

Prototype Home Door Security with Fingerprint Sensor and Bluetooth Modules Using the Arduino Uno as a Controller

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ABSTRACT

Conventional door security systems are vulnerable to theft because they are easily broken into. Therefore, it is necessary to apply a safer door security system with the latest technology to minimize theft. The goal is to make it simple for users to unlock the door by using a Bluetooth system controlled by an Android smartphone. The fingerprint sensor here is connected to the Arduino Uno, which functions to record registered user fingerprints. The fingerprint function is to open the door after the finger is placed on the fingerprint sensor. The specialty of this system is that only registered fingerprints can open the door. Meanwhile, using Bluetooth, a locked door is opened using the Android system. When fingerprints are close to the sensor, the average response time is 1.6 seconds, with the condition that the finger is not wet or dirty. When the finger is in clean condition and the finger is in dusty conditions, the average accuracy of the sensor in fingerprint reading is 297.5, whereas when the finger is wet, the system refuses access to the fingerprint sensor. The Bluetooth system with Android is affected by the distance between the Android and the system and is also affected by obstacles (walls). The system will remain connected to Android with a range of less than 22 meters. Information that the door lock has been unlocked will be visible on the Android screen via Bluetooth. The method used is a prototype so that the design of this system can be developed according to the wishes and size of the house's door.

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1. INTRODUCTION

The rise of theft and robbery incidents that can occur anywhere and anytime makes the security system very important. There are many things you can do to avoid criminal acts such as robbery and theft that occur in residential and office areas, one of which is by hiring a security guard, but this is not cheap and requires a monthly fee. Usually, break-ins and thefts in homes and offices are carried out through door or window access. To anticipate windows, iron bars are usually installed, while locks are usually installed on the doors of houses to anticipate security, where the security of door locks on the market can be said to be no longer safe. With the help of two cables, someone can open the door easily.

In 2019 an RFID-based automatic door security was designed. The way this system works is to bring the tag closer to the card's RFID reader, then the door will open. However, this system relies heavily on tag cards; if the tag card is lost or forgets the place where it was left, it will automatically become a serious problem in a project, so a system like this is considered ineffective because it is still very dependent on a priority point. Then, in 2020, a sensor-based laboratory door security system will be designed with a fingerprint and magnetic lock. The workings of the system use a sensor's fingerprint as a means of opening a magnetic lock attached to the door. This system is considered less effective because the user's desire to open a magnetic lock from inside the lab is still not fulfilled. And in the same year, 2020, a cupboard lock security system was designed using an Arduino UNO-based fingerprint sensor, where when the fingerprint sensor gets data that is valid from the user, the wardrobe lock will open. However, the results of this system yielded the same principles, successes, and constraints as previous studies that had been conducted in the same year. The difference is the determination of the method of implementation.

This is where the problem started because there was no automatic door security system, and it was reported when the house door was opened to the homeowner, and an alarm sounded when the door was broken into. The process of designing this automatic door safety system uses a quantitative experimental method. An automatic home door security system using a fingerprint consists of three parts: the first part has an input (a fingerprint sensor and push button), which functions as a signal sender to the microcontroller to instruct the output to work later. Process the second part (the Arduino UNO), which functions as a signal receiver from the Input section, and then the data will be managed while simultaneously controlling all circuits, and the buzzer as an alarm indicator indicates that there is incoming data. The third part is the output (Relay), which will be active when it receives instructions from the Arduino. If the input data is correct, then the solenoid attached to the relay will work.

2. METHOD

In this study, there are several important checks that need to be carried out to support the success of the device as an automatic security system for the door of the house.

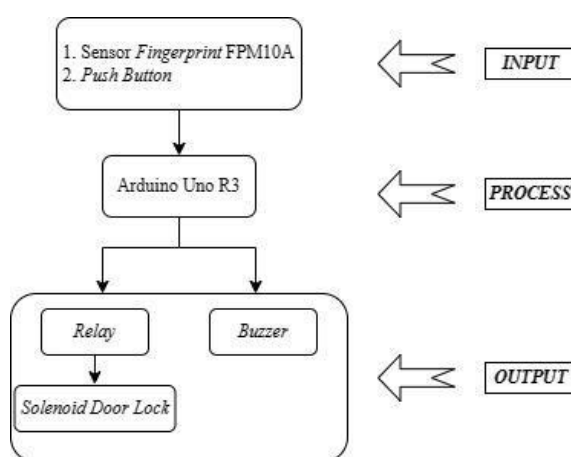


Figure 1. Tool Workflow Chart

2.1. Network Schematic Fingerprint

The FPM10A fingerprint sensor is a sensor that is integrated with a database in memory and stored in the sensor's Electronic Erasable Programmable Read Only Memory (EEPROM).

