Year 2 Project

Design and Build of a Fingerprint Lock

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27 March 2020

Abstract

Nowadays, the biological recognition technology is widely used in different fields. Therefore, in order to investigate how the fingerprint recognition system works, this group aims to design and build a fingerprint lock system. The purpose of this article is to record how the team works as a team to design the project, then implements it. For the topic of this lab, it was chosen to simulate a fingerprint lock, which is a kind of electronic lock and controlled by a chip. The tasks were assigned according to the specialties and interests of team members, while facing the complex problem, team members would work together to solve it. In the end, although the project implements all the functions as designed and the purpose of the lab had been achieved, there is still area could be improved.

Declaration

I confirm that I have read and understood the University's definitions of plagiarism and collusion from the Code of Practice on Assessment. I confirm that I have neither committed plagiarism in the completion of this work nor have I colluded with any other party in the preparation and production of this work. The work presented here is my own and in my own words except where I have clearly indicated and acknowledged that I have quoted or used figures from published or unpublished sources (including the web). I understand the consequences of engaging in plagiarism and collusion as described in the Code of Practice on Assessment (Appendix L).

Contents

1. Introduction

The topic of this group project was chosen to design a fingerprint lock by using the Arduino Uno chip, which involves designing circuits, connecting circuits, writing codes, and lab report. It is a precious opportunity to practice the teamwork skills while completing the project. In addition, the procedure, result and the discussion part will be discussed briefly in an orderly manner in the remaining articles.

1.1 Background

The fingerprint locks have a more convenient use and higher security due to the uniqueness of biological information than traditional locks. In addition, this system is users friendly. Enrolling the fingerprint once and the system can be unlocked in the future. Furthermore, the problem of lost keys can be eliminated effectively. Therefore,

this lock will gradually replace traditional locks in the future market [1].

1.2 Objectives

-Explore the principle of biological recognition and realize the construction of fingerprint lock system using electronic devices and codes.

-Improve the functions based on the existing fingerprint recognition systems in the market.

-Achieve more convenient unlocking.

-Strengthen the ability of teamwork among engineering students, including team communication, manage and leadership skills.

1.3 Theory

Fingerprints are bumpy lines on the front already skin at the end of the finger, and although fingerprints are only a small part of the human skin, they contain a lot of information that is different in patterns, breakpoints and intersections, and they are called ”features” in information processing, which have been medically proven to be different for each finger. What’s more, these features are unique and permanent, so people can match a person to his fingerprints, and people can verify his true identity by comparing his fingerprint characteristics with his pre-saved fingerprint characteristics.

The principle of this project to identify the matching of different fingerprints is to identify the coincidence degree between each fingerprint and the pre-recorded fingerprint. The higher the coincidence degree, the more likely the fingerprint is to be the correct fingerprint. This coincidence degree will be converted into a value by the chip. When the value is higher than the predetermined standard value, the chip will judge that the fingerprint overlaps, and the lock will be opened, otherwise the lock will be closed.

2. Materials and methods/procedure

2.1 Material list

This is the list of equipment used by the team. The specification of some of the parts will be listed in appendix A.

1 Arduino Uno

1 LCD display

1 Fingerprint sensor

1 Relay module

1 Buzzer

1 Keypad

1 Breadboard

1 1000ohm resistor

1 LED

Software: Arduino 1.8.5

Among above components, in the system, LCD display is used to provide instructions to user and display the system working state, the fingerprint sensor is used to read and stored fingerprints, relay is used to switch the LED, buzzer used for used for the input error message 3 times after tips and warnings, a keyboard for entering passwords and password, and edit fingerprint LED used to indicate a lock state, while programming based on the Arduino uno.

2.2 Procedure

2.2.1 Design

The first step is to design the project, the design of the project is mainly divided into two parts: functional design and circuit design. The results of the design are shown in the following two pictures. The first picture is the logical diagram of the function realization of the team project, as shown in figure 1. In the team's design, users can enter the device in two channels, fingerprint sensor or keypad. Once a correct password or fingerprint is entered, the relay would drive and the LED would be lighting, which indicates that the lock is unlocked. If wrong passwords or fingerprints are entered 3 times in a row, the buzzer would be ringing and the system would be locked for 30 seconds. This design is to ensure the security of the system. Additionally, the two initial passwords will be used for editing fingerprints and passwords in the system, respectively. This is the team's design of the entire project, and the programming of the project is based on this logical diagram.

