

Security Door Lock Using Multi-Sensor System Based on RFID, Fingerprint, and Keypad

Joni Welman Simatupang and Ramses Wanto Tambunan

Electrical Engineering Study Program, Faculty of Engineering, President University, Cikarang, 17530 - Indonesia
joniwsmtp@president.ac.id, ramses.tambunan7@gmail.com

Abstract—Thefts problem in household needs to be anticipated with home security system. One of simple methods is using automatic solenoid door lock system, so that it is difficult to be duplicated and will reduce the chance of theft action when the house is empty. Therefore, a home security system prototype that can be accessed by utilizing biometric fingerprint, Radio Frequency Identification (RFID), and keypad sensors was designed and tested. Arduino Uno works to turn on the door lock solenoid, so door access will be given when authentication is successful. Experimental results show that fingerprint sensor works well by being able to read fingerprints perfectly and the average time required to scan a fingerprint was 3.7 seconds. Meanwhile, Radio Frequency Identification (RFID) sensor detects Electronic-Kartu Tanda Penduduk (E-KTP) and the average time required for Radio Frequency Identification (RFID) to scan the card is about 2.4 seconds. Keypad functions to store password to unlock the door which produces the average time of 3.7 seconds after 10 trials. Average time to open with multi-sensor is 9.8 seconds. However, its drawback is no notification or SMS which directly be accessed by a cellphone or website with Wi-Fi or Telegram applications allow homeowners to monitor their doors from afar as to minimize the number of house thefts.

Keywords—*Sensor, Door lock, RFID, Fingerprint, Keypad.*

I. INTRODUCTION

Smart home refers to a convenient home setting where appliances and devices can be controlled automatically remotely from anywhere with an internet connection using a mobile device or other network device. Devices in a smart home are interconnected via the internet, allowing users to remotely control functions such as home security access, temperature, lighting, and home theater, door locks, televisions, thermostats, home monitors, cameras, lights, and even appliances. such as a refrigerator can be controlled through a single home automation system [1]. In Kartu Tanda Penduduk (Indonesia Identity Card) there is a Radio Frequency Identification (RFID) chip so can be detected with RFID reader. Over the past few years, researchers have explored various technologies and methodologies for the security of private property such as main doors. Security requirements can be achieved by designing different types of door locks such as mechanical locks or any electric locks. The requirement for security has become one of the principal factors behind individuals' endeavors to fabricate their own homes.

Each house is furnished with at least one fundamental passageways [2]. The primary entryway is one of the

imperative security focuses. The presence of instruments or safety efforts to control admittance to homes has been demonstrated to give the ideal wellbeing and security. Since each house is outfitted with an entryway, the entryway is furnished with a lock [3]. With an end goal to guarantee security, different sorts of entryway locks, both mechanical and electronic, have been executed. Indeed, even in the wake of utilizing such a lock, underhanded endures because of the way that such a lock has its own disadvantages. Some keys can be recovered, while others can be crippled here and there. Thus, it is important to observe different kinds of locks that are not handily harmed and regardless of whether they can be broken into, the undertaking won't be all around as simple as different sorts of locks. The point of this paper is to introduce a protected shrewd entryway lock which is intended to offer high security, simple access and control. Subsequently, the proposed framework utilizes RFID labels and Global System for Mobile (GSM) modules to carry out a safe yet simple to-utilize framework. It has the likelihood to supplant the customary entryway lock framework.

II. RELATED WORKS

Many researchers have used Radio Frequency Identification (RFID) innovation in making reference access control systems about door security. In [4], the authors used only RFID sensor so that only one protection. Paper [5] explains the security system with one keypad sensor as protection. Ref. [6] explains the security with two sensors using RFID and fingerprint, while in [7] the security system only via Bluetooth. Furthermore, paper [8] explains the security system of smart door lock with RFID and Keypad.

Initially, this work only uses an RFID card that attach to RFID reader and trying to scan a finger with a Fingerprint sensor. Then, we thought that there is no security system with a password because if you don't use any input password, the security system feels less secure because the password is only known by the owner. Therefore, the proposed prototype is slightly different because we use 3-input sensors as security system components, namely Fingerprint, RFID, and Keypad. Comparison works or performances is shown in Table 1.

Table 1. Comparison performance with previous works.

Paper	RFID	Fingerprint	Keypad	Relay	Solenoid
[4]	√	X	X	√	√
[5]	X	X	√	√	√
[6]	√	√	X	√	√
[7]	X	X	X	√	√
[8]	√	X	√	√	√
This work	√	√	√	√	√

III. DESIGN AND IMPLEMENTATION

There are three main sensors implemented in this prototype, which are fingerprint, Radio Frequency Identification (RFID), and keypad. Others are supporting components.

