumption and low failure rate [8]. So capacitive fingerprint would be used more frequently in daily life than optical fingertips.

Therefore, this paper mainly designed an intelligent fingerprint drawer, which could meet the intelligent demand. It realized the function: "hand off cabinet lock, hand in cabinet open".

II. Design of Fingerprint Identification System

This fingerprint identification system took the Arduino uno R3 as main board, and the control circuit to carry on the auxiliary control. The program framework mainly consisted of 3 parts: declared variables and interface name, setup (), loop () [9].The Arduino uno R3 had 14 digital I / O ports (6 of which could be used as PWM outputs), 6 analog ports, a 16MHz crystal oscillator, a USB interface, a DC power outlet, an ICSP header, and a reset button. The specific parameters were shown in table 1:

TABLE I. PARAMETER LIST OF ARDUINO UNO R3

Microprocessor	ATmega328P
Working voltage	5V
Input voltage (recommended)	7-12V
Input voltage (limit)	6-20V
Digital input / output pin	14 channels
PWM Digital I / O Pin	6
Analog input pin	6
DC current per input / output pin	20 mA
DC current of 3.3V pin	50 mA
Flash memory	32KB，
SRAM	2 KB (ATmega328P)
EEPROM	1 KB (ATmega328P)
Clock frequency	16 MHz
Length	68.6 mm
Width	53.4 mm
Weight	25 g

The basic programming ideas for fingerprint drawers were as follows:

Defined and called the function library including the fingerprint identification module function library <Adafruit_Fingerprint.h> and soft serial port settings function library <SoftwareSerial.h>, declaration variables and interface names. The fingerprint identification function getFingerprintIDez () and the pin interface and the soft serial port of the auxiliary components were used for the data exchange between the fingerprint module and the development board. The function Setup () with the baud rate of 9600 was used for the development board to communicate with the fingerprint module. If the buzzer beeped two times the connection was successful, and otherwise it failed, the red light would be on. Set each auxiliary component pin mode for read or output mode. Opened the serial port monitoring, it's easy to read fingerprint identification module status when debugging.

The defined Loop () main function could check the opening or closing status of drawer before running the main program and judged by reading the pin level. If the drawer closed, interrupts should close, and the fingerprint identification function ran, fingerprint module was waiting for fingerprint input status. If the drawer opened, the break also opened, and the fingerprint module was dormant.

The fingerprint identification function was "int getFingerprintIDez ()". Firstly, the fingerprint image was obtained. The module would look for the fingerprint state before the living fingerprint was recognized. When the fingerprint was identified, the fingerprint image was obtained by the capacitive pressure plate, and the fingerprint image was obtained successfully then went to the next step. If failure it returned to the value -1 and the red light emitting diode was light up. The next step was fingerprint image binarization, the purpose of which was to convert the grayscale image of fingerprint into a binary image which could be recognized by the module. If the recognition was ok then it continued to the next step but if it failed it returned to value -1 and illuminated the red light emitting diode. Last step was the fingerprint search and comparison; if successful the green light emitting diodes was lit up, if failure the red was light up. Here chose the light emitting diodes as indicators for its low energy consumption, low working voltage, high luminous efficiency and small size [9].

III. The Basic Pre-implemented Function and the source Code Program

In order to enable the intelligent fingerprint identification drawer to bring users a perfect experience and use it more humanly. The fingerprint identification system must judge accurately and run rapidly. The process of using the drawer was divided into the following stages:

The intelligent fingerprint identification drawer must be able to tell the user that the fingerprint identification module works properly after the power was on. When the development board connected to the fingerprint identification module successfully, the buzzer would issue a "tick" and allow the user to use the drawer. If the fingerprint module communication failed, the system lighted up the red light emitting diode to inform the user. And then the user must carry on the fingerprint acquisition again till the green light was on.

After the drawer was open, the interrupt function should be turned on at this time in order to avoid errors reported by the fingerprint identification system and the fingerprint system must enter the dormant state. When the drawer was closed, the fingerprint system would work again.