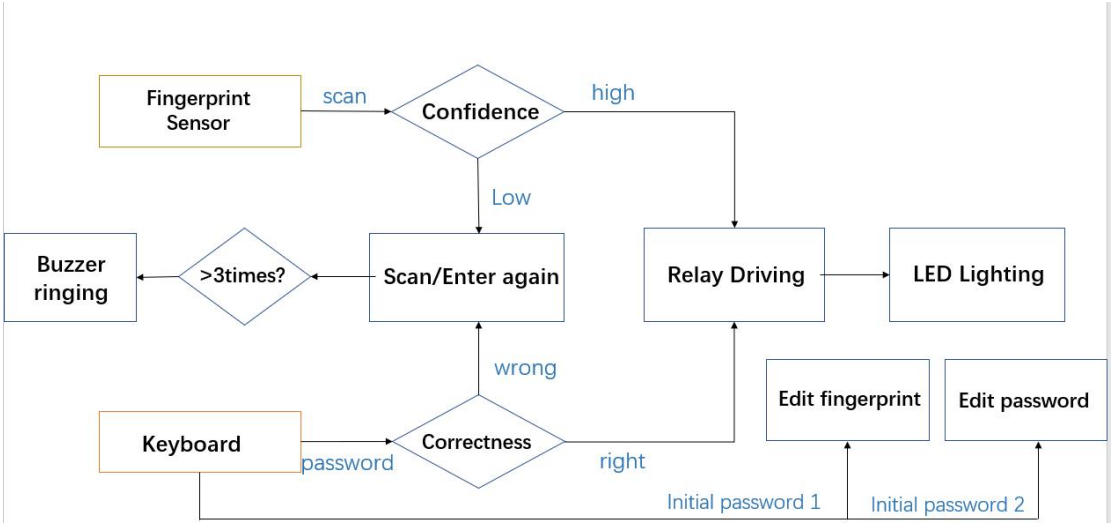


Figure 1. Block diagram of the project.

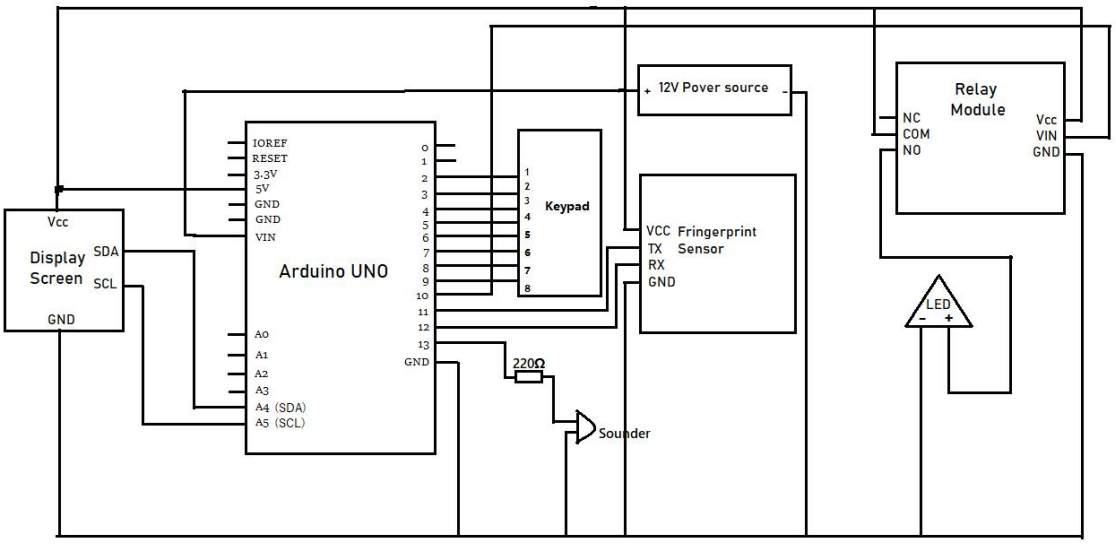


Figure 2. The circuit design of the project.

2.2.2 Test for each component

First, the team USES the program in the Arduino library and makes appropriate adjustments to confirm the working status of each part.

a. Test for LCD (Program in appendix B)

According to figure 2, connect the LCD to the Arduino, connect the computer to the Arduino to supply power and upload the program. Observe the LCD working and 'Hello World' appears. This indicates that the LCD is working properly.

b. Test for fingerprint sensor (Program in appendix C)

Connect the fingerprint sensor according to figure 2, open the Arduino serial port monitor, link the computer with the Arduino board and upload the program. The serial port monitor shows that the fingerprint sensor is detected, and then prompts the input of the first fingerprint. After two consecutive inputs, the fingerprint is stored and the fingerprint number is input. The fingerprint is then

required, and when the finger is placed on the sensor, the confidence of the corresponding fingerprint is given on the monitor. The fingerprint sensor test completed.

c. Test for keypad (Program in appendix D)

Connect the keyboard to the Arduino board and connect the Arduino board to the computer. Open the serial port monitor. When any key is pressed, the monitor shows that the corresponding key is pressed. All 16 keys were tested correctly.

d. Test for buzzer (Program in appendix E)

Connect the buzzer as shown in the figure. After running the program on the Arduino, the buzzer will sound for three seconds and then stop for three seconds and keep repeating. This indicates that the buzzer is working properly.

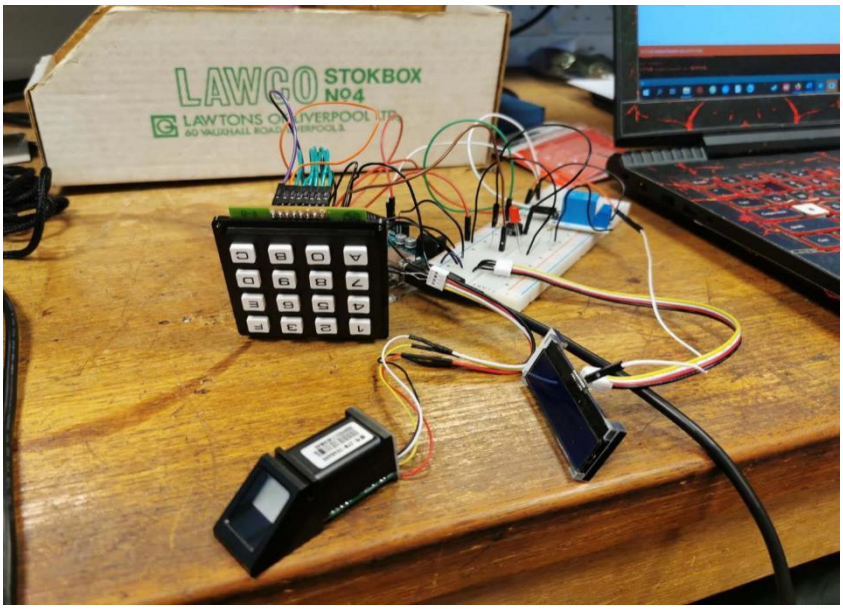
e. Test for relay (Program in appendix F)

As shown in figure 1, connect the relay and LED lamp, add 1000ohm resistance between them. Connect the Arduino board to the computer, run the program, then the relay makes a light sound, followed by the LED lighting and then goes out after three seconds, the process is repeated. This indicates that the relay is working properly.

