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Microcontroller-Based Door Security System Design Using Fingerprint

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ABSTRACT

Technology encompasses all means that fulfill human needs for survival and comfort, and provides specific benefits in various sectors. In this modern era, technology permeates various aspects of everyday life, including security. The objective of this research is to design and implement a door security system based on a microcontroller utilizing fingerprint technology. This system is designed to allow restricted access to a room or area by verifying the user's identity through their fingerprint. The equipment used in this research includes Arduino UNO microcontroller, NodeMCU ESP8266, electromagnetic lock, fingerprint scanner, keypad, relay, door sensor, and Arduino IDE. Prototyping method is employed in the development of this system, with a focus on creating a model or prototype before full implementation. The results of this research indicate that the door security system can recognize registered fingerprints. The evaluation will cover the success of fingerprint recognition and the overall system performance. This research is expected to contribute to the development of biometric-based security technology.

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1. INTRODUCTION

Technology encompasses all facilities that provide human needs for survival and comfort, and provides specialised benefits in various sectors. In today's modern era, technology encompasses various aspects of daily life, including security technology. Security technology is one of the important aspects in this modern era, used to protect devices, computers, offices, homes, and more[1]. In the field of security technology, there are various media and methods of use. There are also those that utilise automated systems/internet, where these systems can be operated through a network and accessed remotely, known as the Internet of Things (IoT).

The Internet of Things (IoT) is an innovative technology that aims to utilise the continuous connectivity of the internet to connect objects around us in our daily activities, making it easier and more efficient. In security aspects, for example in securing doors, this technology can utilise RFID (Radio Frequency Identification), websites, applications, and other methods[2].

Fingerprint is an electronic device that utilises a scanner sensor to detect an individual's fingerprint, which can then be used for identity verification[3]. It is important to remember that each person has a fingerprint with a unique code[4]. It is this code that is used to identify a person. Nowadays, fingerprint sensors can be found in various electronic devices such as smartphones, entry doors, attendance devices, and various other electronic devices.

The Arduino UNO is a single-board microcontroller that operates on open-source principles and is based on the wiring platform. Its purpose is to simplify the application of electronics across different domains.Arduino Uno is a microcontroller board based on ATmega328 (datasheet)[5]. This board is equipped

with 14 digital input/output pins, where 6 of the input pins can be used as PWM outputs, as well as 6 analogue input pins. It also comes with a 16 MHz crystal oscillator, USB connection, power jack, ICSP header, and reset button. To activate the microcontroller, simply connect the Arduino Uno Board to a computer via a USB cable or use a power source with a DC adapter or AC battery. The approach to be applied is the prototyping method. By using this method, the development of a system that is constantly being improved can be made easier and simpler through collaboration between users and analysts[6]

2. RESEARCH METHOD

This research adopts the Prototype method, which is a system development approach that utilises prototypes to illustrate the system in detail. It is intended that the client or system owner gains a clear understanding of the system to be developed by the development team. The system prototype produces features and acts as a model of the information system. A system prototype that fulfils all requirements is ready for implementation, as shown in Figure 1.

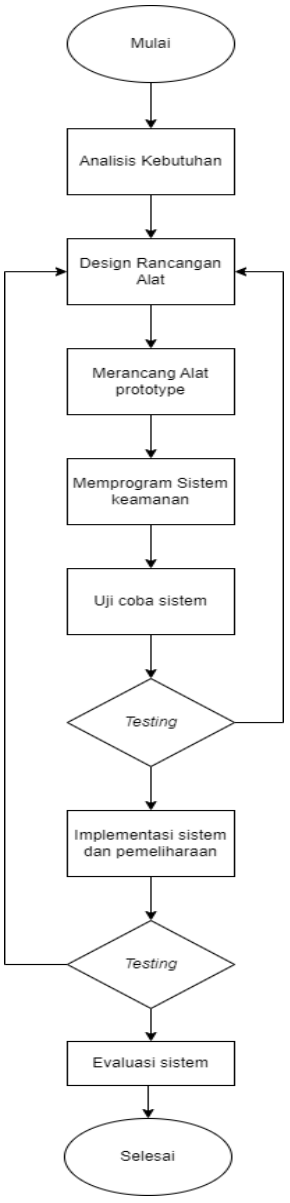

Figure 1. Flowchart of Research Method and System

2.1 Requirement Analysis

Before moving to the next stage, researchers will conduct an analysis to understand the needs and functions of the equipment. In addition, the concept and materials to be used during the design and development process of this tool will be analysed**.**

2.2 Tool Design

Designing a tool design is the first step before creating a piece of equipment or product. This is done to provide guidance in the manufacturing process, so that it can be carried out in a more structured and directed manner, with the hope of reducing or avoiding errors. Therefore, researchers started by making a tool design first.