A. Radio Frequency Identification (RFID)

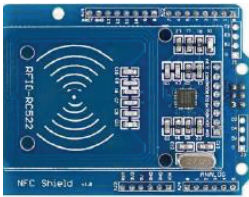


Fig. 1 RFID Chip [4].

The RC522 Radio Frequency Identification (RFID) Reader module as shown in Fig. 1 is designed to create a 13,56 MHz electromagnetic field that used to communicate with Radio Frequency Identification (RFID) tags. The operating voltage of the module is from 2.5 V to 3.3V. Passive Radio Frequency Identification (RFID) tags do not have their own power resource. Active Radio Frequency Identification (RFID) tags has already lost some of its advantages such as low cost and long-life time when embedding with power resources.

B. Keypad



Fig. 2. Keypad Module [5].

The keypad module as shown in Fig. 2 works by giving an input password to get an access to open the solenoid door lock. This component gets voltage of 3,3 Volts from the Arduino Uno microcontroller.

C. Arduino Uno

Arduino Uno microcontroller board module with detailed specifications used in this prototype. It has 14 digital input or output pins, where 6 of which can be used as PWM outputs, 6 analog inputs, a 16 MHz ceramic resonator [9]. A USB connection, a power jack, an ICSP header, and a reset button to support the microcontroller by simply connecting it to a computer with USB cable or power it up with an AC-to-DC adapter or battery to get started.

D. Fingerprint AS608



Fig. 3. Fingerprint Sensor [10]

Fig. 3 shows biometric fingerprint that works with voltage of 3.3 Volts and can store fingerprints with a maximum of 127 different numbers, making it possible for this sensor to be very large and can be made on a high scale.

E. Electronic-Kartu Tanda Penduduk



Fig. 4. E-KTP identity card.

Fig. 4 shows an E-KTP card as the identity of an Indonesia citizen. Now, E-KTP has been equipped with an RFID chip so that it is possible to use as one of sensors.

F. Relay

Relay is component module which functions and works like a switch that is operated electrically and its behavior just like an electromagnetic component [5].

G. LCD 16X2

LCD which is ideal for displaying text or characters, hence it is called as 'Character LCD'. The display is LED backlit which can display 32 ASCII characters in two lines with 16 characters on each line [11].

H. Buzzer

Buzzer as an audio signaling devices such as pagers or buzzers may be of the electromechanical or piezoelectric or mechanical type. Its main function is to convert the signal from audio into sound. Generally, it is powered via DC voltage and is used in timers, alarm devices, printers, alarms, computers, etc [12].

I. Design of Full Device Prototype

The method used in this research is an experimental setup, with aims to build and test a 3-inputs door lock prototype with fingerprint, RFID, and keypad sensors as a (modern) home security system prototype.



Fig. 5. Full device prototype of 3-level security system (front-view).

Fig. 5 shows the full embedded device prototype on a door. Therefore, we can directly test it in the field and of course the results of this method can be maximized or revised again if during our experiments we find things that are not appropriate. As we can see there are several sensors to be able to run the RFID security door lock. There are 3 main sensors that are the benchmark for the success of the results of this project, namely fingerprint, RFID, and keypad. The first is the Fingerprint sensor which functions to read biometric fingerprints, this fingerprint can store fingerprint data for up to 127 fingerprints, so this component fits perfectly with the success of this work. Then there is an RFID (Radio Frequency Identification) sensor that functions as a card reader in which there is an RFID chip transmitter, which is used in this project is my own E-KTP, where the E-KTP has a chip in it that allows it to be read by the RFID Reader. And

the last sensor is that we use the keypad sensor which functions as a password so that the numbers 1 to 9 and the letters ABCD so that this component is very relevant to the success of this work which can maximize the security system. Then there are additional components such as relay and buzzer. Relay functions as a digital switch. If the results of the three main sensors are successful and correct, then the relay will trigger the voltage to the solenoid which functions to open the door. If someone wants to try to open the door and try the three main components starting from the first (which is the fingerprint), but fails, then Arduino will trigger and give voltage to the buzzer as a signal that someone wants to try to open the door but fails. So, it is likely that someone is a thief. This 3-inputs security door lock system prototype can be multifunctionally on one side of layered security.