2.2. Network Schematic Bluetooth

The Bluetooth module used is the HC-05, which works through communication between the TX and RX pins, which are then connected to the TX and RX pins of the Arduino by crossing, so that the data transmission process runs optimally.

2.3. Network Schematic Relay

In this scheme, we use relay 1, which has three pins of input (VCC, GND, and IN) and three pins of output (NC, COM, and NO) connected to AC or DC current loads. The relay works when an electric current flows into the coil, and then the output will automatically work. The following is a schematic design of a relay and door lock solenoid with Arduino.

2.4. Network Schematic Buzzer and Push Button

To monitor the beep alarm signal when there is a command from the microcontroller, a buzzer component is needed. The buzzer has two pins, namely In and Gnd. Enter the Arduino digital pin to be controlled.

2.5. LCD circuit schematic

A liquid crystal display is a device that functions as a display of numbers or text so that it is easier to understand. In this case, a 16x2 LCD is used as a means to display text and characters. Anyone who has placed a fingerprint on the sensor will display text in accordance with what is programmed later.

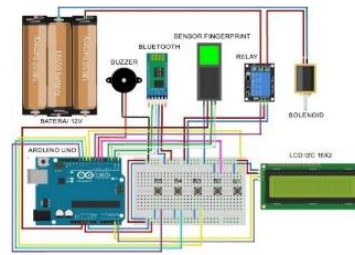


Figure 2. Tool Planning Schematic

2.6. Application Design Scheme Smartphone Android

In this section, an application will be created using the MIT App Inventor software to connect to the HC-05 Bluetooth module later. In the previous chapter, we discussed the MIT App Inventor software. MIT App Inventor is an Android application maker software that can be used free of charge, but it cannot be downloaded and can be used online at the link: <https://appinventor.mit.edu>. The initial step before entering the main menu is to log in first. Then it will be directed to the Gmail account that will be used to enter the application development stage. then create an Android application design as desired. The programming language used on the MIT App Inventor system uses the C programming language as well as Arduino, but uses a different method, namely using block code that is arranged based on the appropriate block code form. After all the program block codes have been compiled, the next step is to download the application. The communication used to activate the application as a media controller between the smartphone and tools is Bluetooth.



Figure 3. Appearance of Application Design



Figure 4. Application Icons and Application Display on Smartphones.

3. RESULTS AND DISCUSSION

Several subsystem tests, namely testing the fingerprint sensor connected to the Arduino Uno microcontroller to read available user data from the sensor memory. Second, the testing phase on the HC-05 Bluetooth module which is connected to Arduino via serial communication, and other tests such as the buzzer, relay, and push button.

3.1. Fingerprint Sensor

Before testing the fingerprint, it is necessary to register the fingerprint first using the default program from the fingerprint sensor, namely "ENROLL". It then registers the user using ID numbering and multiple fingerprints. There are two ways to attach fingerprints. For the first scan, the sensor will take an image of the fingerprint pattern, while for the second attachment, it verifies the fingerprint pattern, and the reading results will be stored in the sensor's memory. The FPM10A fingerprint sensor will be tested to see how fast it can read, differentiate, detect, and scan fingerprint patterns using registered or unregistered user fingerprint data to find out the status of the results read by the sensor, and the results of reading the data will be displayed via the LCD.