2.2.3 Complete circuit connection and code

After each part is tested, the entire circuit is connected according to figure 2. The completed wiring diagram is shown in figure 3. The code is then written and adjusted until the entire system works as expected then four 1.5v batteries were

used to power the system instead of the computer. The overall code is given in



Appendix G.

Figure 3. Wiring of the system.

2.2.4 Build the shell for the device

Finally, for the sake of aesthetics and protection of the circuit, the team made a shell for the circuit. The final product is shown in figure 3.

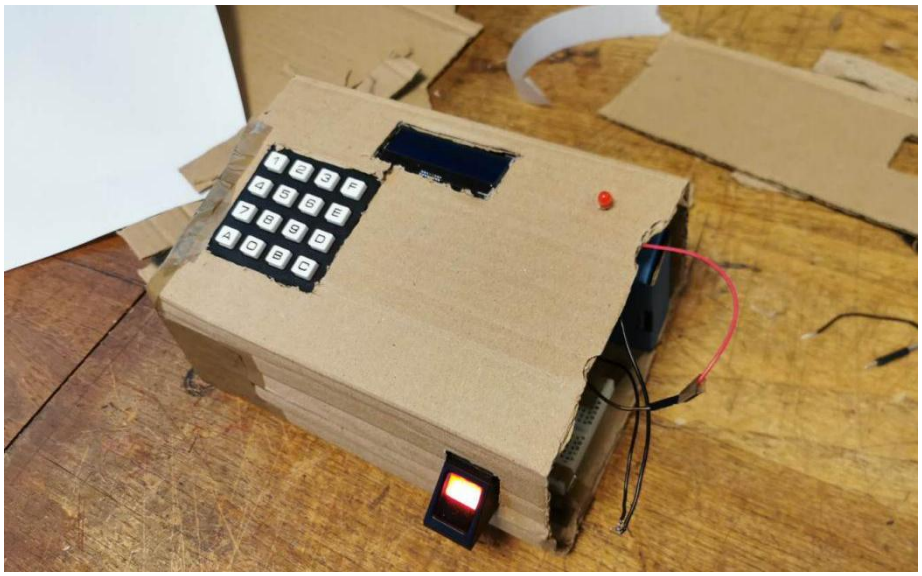


Figure 4. Appearance of the fingerprint lock.

3. Results

In this project, Arduino UNO are the control chip to store the code running in the system and transmit instructions to all components. The relay module controls the unlocking of the fingerprint lock by changing the input voltage. The LED screen show users' information and users are allowed to input passwords and commands into the system using the matrix keypad.

After the project, four functions are designed into the fingerprint password lock by building the circuit and programming, which are fingerprint and password unlock, password changing, fingerprint editing and alarm system.

3.1 Password changing

For the fingerprint lock system, there is a password to change the unlock password- 'E273'. When 'E273' is input using the keypad, you are allowed to input a new password.

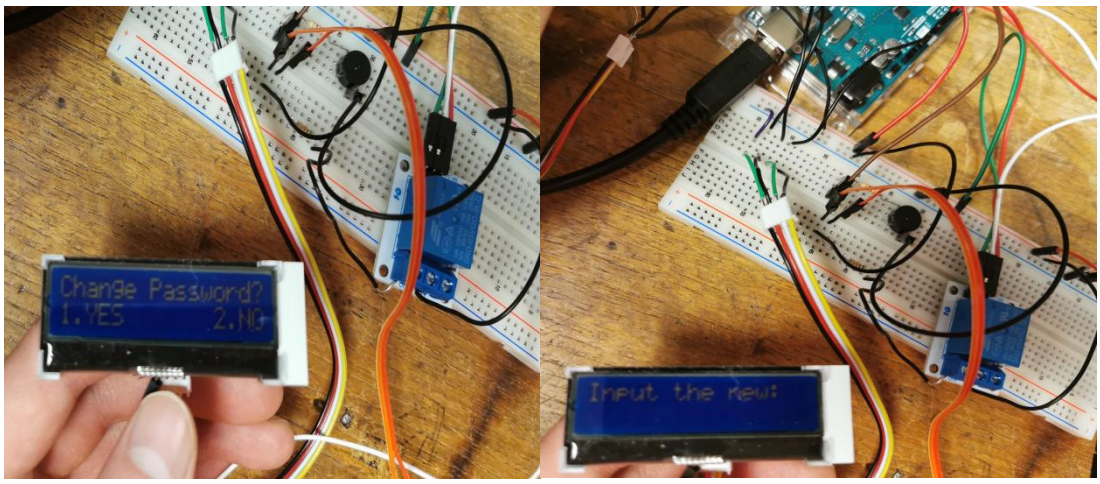


Figure 5. Password changing.