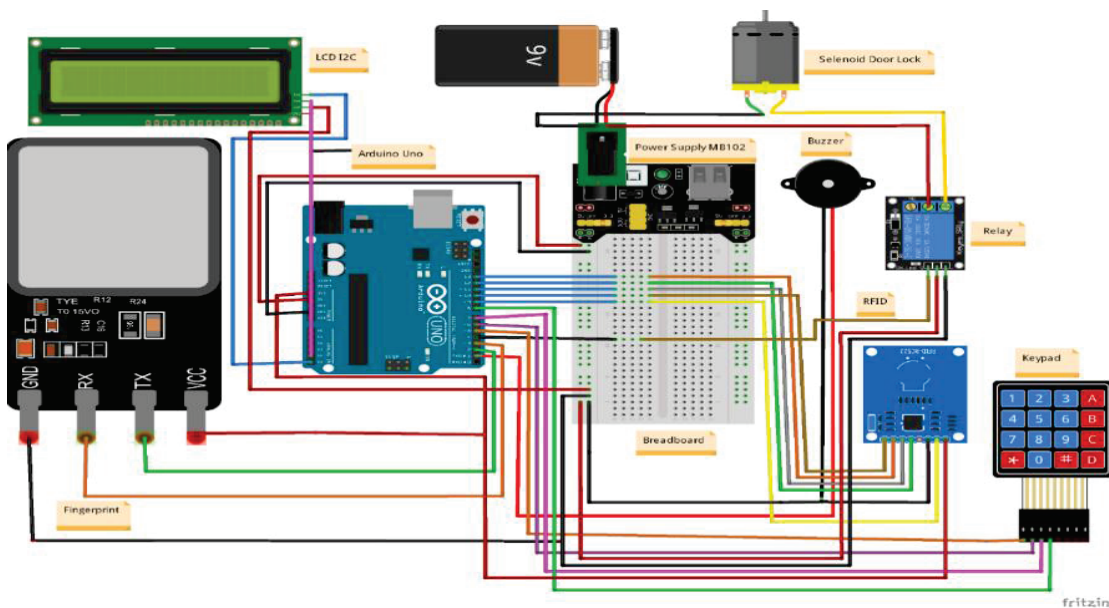


Fig. 6. Schematic diagram of device full prototype.

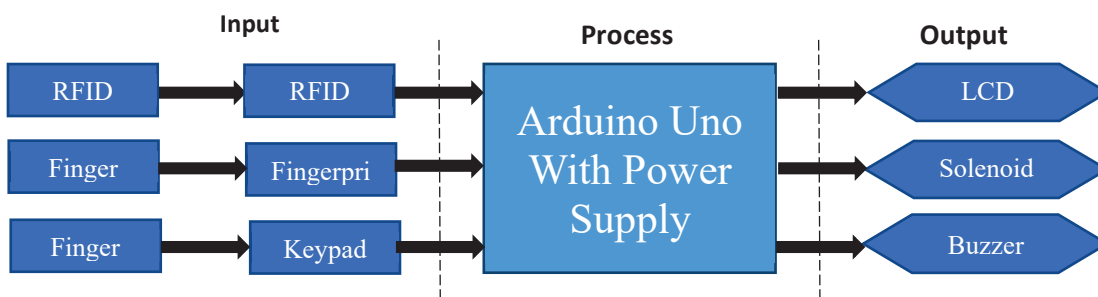


Fig. 7. Block diagram of device prototype.

Fig. 6 shows us a schematic diagram of our full device prototype after finished assembly. The main components are three sensor which is fingerprint sensor, RFID chip, and keypad (polyphonic tone) sensor to input password to get the door is open. The main voltage is 3,3 V for fingerprint sensor and also RFID module. But, it is 5 V for the keypad module, LCD 16X2 and I2C, Buzzer and also the input 5V, and Relay. While for the solenoid door lock, its input voltage must be 12 V and 9 V and also MB102 as the power

supply for all the device prototype must be applied to maintain the constant and stable voltage.

Fig. 7 explains the block diagram of this prototype. There are power supply and two input which is RFID Tag and fingers and three output which are LCD Screen, Solenoid Door, and Buzzer. There are also three main sensors for this project, which are RFID module, Fingerprint sensor, and Keypad module. In the middle part is the Arduino Uno with power supply for the processing all sensors. Again, for output, there are LCD screen 16X2 for display, solenoid door, and also a buzzer for the notification if there is something wrong with the input.

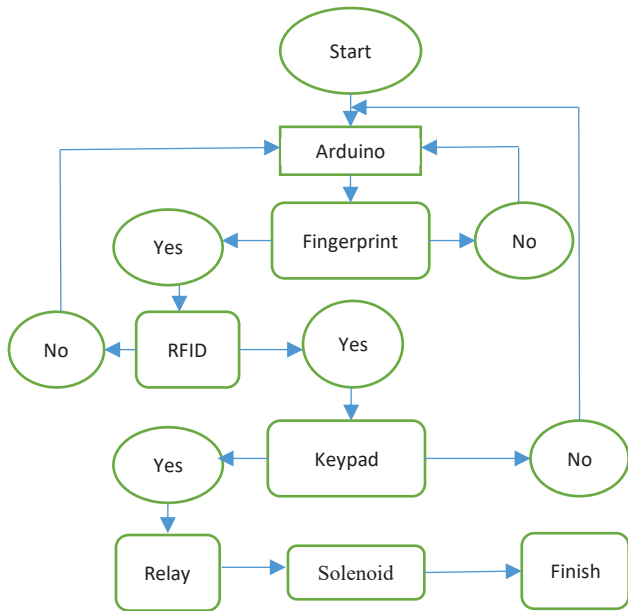


Fig. 8. Flowchart of full device prototype.