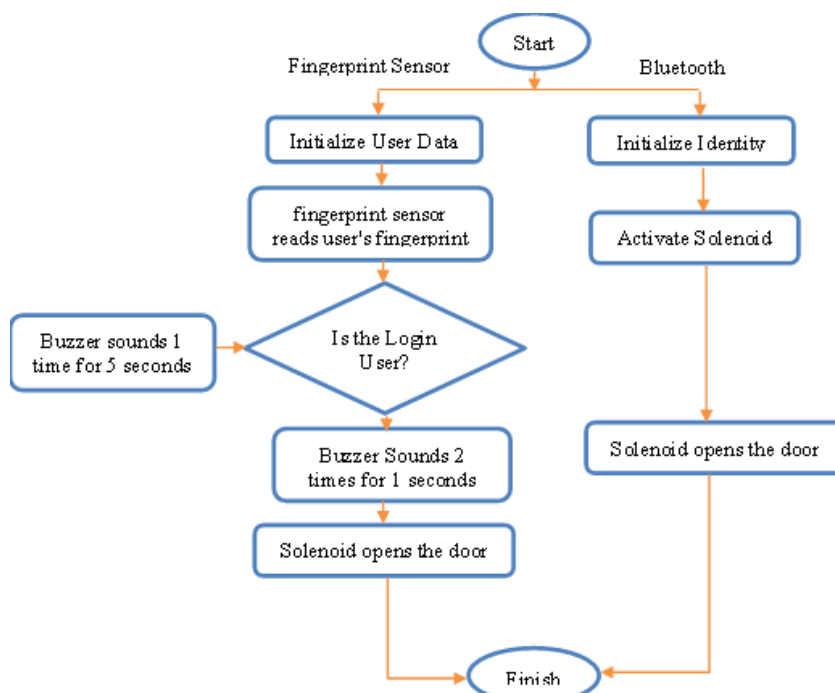


Figure 5. Flow Chart for the Whole System



Figure 6. Test Fingerprint Sensor

3.2. Bluetooth Sensor

Testing the HC-05 Bluetooth module using the help of an Android smartphone, because what will be measured is the connection distance that can be reached by the Bluetooth module, and adding obstacles or non-obstacles in the form of walls in order to find out how far the HC-05 Bluetooth module can be connected.

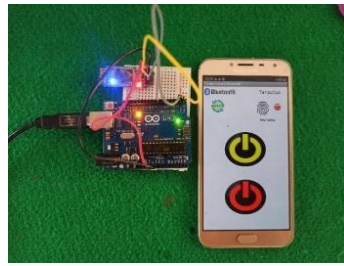


Figure 7. Test Module Bluetooth

3.3. Buzzer

A buzzer is generally an electronic component that can emit an alarm sound. Here, the researcher will test the buzzer using the power supply by connecting the two buzzer pins to the positive and negative sides of the power supply to find out if the buzzer is making a sound or not.

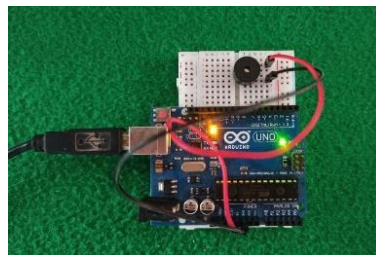


Figure 8. Test Buzzer

3.4. Relay

Electronic components that can be used as AC or DC voltage switches are relays, which are commonly referred to as automatic switches. The researcher tested this relay by connecting the in relays pin to the Arduino VCC and GND to find out whether the type of relay is a low or HIGH type. In addition, the relay output status connected to the door lock solenoid will also work if the active type is appropriate.

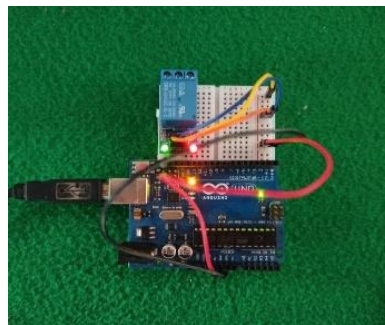


Figure 9. Test Relay

3.5. Whole System

The overall test is divided into two parts: the first is the overall test of the HC-05 Bluetooth module, and the second is the overall test of the FPM10A fingerprint sensor.

1. System with Bluetooth

Connect the Bluetooth module with an Android smartphone first with different Android brands so that you can find out the output results that work, such as buzzers, relays, and door lock solenoids. When the green button icon is pressed, the status of the button will display "Open Lock", then the LCD display will change to "Open Lock via Bluetooth," and the solenoid door lock as a door lock will also be open. Conversely, when the red button is pressed, the button status will display "Lock Closed" and the door lock solenoid will lock again.