3.2 Fingerprint editing

There is also a password to enroll or delete fingerprints- '0000'. When adding a new fingerprint, users are supposed to input an ID (any number between 1 and 9). Then users should put the fingers on the fingerprint sensor. The fingers should be removed and put on the sensor again to ensure the accuracy of the fingerprint data. If the fingerprints inputted are the same, the fingerprint will be stored. In addition, it is mentioning that maximum 9 fingerprints can be stored.

Figure 6. Fingerprint editing.

3.3 Fingerprint and password unlocking

For the fingerprint unlocking, when fingers are put on the fingerprint sensor, verification will be completed by comparing the data of authorized fingerprint image with incoming fingerprint image. If the two images are the same, the system will be locked. For the password unlocking, the initial password is '1234'. Users can change the password and then unlock the system using the matrix keypad. When the system is unlocked, the light-emitting diode will light up (the LED light are an alternative to the electromagnetic lock).

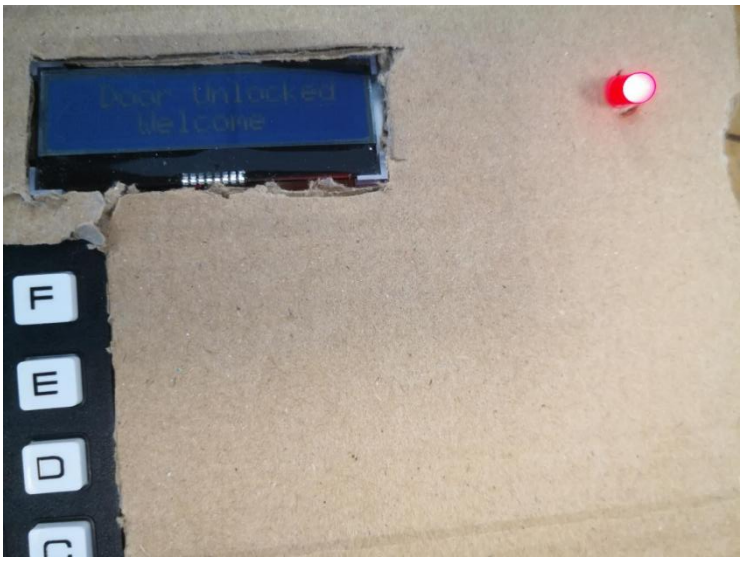


Figure 7. Fingerprint and password unlock.

3.4 Alarm system

When the password or fingerprint is incorrectly entered, the times of errors will be recorded. When the times of errors reach three, the buzzer will sound for 10 seconds and then the keypad will be locked for 30 seconds. Any input during the locking period will lead to a reset of locking time.

Figure 8. Unlocking of the keypad

During the project, the fingerprint sensor is not sensitive enough which could lead to unlocking failure. And the buzzer sounds normally but the volume is too low. In addition, due to the limitation of budget, the electromagnetic lock is replaced by a light-emitting diode.

4. Discussion

4.1 Significance of the project

This project is an improvement based on the traditional lock. There are two main merits for the fingerprint lock. Firstly, the fingerprint lock is more secure compared with the traditional lock because it does not need a key but fingerprints which is not susceptible to being picked or copied and is effective to eliminate the problem of lost keys. Secondly, the fingerprint lock system is user-friendly. Users just need to enroll fingerprints once and the system can be locked.

4.2 Limitations of the project

There are several limitations founded during the project. In this project, the first limitation is that the fingerprint lock system is powered by four 1.5-volt batteries, hence when the battery power is low, the following problems will appear: (1) The LCD screen's brightness is low which means that the information showed cannot be seen clearly by users. (2) The fingerprint sensor sensitivity is reduced which causes fingerprint recognition to fail. The second limitation is that the buzzer

sounds low due to the rated voltage limit of the buzzer. The third limitation is the limited number of fingerprints that can be enrolled due to insufficient Arduino memory. The last limitation is the budget, as mentioned in the Results, the electromagnetic lock is replaced by a LED.

4.3 Future improvement

Based on the above limitations, there are aspects can be improved in the future: (1) The fingerprint lock should be connected to a continuously stable power supply to prevent system failure. (2) Connecting the buzzer to the amplifier to increase the volume. (3) Simplifying the code of the fingerprint lock system and using larger memory chips. (4) Increasing the complexity of passwords, such as increasing the number of password digits, combining letters and numbers and using upper and lowercase letters.

4.4 Applications

In a broad sense, as a product that can be used in many ways, the password fingerprint lock can replace the traditional physical lock and can also be used in fields where traditional locks cannot be used, such as electronic devices. Furthermore, the product can be used as part of other systems, such as safes, home appliances, and access control systems. Therefore, it can be seen from the field of its application that fingerprint lock has a positive impact on social security issues, whether it is citizens' life security, property security or private security.

4.5 Ethical considerations

Although the fingerprint lock system is more convenient and more secure than the traditional lock, there is a potential threat, that is, when the user's pre-recorded fingerprint can be stolen, which means the user's privacy information will be exposed. In this case, to protect user's privacy, the deletion function is designed to clear user's personal information. And in the future development, the fingerprint information can be stored to the network. During each identification, the device will first call the fingerprint stored in the cloud and then compare it with the input fingerprint. Without a physical carrier, the risk of fingerprints being stolen is eliminated, and the user can edit the information from the cloud.

4.6 Sustainability

One way to improve the product in terms of sustainability is that the environmentally friendly materials, can be used as the shell of the product, which can reduce pollution during recycling and consumption during production. Besides, the life of products could be increased to reduce the cycle of recycling.