Fig. 8 shows the flowchart for this work. The first step is Arduino get input from power supply and Arduino giving output voltage to Fingerprint and if the Fingerprint is correct going to RFID and if RFID is correct so the going to Keypad module and if giving input password is correct is going to relay and then Solenoid can open the door and then repeat again from the start.

IV. RESULTS AND ANALYSIS

The results will be divided into three parts, to make it easy for readers to understand. The first result is taken from the fingerprint sensor experiments as shown in Fig. 9.



Fig. 9. Point of view scan the fingerprint sensor.

Table 2. The average time results to scan finger.

Total Experiment	Time (s)
1	3,6 s
2	3,8 s
3	3,5 s
4	3,7 s
5	3,9 s

In this test we used finger as input for the biometric

fingerprint sensor. Table 2 shows the results of 5 correct fingerprints trials. The average time for the door access is 3.7 seconds.

The second results are taken by using E-KTP to be scanned by the RFID reader module as shown in Fig. 10. The E-KTP is moved closer to the RFID for reading.



Fig. 10. Point of view scan the RFID card with E-KTP.

Table 3. The average time results to scan E-KTP.

Total Experiment	ID Card	Time (s)
1	04 7B 12 6A 43 5A 80	2,0 s
2	02 AC 95 11 40 4D F0	2,2 s
3	04 25 FA C8 78	2,5 s
4	B0 03 DE ED 28	2,1 s
5	02 C4 B9 D0 22	2,2 s
6	D9 24 22 F1	2,6 s
7	04 25 5CFA 81 5B	2,4 s
8	02 AC9511 40 4D F0	2,9 s
9	02 B6 DC 11 10 D0	2,4 s
10	CF B7 F5 DC	2,7 s

Table 3 above shows the results from RFID scanner to get the ID if correct and the average time to process one E-KTP reading is about 2.4 seconds.

The third result is taken from the Keypad sensor by processing the input password as shown in Fig. 11.

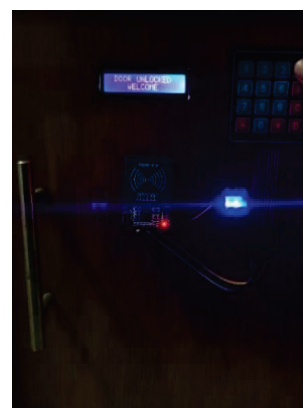


Fig. 11. Point of view input password to keypad sensor.

Table 4. The average time results to scan password.

Total Experiment	Time (s)
1	3,6 s
2	3,8 s
3	3,5 s
4	3,7 s
5	3,9 s

In Table 4, the results show five times correct input password and the average time to scan the password is 3.7 seconds. In this last testing we input the password and if the password is correct so it will be triggering the relay and the relay will deliver a 12 V to solenoid and the door will be automatically opened. There might be a delay when the door is opened for 3 seconds before the door is closed again. Then this experiment can be repeated from the beginning by scanning the finger using fingerprint sensor.

V. CONCLUSION

Multi-sensor security door lock system with fingerprint sensor, RFID module, and keypad sensor has been successfully designed, implemented, and tested. When a finger is brought near to the fingerprint sensor, the sensor will read the results of the fingerprint and even can store up-to 127 fingerprints, which allows this prototype work to be tested on a large scale. Furthermore, it is also safe from fingerprint similarities can be proved in Fig. 13. that the fingerprint sensor can only process fingerprint readings with the thumb that I have inputted into the arduino code. The average time required to perform a fingerprint scan is 3.7 seconds. Then when the ID card with the RFID chip approaches the RFID reader, it will open the door if the ID card has been input into the Arduino code. And if the ID card has not been input, it will emit a buzzer sound and access is denied and the door remains locked. Then the average time required for RFID to scan the RFID card is 2.4 seconds after 10 trials. And finally the keypad sensor functions well which after doing five attempts (trials) by entering a password with the resulting average time is 3.7 seconds. Total average time to open a door with 3-inputs multi-sensor prototype is 9.8 seconds. Future improvement can be made by adding Node MCU (ESP8266) so the homeowner will feel more secure because this Node can monitor a home condition in real-time and message notification can be sent directly (e.g. by Telegram) using Wi-Fi. This is automatically done so that the security features of the prototype will be more excellent and the owner could be freed from home theft cases.

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