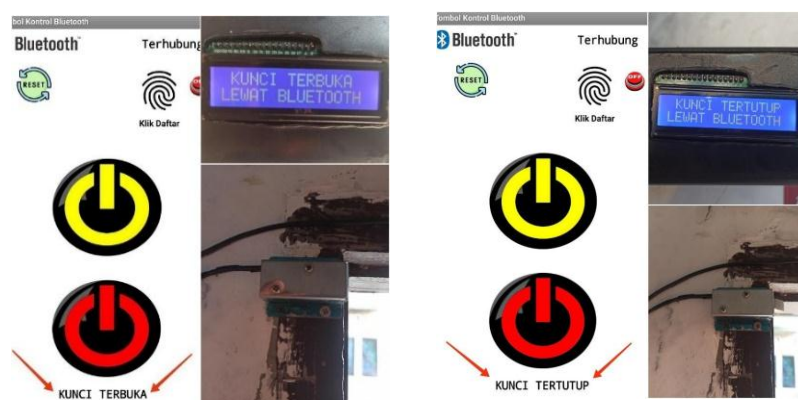


Figure 10. Display of Open-Closed Door Status on the Application

Table 1. Module Testing Bluetooth

No	Connection Distance	Obstacles (Wall)	Non Obstacles	Connection Time (Second)	Status Bluetooth	
					Connect	Disconnected
1	1 Meter		✓	0.5	✓	
2	4 Meter		✓	0.5	✓	
3	8 Meter	✓		0.5	✓	
4	12 Meter	✓		0.5	✓	
5	14 Meter	✓		0.5	✓	
6	18 Meter	✓		1.55	✓	
7	20 Meter	✓		1.70	✓	
8	22 Meter	✓		1.80	✓	
9	24 Meter	✓		-		✓
10	26 Meter	✓		-		✓
11	28 Meter	✓		-		✓
12	30 Meter	✓		-		✓

Table 2. Connection Testing Bluetooth System and Android

No	Android	Connection to Module Bluetooth HC-05		Buzzer (Sound) 2 times for 1 second	Status Relay		Status Solenoid Door Lock	
		Connect	Disconnected		ON	OFF	ON	OFF
1	Redmi Note 8 Pro	✓		✓	✓		✓	
2	Samsung J4+	✓		✓	✓		✓	
3	Realme 6 Pro	✓		✓	✓		✓	
4	Samsung A50S	✓		✓	✓		✓	
5	Samsung J4	✓		✓	✓		✓	

In the overall test table results of the HC-05 Bluetooth Module, the connection distance between the HC-05 Bluetooth Module and Android can be connected at a distance of 22 meters; it's just that starting from a distance of 16–22 meters, the speed of data transmission or connection is a little slow. The application connection status on Android is still in the connected condition. If the distance is more than 22 meters, the connection from Android to the Bluetooth module will be lost. In addition, the application has support for all types of Androids, so it allows users to use it without having to think about what kind of Android is used.

2. System Using Fingerprint

It's the same with the overall testing of the Bluetooth module, but what distinguishes the researcher is using a true-false system, where the intention is to log in with the owner's fingerprint and the non-owner's fingerprint to find out the working outputs such as buzzers, relays, and door lock solenoids. the process of attaching fingerprints to the green light area on the fingerprint sensor. If the owner or non-owner performs fingerprint scanning, the output will be known based on the customized program. For example, if a non-owner's fingerprint is pasted, the buzzer will sound once for 5 seconds, and the owner's fingerprint will sound twice for 1 second. In addition, when reading user data, the LCD will display data in the form of the fingerprint ID number, if the login is the owner, and the value of the accuracy of the fingerprint pattern. The level of accuracy will be tested by sticking fingerprints in wet or dusty conditions and examining the layout of the fingerprints at the time of attachment in order to find out whether the owner's fingerprints can be detected and also the effect on login.



Figure 11. Fingerprint Scanning Process



Figure 12. Display of User ID and Data

From the results of the overall testing table for the fingerprint sensor (Tables 3 and 4), it can be analyzed that in wet fingerprint conditions, the sensor cannot read or detect fingerprints even though the fingerprint is the owners, whereas in dusty conditions, the sensor can read the owner's fingerprints with a known accuracy value. In this case, the fingerprint sensor can only detect dusty conditions. The process for logging in using the fingerprint sensor has no effect on the value of fingerprint accuracy as long as it is tested 20 times.

Table 3. Sensor Testing Fingerprint when Finger Conditions Wet and Dusty

Testing	Sensor Fingerprint		Accuracy & Description	Status Buzzer (Sound)		Status Relay & Solenoid	
	Login	Fingerprint Condition		2 times for 1 second	1 time for 5 seconds	ON	OFF
	Owner	Wet Dusty					
1	✓		138	✓		✓	
2	✓		129	✓		✓	
3	✓		333	✓		✓	
4	✓		290	✓		✓	
5	✓		628	✓		✓	
6	✓	✓	Access denied		✓		✓
7	✓	✓	Access denied		✓		✓
8	✓	✓	Access denied		✓		✓
9	✓	✓	Access denied		✓		✓
10	✓	✓	Access denied		✓		✓