5. Conclusion

This project can implement the pre-designed content brilliantly, which includes not only the editing of fingerprints, such as pre-recording fingerprints, comparing fingerprints, removing fingerprints, but also accessibility features such as password-assisted unlocking and alerting to incorrect fingerprints. What's more,

the teamwork skills were mastered through lab process, such as how to communicate effectively within the team. However, there also exist some limitations in project, such as the sensor is sometimes not sensitive enough, and the pins of liquid crystal display are not match the jumpers provided by laboratory. Although they did not affect the overall use of the project, they could still be improved to make the project more smoothly in operation. To solve these limitations, replacing more advanced equipment is the most effective, but given the limited budget for the experiment, the cost of the work needs to be controlled at about 100 pounds, so replacing the equipment is not the best option. Therefore, in order to solve these limitations, change the objective conditions can achieve, such as keeping the finger clean so that it does not affect fingerprint identification, or adjust the liquid crystal display pin gap to successfully connect the jumpers. In summary, the skills of teamwork have been well developed in this lab, such as how to assign team tasks and how to assist teammates to complete tasks. In addition, the project has also achieved the desired function, although there are limitations but does not affect the use of the project.

Reference:

[1] J. Baidya, T. Saha, R. Moyashir and R. Palit, "Design and implementation of a fingerprint based lock system for shared access," 2017 IEEE 7th Annual Computing and Communication Workshop and Conference (CCWC), Las Vegas, NV, 2017, pp. 1-6. Online: https://ieeexplore.ieee.org/document/786844.

Appendices

Appendix A: Specification of components

A.1 Specification of LCD (Pin function)

Pin No.	Symbol	Level	Description
1	VOUT		DC/DC voltage converter. Connect a capacitor between this terminal and VIN when the built-in booster is used.
2	CAP1N		For voltage booster circuit(VDD-VSS) External capacitor about 0.1u~4.7uf
3	CAP1P		
4	VDD	3.0/5.0V	Power supply
5	VSS		GND
6	SDA		(In I2C interface DB7 (SDA) is input data. SDA and SCL must connect to I2C bus (I2C bus is to connect a resister between SDA/SCL and the power of I2C bus).
7	SCL		(In I2C interface DB6 (SCL) is clock input. SDA and SCL must connect to I2C bus (I2C bus is to connect a resister between SDA/SCL and the power of I2C bus).
8	$\overline{\text{RST}}$		$\overline{\text{RESET}}$ active low. If not used tie to VDD.

A.2 Specification of LCD relay

DC Relay Wildcard Specifications	
Channels	Three independent, optically isolated solid state DC relays
Voltage	Controls 3 - 60 VDC
Current	Switches up to 3 A continuously, 12 A surge for 10 msec.
Isolation	Optically isolated to 2500 V rms
Maximum ON Voltage Drop	0.4 VDC
Maximum OFF Leakage Current	100 µA
Turn On/Off Times	Max turn on/off times of 50/300 µsec
Operating Temperature	-30 to +80 °C
Connections	Easy-to-connect-to screw terminals