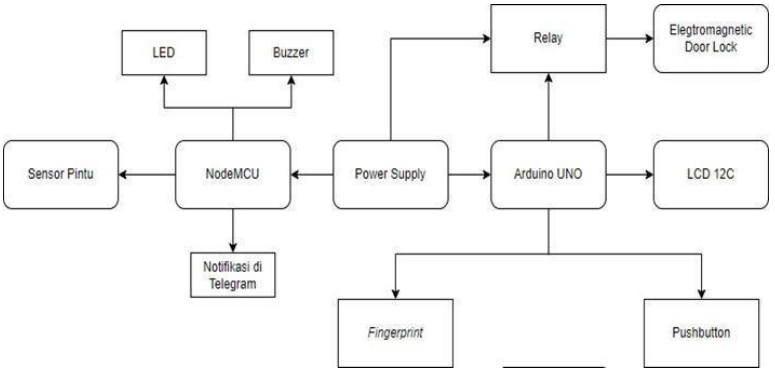

Figure 2 Design and build equipment

2.3 Tool Components

A. Hardware Components

In the design of the tool design, the door security system tool uses hardware and software.

1. The adapter is a tool that functions to convert AC voltage (electricity from PLN) into DC. The adapter selection is adjusted to the DC voltage that has been converted by the adapter from the AC voltage.
2. Relay
   Relay is a device that works based on electromagnetic principles to drive a number of connected contactors or electronic switches that can be controlled from other electronic circuits using electricity as an energy source.
3. Em lock
   Em Lock or electromagnetic lock is an automatic door locking device consisting of an electromagnet and a dynamo plate. The principle works by using a magnetic field to lock the door.
4. PCB
   (Printed Circuit Board) is a board used to connect electronic components with conductor lines.
5. NodeMCU
   NodeMCU is an electronic module based on the ESP8266 chip that has the ability to perform microcontroller functions and can be connected to the internet via Wifi[7].
6. Keypad
   The keypad is used as input to enter an existing pin, code, or password to unlock the door.
7. Sensor Magnetic switch door
   The Magnetic switch door sensor serves as an indicator if the door is open and is placed on the Electromagnetic Door Lock.
8. Arduino ATmega328
   The Arduino ATmega328 is a microcontroller used as the brain of the equipment that will control several other components, such as relays, fingerprints, keypads, and pushbuttons.
9. Fingerprint
   Fingerprint is a sensor device that functions to detect fingerprints.'

B. Software Component

1. Telegram is one of the communication applications that are available on smartphones, and this application also has the ability to create a telegram bot programme. In the design of the device, this application is used to monitor the security of the door where there will be a notification when there is an entry.
2. Arduino IDE is software used to develop microcontroller applications starting from the process of program creation, compilation, to uploading.

2.4 System Testing

The researcher tested the system using the software after it was programmed. Before testing, the researcher programmed the system first and verified or checked it using the software to ensure whether there were any problematic programmes or it was completely valid. Once it was confirmed that there were no errors, the programme was uploaded to the microcontroller used.

3. RESULT AND DISCUSSION

The results of the needs analysis from using this Security system require several Security systems desired by users, which are as follows;

a. The security system needed by users is a security system that can lock the door automatically using a magnet.
b. Security system that can be accessed using fingerprints to facilitate access but still prioritise safety.

1. Tool Design

In this step, researchers create drawings or designs of equipment or products as a guide in the production process, aiming to ensure that the process runs in a structured and directed manner to avoid errors. Researchers use the Fritzing application to design equipment designs using the components that will be used. This application can be accessed through the website. Based on the previous needs analysis, researchers made a tool design design according to the microcontroller and other components that had been planned. The tool design can be seen in Figure 3.

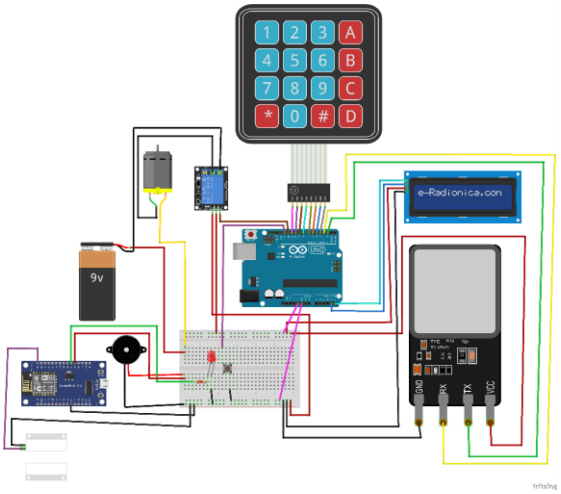

Figure 3 Design of the device

2. Programming The System

The door security system tool that can be accessed using a fingerprint requires software because there are two modules that need to be programmed in order to command some of the components used, and the two modules are Arduino UNO, and ESP8266, for the ESP8266 module it is used so that it can connect to the internet network To program the two modules using Arduino IDE software.