According to the basic functions of the pre-implementation, the corresponding program should compiled with the function. Some of the program contents are as follows:

```
# Include <Adafruit_Fingerprint.h>// Call Fingerprint Module Library
# If ARDUINO >= 100
# include <Software Serial.h>
```

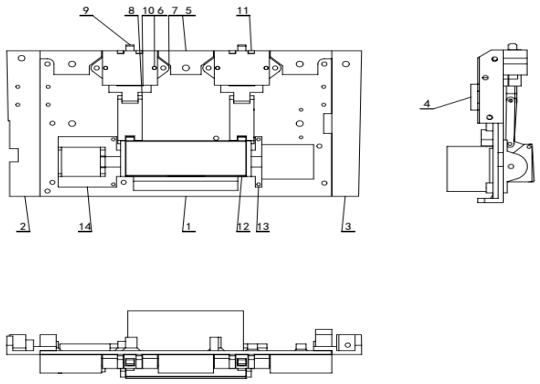
```
#else
# include <New SoftSerial.h>
#endif

Int getFingerprint IDez (); // Define fingerprint identification function
Int buttonpin = 2;
Int gled = 4; // Define pin 4 as green light emitting diode port
 ⋮
P = finger. fingerFastSearch (); // Search fingerprints and compare them
If (p!= FINGERPRINT_OK)
{
Digital Write (rled, HIGH);
Delay (500);
Digital Write (rled, LOW); // Fingerprint search, if no match, red light on, return to value - 1
Return -1;
}
Digital Write (gled, HIGH); // Find the fingerprint and the green light is on.
Delay (500);
Digital Write (gled, LOW);
}
Void Dian ()// buzzer generator function
{
Digital Write (buzzer, HIGH);
Delay (50);
Digital Write (buzzer, LOW);
Delay (100);
}
```

When the system was interrupted, the interrupt function in the Arduino function library would conflict with the fingerprint recognition module, which would lead to no response for the interrupt failure and interrupts could be generated here by reading pin status. Firstly, the second pin is defined as reading pin, and the second pin is set as high level. The limit switch was disconnected and the other end was grounded. Closed the upper limit switch and the pin 2 was grounded. Now the pin 2 was in a low level. The system enters a dead cycle and interruption occurred.

IV. THE STRUCTURE DESIGN, PROTOTYPE AND ASSEMBLY FOR THE INDIVIDUAL DRAWER

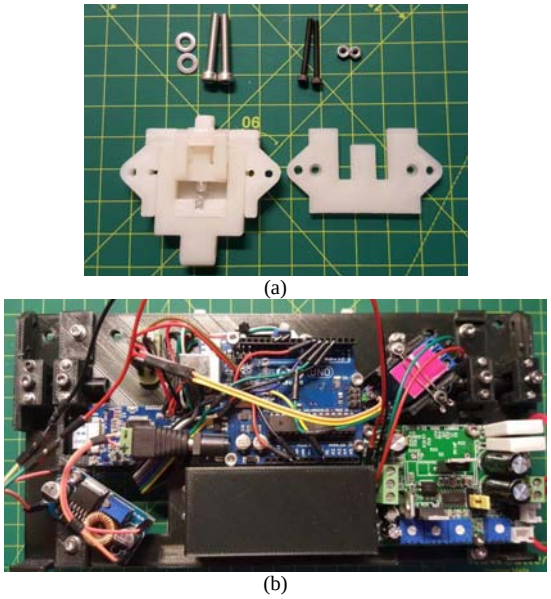
In order to enhance the structure integrity of the drawer the circuit board parts and drawer structure parts must well combined. The structure was designed to meet its individual requirements [10], [11]. And the designed parts were rapidly made by 3D printing, here the FDM method was selected. And reasonable 3D printing parameters were set for all parts to obtain good external surfaces [12], [13]. At last, the parts were assembled. Drawer internal structure effect as shown in Fig. 3, mainly by the drawer back wall, left and right wall, main connecting rod, cover, lock tongue, handle and other components, its specific layout and quantity were showed in the figure 3.



1. the rear wall of the drawer 2. the right wall 3. the left wall 4. the aluminum pipe cover 5. the top wall 6. the rear cover 7. the closed cover 8. the main linking rod 9. the locking tab 10. the rod 11. the hook 12. the handle 13. the handle rack A 14. Handle rack B

FIGURE III. THE STRUCTURE OF THE DESIGNED INTELLIGENT FINGERPRINT DRAWER

After 3D printing the lock tab and the reset spring were assembled, the rod and the hook were loaded, and then the back closed cover was sealed with assembly test, as shown in Figure 4(a). The circuit module mainly includes the following modules: fingerprint identification module, Arduino UNO R3 development board, electromagnet drive module, step-down module and so on. Next step is the installation of wiring and the relay modules, wiring requirements to leave room for future changes, wire routing must be clear and easy to identify. Finally, the effect diagram was completed, shown as Figure 4(b).



(a)

(b)

FIGURE IV. (A). THE 3DPRINGTING LOCKING PARTS (B).THE ASSEMBLY OF THE WIRING MODULE

Finally, the whole module should be installed in the drawer. When installing, pay attention not to the M4 screw should be used when connecting. After installation, the effect should

reach the following standard, drawer front effect map, as shown in Figure 5.