Appendix B: Test code for LCD

Test code for LCD.txt

Appendix C: Test code for the fingerprint sensor

Test code for the fingerprint sensor

Appendix D: Test code for the keypad

Test code for the keypad.txt

Appendix E: Test code for the buzzer

Test code for the buzzer.txt

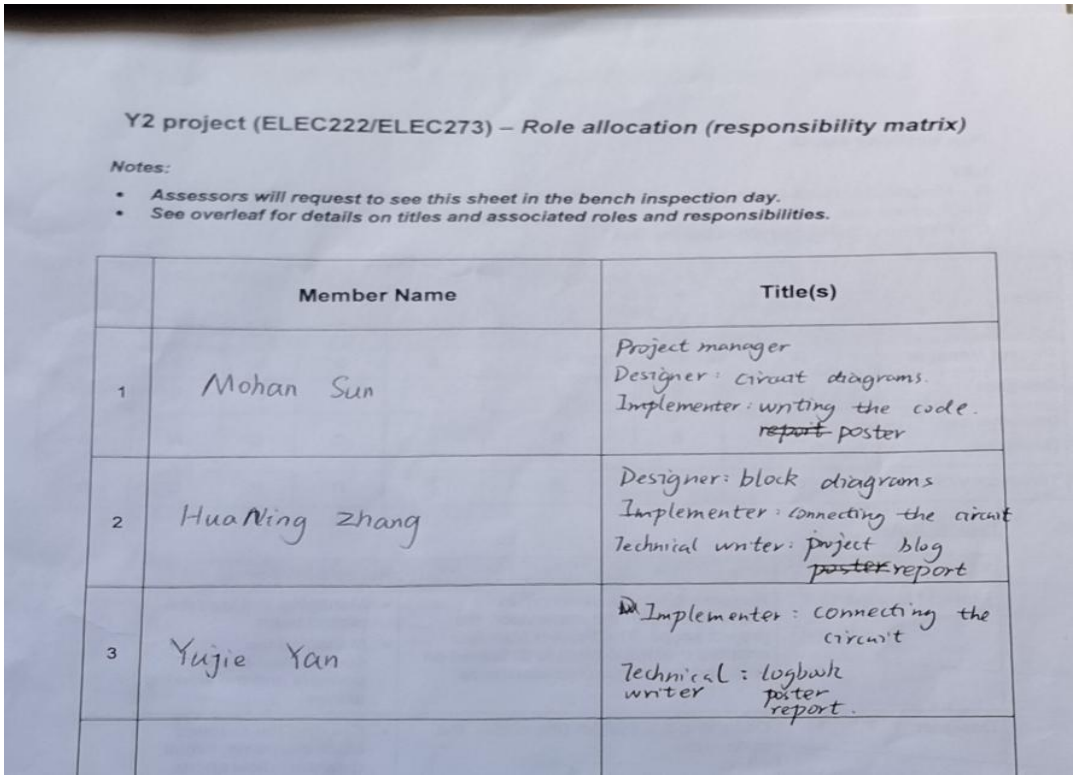
Appendix F: Test code for relay

Test code for relay.txt

Appendix G: Code for the system

Code for the system.txt

Appendix H: Group responsibility matrix



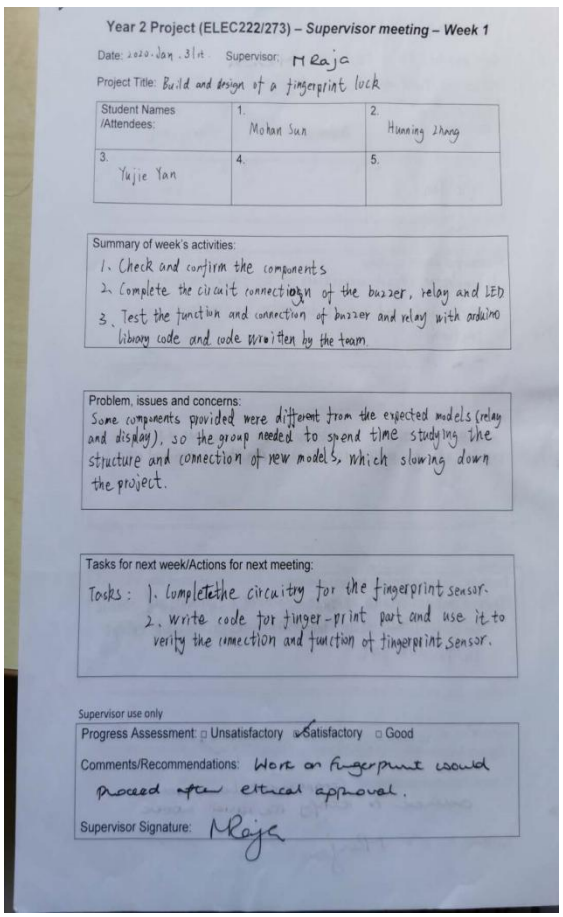
Y2 project (ELEC222/ELEC273) – *Role allocation (responsibility matrix)*

Notes:

- ***Assessors will request to see this sheet in the bench inspection day.***
- ***See overleaf for details on titles and associated roles and responsibilities.***

	Member Name	Title(s)
1	Mohan Sun	Project manager Designer: circuit diagrams. Implementer: writing the code. ~~report~~ poster
2	HuaNing Zhang	Designer: block diagrams Implementer: connecting the circuit Technical writer: project blog ~~poster~~ report
3	Yujie Yan	~~Im~~ Implementer: connecting the circuit Technical writer: logbook ~~poster~~ report.

Appendix I: Supervisor meeting log



Year 2 Project (ELEC222/273) – *Supervisor meeting – Week 1*

Date: 2020. Jan. 31st Supervisor: MRaja

Project Title: Build and design of a fingerprint lock

Student Names /Attendees:	1. Mohan Sun	2. Huaning Zhang
3. Yujie Yan	4.	5.

Summary of week's activities:

1. Check and confirm the components
2. Complete the circuit connection of the buzzer, relay and LED
3. Test the function and connection of buzzer and relay with arduino library code and code written by the team.

Problem, issues and concerns:

Some components provided were different from the expected models (relay and display), so the group needed to spend time studying the structure and connection of new models, which slowing down the project.

Tasks for next week/Actions for next meeting:

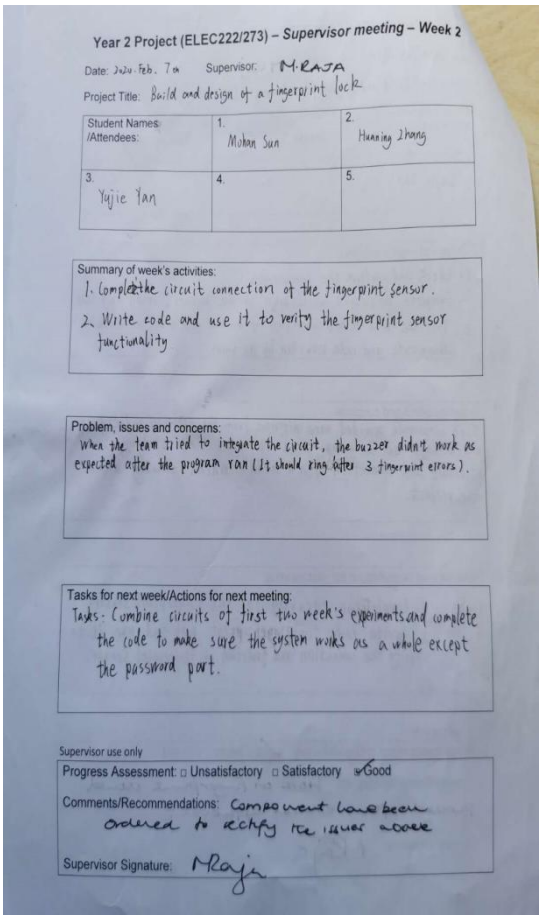
Tasks: 1. Complete the circuitry for the fingerprint sensor.
2. write code for finger-print part and use it to verify the connection and function of fingerprint sensor.