A. Arduino Uno Installation

The Arduino UNO module needs to be programmed so that it can command several other modules and the module is a fingerprint sensor.

- Set Up on Fingerprint

```
void tambah_sidikjari() {
  eadd = EEPROM.read(10);
  delay(200);
  eadd += 1;
  if (eadd > 50) {
    eadd = 0;
  }
  EEPROM.write(10, eadd);
  getFingerprintEnroll(eadd);
}

void hapus_sidikjari() {
  finger.emptyDatabase();
  eadd = 0;
  EEPROM.write(10, eadd);
  lcd.clear();
  delay(15);
  lcd.setCursor(3, 0);
  lcd.print("Sidik Jari");
  lcd.setCursor(1, 1);
  lcd.print("Telah Dihapus");
  delay(2500);
  lcd.clear();
  delay (15);
  menu_utama = true;
}
```

Figure 4 Adding and Deleting Fingerprint Indexes

```
uint8_t getFingerprintEnroll(int id) {
  int p = -1;
  lcd.clear();
  delay(15);
  lcd.setCursor(1, 0);
  lcd.print("Silahkan Scan");
  lcd.setCursor(3, 1);
  lcd.print("Sidik Jari");

  while (p != FINGERPRINT_OK) {
    p = finger.getImage();
    switch (p) {
      case FINGERPRINT_OK:

        break;
      case FINGERPRINT_NOFINGER:

        break;
      case FINGERPRINT_PACKETRECIEVEERR:

        break;
      case FINGERPRINT_IMAGEFAIL:

        break;
      default:

        break;
    }
  }
```

Figure 5 Fingerprint Scan Coding

Figure 4 and 5 shows the code to add and delete fingerprint indexes that will be registered and those that have already been registered. Therefore, to use the fingerprint sensor, it is necessary to do the coding or programming process first. Whereas in Figure, the focus is entirely on the programming process to register or scan fingerprints on the fingerprint sensor implemented in the device that has been designed**.**

B. System Testing

Operating this sensor requires registering each person's fingerprint against the sensor. Here is how to operate:

- **Or fingerprint input on the sensor fingerprint**
    - Click the letter "A" on the keypad, and there will be a command on the display "please scan fingerprint" as shown below.

Figure 6 Display of "Please Scan Fingerprints”

- Place your fingerprints according to which finger you want to use,
- Follow the command that will appear on the display.

Figure 7 Display text "Release

- Fingerprint saved or successfully saved

Figure 8 Display Text "Successfully Saved”

- **Delete Fingerprint data**
  1. To delete all the fingerprint data registered on the
  2. system, admin can click the letter "B" on the keypad,
  3. Fingerprint data deleted.

Fingerprint sensors can be accessed by 162 fingerprints but the system is programmed with only 50 fingerprints and when 50 fingerprints are registered the system will automatically delete them, in the sense that for people who have registered in the sensor if there are already 50 fingerprints stored the system will deny access to the fingerprint.

3. Fingerprint detection accuracy

Table 4.1 Fingerprint Accuracy Experiment

Experiment	Information		Amount
	Succeed	Fail	
first	15 times	5 times	20 times
second	18 times	2 times	20 times
third	16 times	4 times	20 times
fourth	19 times	1 times	20 times
Fifth	17 times	3 times	20 times
Total	85 times	15 times	100 times

In Table 4.1, from five sets of experiments, with each experiment being conducted 20 times, totaling 100 trials. The results show that the fingerprint sensor functions well because it succeeded 85 times and failed 15 times. This results in a success rate of 85% and a failure rate of 15%.

3. CONCLUSION

The results of this research involve the utilization of a prototyping approach to design and create a door security system that can be accessed via IoT-based fingerprint. This process involved the development of a model or prototype of the door security system prior to its full-scale implementation. The system employs biometric technology (fingerprint) as means of gaining access to unlock the door. Additionally, it has the capability to send notifications about the door's status through the Telegram application. The operation of the IoT-based fingerprint door security system functions as follows : when a fingerprint is detected by the sensor is correct, the system will interrupt the electric current to the electromagnetic door lock through a relay, allowing the door to open. The measurement results encompass voltage measurements needed by the microcontroller, along with an assessment of the success and failure rates in fingerprint recognition based on a series of experiments. The evaluation outcomes of the IoT-based fingerprint door security system reveal that the system is unable to identify the owner of the fingerprint attempting to access it, and the monitoring through the Telegram application via a bot fails to dispatch notifications concerning system access.

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