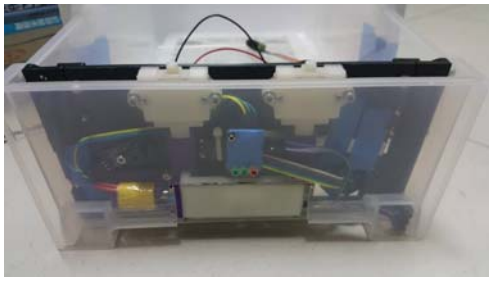


FIGURE V. THE FRONT OF THE DRAWER

V. THE DEBUGGING FOR THE INTELLIGENT FINGERPRINT IDENTIFICATION DRAWER

After the completion of the assembly, the function of the designed system would be tested. When testing, all possible situations for users must be tested comprehensively. The test conditions were dry working environment, normal room temperature, anti-drop and no collision. The control circuit and working reliability of intelligent fingerprint drawer were tested emphatically.

Firstly, the electrical test was carried out. After the drawer was powered on, it should be stationary for a period of time to confirm that there was no short circuit, circuit break and the circuit control board was running well. See Figure 6.

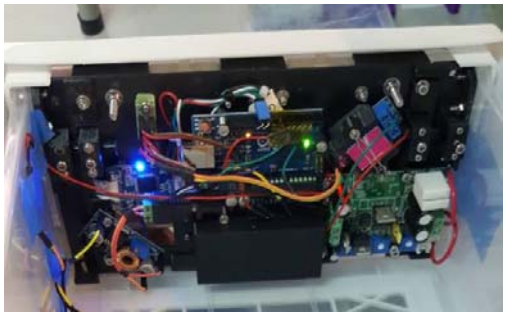


FIGURE VI. THE FUNCTION TESTING

Then the user input the fingerprint. Because each finger joint of the hand had a 90° angle range of motion [11], it is not expected of the drawer that the capacitance pressure plate could not be pressed normally when the user inserted the finger. The test contents included fingerprint recognition response speed, mechanical module movement effect and interruption effect. The main data of the test were shown in Table 2.

TABLE II. TEST RESULTS

Test items	Response time (in seconds)
Response Speed of Fingerprint Recognition	< 1
Opening speed of electromagnet	< 0.6
Total time of unlocking	< 1.6

The test showed that the operation of the mechanical part was flexible and stable. After the drawer was pulled out, the locking tab could be prevented from being held up by the hook, closed the drawer, and the locking tab could be ejected and reset.

VI. SUMMARY

From the above results, it showed that the designed system of intelligent fingerprint identification drawer was creative and reliable. The opening speed of electromagnet followed unlocking time could only be 1.6 seconds. It would be improved and popularized in individual design of smart home greatly in future.

REFERENCES

[1] CHEN Jiyan. Development and application of automatic fingerprint identification technology [J]. Disc software and Application of computer,2013, (9): 56-57.

[2] WU Xiaoyan, Li Ling, Deng Sha, Chinese bio-metrics industry market research and investment analysis report 2014-2018 [R], Beijing, Prospective industry research institute,2016:1-50.

[3] WANG Shuguang. A Review of fingerprint identification techniques [J]. Information security research,2016, (4):343-355.

[4] GUTIERREZ, P.D., LASTRA, M., HERRERA, F.,et al. A High Performance Fingerprint Matching System for Large Databases Based on GPU[J]. IEEE Transactions on Information Forensics & Security,2014,9 (1):62-71.

[5] Rodrigues R D M, Costa M G F. Fingerprint verification using characteristic vectors based on planar graphics[J]. Signal Image & Video Processing, 2015, 9(5):1-15.

[6] Sankaran A, Vatsa M, Singh R. Latent fingerprint matching: A survey[J]. Access IEEE, 2014, 2(2):982-1004.

[7] DU Shuchun. Guide for the use of common electronic components [M]. Beijing: Tsinghua University Press,2016:3-66 ;

[8] LIU Ning, key Technology of automatic fingerprint Identification system [M]. Beijing: Jilin University Press,2015:7-79 ;

[9] SONG Nan, Han Guangyi , Arduino development from the very beginning [M]. Beijing:Tsinghua University Press,2014:2-100.

[10] PU Lianggui, Chen Dingguo, Wu Liyan. Mechanical design [M]. Beijing: higher Education Press 2013:2-80.

[11] CHEN Zhoujuan, Song Ruiyin, Li Hong. Principle of machinery [M]. Wuhan: Huazhong university of science and technology press.2013:2-90.

[12] CHEN Jimin. Basic course of 3D printing technology [M]. Beijing: National defense industry press,2016:2-80.

[13] Joan Horvath. Mastering 3D Printing[M]. Apress:2014:1-50.