Supervisor use only

Progress Assessment: □ Unsatisfactory ☑ Satisfactory □ Good

Comments/Recommendations: Work on fingerprint should proceed after ethical approval.

Supervisor Signature: MRaja



Year 2 Project (ELEC222/273) – *Supervisor meeting – Week 2*

Date: 2020. Feb. 7th Supervisor: M.RAJA

Project Title: Build and design of a fingerprint lock

Student Names /Attendees:	1. Mohan Sun	2. Huaning Zhang
3. Yujie Yan	4.	5.

Summary of week's activities:

1. Complete the circuit connection of the fingerprint sensor.
2. Write code and use it to verify the fingerprint sensor functionality

Problem, issues and concerns:

When the team tried to integrate the circuit, the buzzer didn't work as expected after the program ran (it should ring after 3 fingerprint errors).

Tasks for next week/Actions for next meeting:

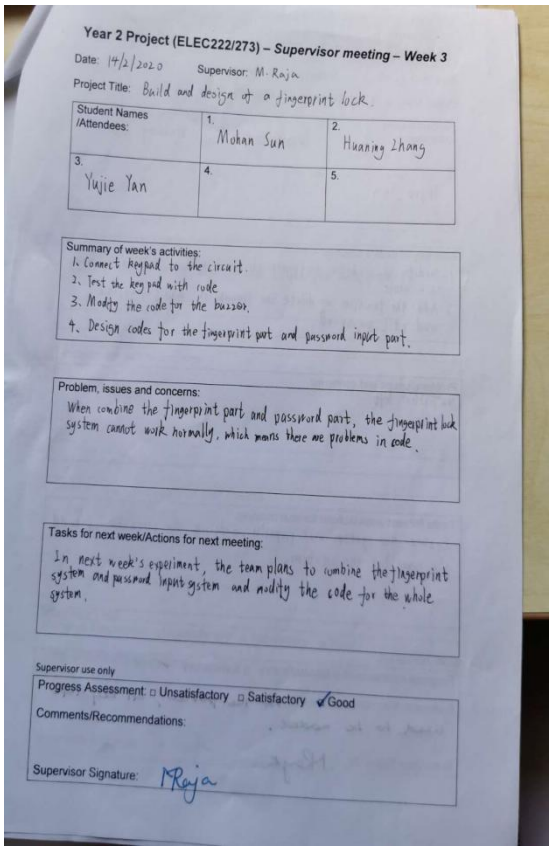
Tasks: Combine circuits of first two week's experiments and complete the code to make sure the system works as a whole except the password part.

Supervisor use only

Progress Assessment: □ Unsatisfactory □ Satisfactory ☑ Good

Comments/Recommendations: Component have been ordered to rectify the issues above

Supervisor Signature: MRaja



Year 2 Project (ELEC222/273) – *Supervisor meeting – Week 3*

Date: 14/2/2020 Supervisor: M. Raja

Project Title: Build and design of a fingerprint lock.

Student Names /Attendees:	1. Mohan Sun	2. Huaning Zhang
3. Yujie Yan	4.	5.

Summary of week's activities:
1. Connect keypad to the circuit.
2. Test the keypad with code
3. Modify the code for the buzzer.
4. Design codes for the fingerprint part and password input part.

Problem, issues and concerns:
When combine the fingerprint part and password part, the fingerprint lock system cannot work normally, which means there are problems in code.

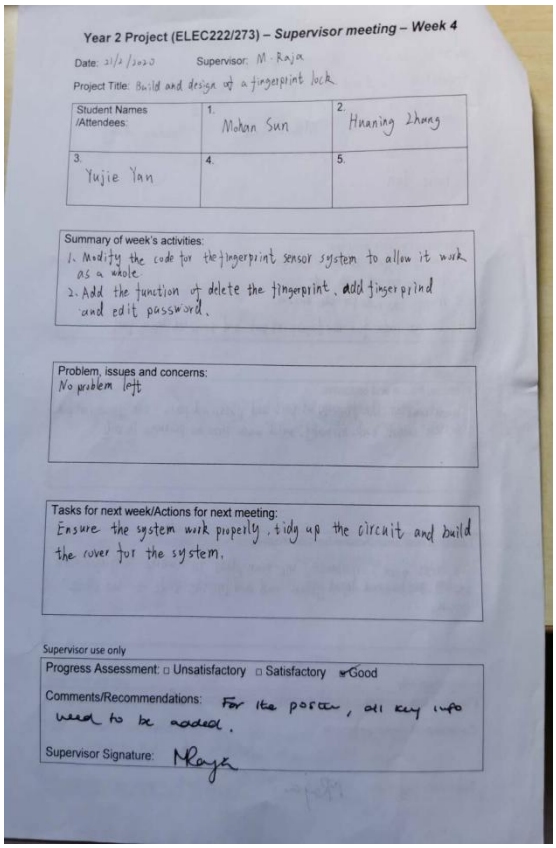
Tasks for next week/Actions for next meeting:
In next week's experiment, the team plans to combine the fingerprint system and password input system and modify the code for the whole system.

Supervisor use only

Progress Assessment: □ Unsatisfactory □ Satisfactory ✓Good

Comments/Recommendations:

Supervisor Signature: MRaja



Year 2 Project (ELEC222/273) – *Supervisor meeting – Week 4*

Date: 21/2/2020 Supervisor: M. Raja

Project Title: Build and design of a fingerprint lock

Student Names /Attendees:	1. Mohan Sun	2. Huaning Zhang
3. Yujie Yan	4.	5.