Table 4. System Testing When Using Sensors Fingerprint for Users and non-Users

Testing	Sensor Fingerprint Login		Status Buzzer (Sound)		Status Relay		Status Solenoid Door Lock	
	User	Non-User	2 times for 1 second	1 time for 5 seconds	ON	OFF	ON	OFF
1	✓		✓		✓		✓	
2	✓		✓		✓		✓	
3	✓		✓		✓		✓	
4	✓		✓		✓		✓	
5	✓		✓		✓		✓	
6		✓		✓		✓		✓
7		✓		✓		✓		✓
8		✓		✓		✓		✓
9		✓		✓		✓		✓
10		✓		✓		✓		✓

4. CONCLUSION

An automatic home door security system using a fingerprint sensor and Bluetooth control based on the Arduino Uno makes it easy for users to unlock doors both from the outside and from the inside only with Bluetooth control using an Android smartphone. It also uses a fingerprint sensor to ensure security at residential doors that are not accessible to anyone. The method used in this study is a quantitative experimental method. The result of this system is that the user's fingerprint data will be displayed via the LCD, which contains the ID number and fingerprint accuracy value when taped, as well as information that the door lock has been opened via Bluetooth. with an average fingerprint sensor reading speed of 1.65 seconds, an accuracy of 297.5, and a maximum distance of a Bluetooth connection with Android of 22 meters.

To improve this tool in the future, it is recommended to use a fingerprint sensor with better specifications and not an optical fingerprint sensor. In addition, a system with a fingerprint sensor can also be developed by mining an Internet of Things (IoT)-based system so that it is easily accessible anytime and anywhere without any distance or range limitations.

REFERENCES

- [1] S. Jovi, Rizaldi, Salahuddin, M. Widdha, & Usardi. "Sistem Pengaman Pintu Menggunakan Sidik Jari dan Android". VOCATECH: Vocational Education and Technology Journal 2, 1 (2020): 33-40
<https://doi:10.38038/vocatech.v2i1.32>
- [2] S. B, S. Dwi & Masri. "Sistem Keamanan Penyimpanan Surat Penting Berbasis *Fingerprint*". Jurnal publikasi ilmu komputer dan multimedia. Vol.1, No.2, Januari 2023, pp. 39-34.
<http://ejurnal.stie-trianandra.ac.id/index.php/jupkom>
- [3] W. Slamet, Firmansyah, & AK. Wiwin. "Rancang Bangun Sistem Pengaman Pintu Rumah Menggunakan Android Berbasis Arduino Uno". e-Jurnal NARODROID, Vol. 2 No.1 Januari 2019
- [4] S. Achmady, L. Qadriah, & A Auzan. "Rancang Bangun *Magnetic Solenoid Door Lock* dengan *Speech Recognition* Menggunakan *NodeMCU* Berbasis Android" *Jurnal Real Riset*, Vol. 4, 79-91. 2022
- [5] W. Agiv, G. F, & T. Novianti. "Rancang Bangun Pintu Otomatis Dengan Menggunakan RFID". Jurnal Teknik Elektro Dan Komputer Triac, Vol. 6, 1-6. Retrieved April 13, 2019
- [6] A. Santoso, A. Suryarismi, & A. Nugroho. "Sistem Keamanan Pintu Laboratorium Berbasis Sensor Fingerprint dan Magneti Lock". *JTT (Jurnal Teknologi Terapan)*, Vol. 6, 84-92. Retrieved April 13, 2020
- [7] H. Santoso, H Rochadiani, & H. Mayatopani,. "Pengembangan Berpikir Komputasional Melalui Pemrograman Dasar Dengan MIT App Inventor". *JPM: Jurnal Pengabdian Masyarakat Universitas Pradita*, Vol. 1, 1-10. Retrieved April 13, 2020
- [8] A. Mubarak, I. Sofyan,, A. Rismayadi,, & I. Najiyah,. "Sistem Keamanan Rumah Menggunakan RFID, Sensor PIR dan Modul GSM Berbasis Mikrokontroler". *Jurnal Informatika*, Vol. 5, 137-144. 2018
- [9] M. Iqbal, R. Hardyanto, & W Ciptadi." Sistem Keamanan Ganda Menggunakan Fingerprint Dan Keypad Pada Pintu Rumah (Smart SecuritySystem)". *Seminar Nasional*, 175-178. 2023.
- [10] K. R. S, & G Sembada. "Perancangan Sistem Keamanan Menggunakan Solenoid Door Lock Berbasis Arduino Uno pada Pintu Laboratorium di PT. XYZ". *Jurnal E-KOMTEK (Elektro-Komputer-Teknik)*, Vol. 4, 62-74. 2020

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