Summary of week's activities:
1. Modify the code for the fingerprint sensor system to allow it work as a whole
2. Add the function of delete the fingerprint, add fingerprind and edit password.

Problem, issues and concerns:
No problem left

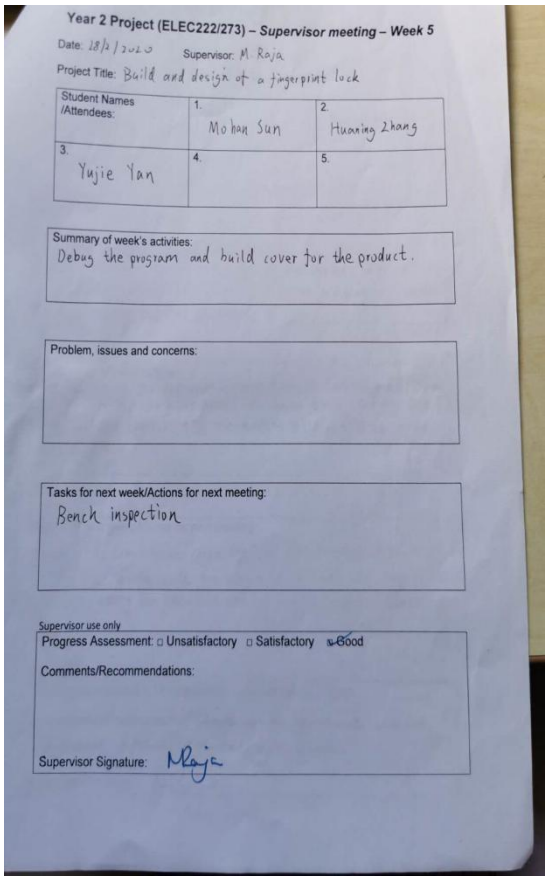
Tasks for next week/Actions for next meeting:
Ensure the system work properly, tidy up the circuit and build the cover for the system.

Supervisor use only

Progress Assessment: □ Unsatisfactory □ Satisfactory ✓Good

Comments/Recommendations: For the poster, all key info need to be added.

Supervisor Signature: MRaja



Year 2 Project (ELEC222/273) – *Supervisor meeting – Week 5*

Date: 28/2/2020 Supervisor: M. Raja

Project Title: Build and design of a fingerprint lock

Student Names /Attendees:	1. Mohan Sun	2. Huaning Zhang
3. Yujie Yan	4.	5.

Summary of week's activities:
Debug the program and build cover for the product.

Problem, issues and concerns:

Tasks for next week/Actions for next meeting:
Bench inspection

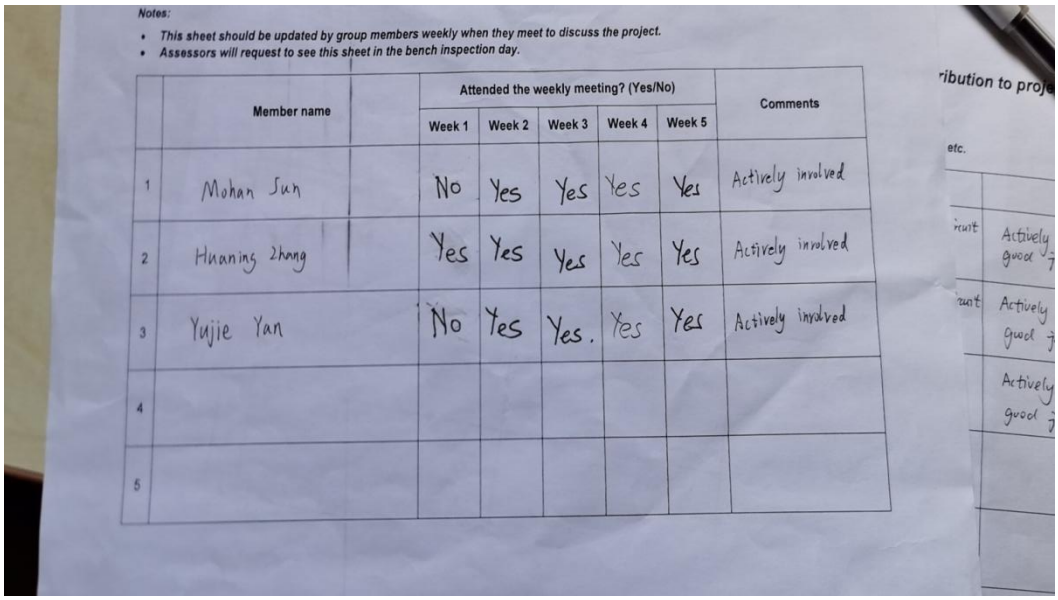
Supervisor use only

Progress Assessment: □ Unsatisfactory □ Satisfactory ✓Good

Comments/Recommendations:

Supervisor Signature: MRaja

Appendix J: Attendance log



Notes:

- This sheet should be updated by group members weekly when they meet to discuss the project.
- Assessors will request to see this sheet in the bench inspection day.

	Member name	Attended the weekly meeting? (Yes/No)					Comments
		Week 1	Week 2	Week 3	Week 4	Week 5	
1	Mohan Sun	No	Yes	Yes	Yes	Yes	Actively involved
2	Huaning Zhang	Yes	Yes	Yes	Yes	Yes	Actively involved
3	Yujie Yan	No	Yes	Yes.	Yes	Yes	Actively involved
4							
5							