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Implementing Fingerprint Attendance with Fuzzy Logic enhances employee attendance efficiency in a modern workplace

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Abstract

The application of fingerprint technology in attendance tools provides a modern solution for managing employee attendance, offering increased operational efficiency, high precision, and robust data security. This technology integrates advanced fingerprint sensor technology and fuzzy logic for accurate attendance evaluations. The uniqueness of individual fingerprints makes identification difficult to counterfeit, thereby reducing the risk of fraudulent activities and data manipulation. The integrity of attendance data ensures its direct integration with the payroll system, simplifying the salary calculation process. The introduction of a fingerprint attendance tool can lead to reduced administrative costs, increased staff productivity, real-time attendance monitoring, and promotion of disciplinary behavior. The research methodology involved capturing an individual's fingerprint image and converting it into a digital template for authentication. The research shows that using fingerprint technology in attendance tools can provide numerous benefits for companies, including prevention of fraudulent activities and data manipulation, ultimately reducing administrative costs and improving data security. The implications suggest that fingerprint technology in attendance tools can be an effective solution for managing employee attendance in modern companies, helping companies achieve their operational efficiency and staff productivity goals.

Keywords: fingerprint, salary, technology.

INTRODUCTION

Current advancements in science and technology have a noteworthy influence on agencies across different sectors. In order to enhance service quality, an efficient mechanism is required to measure employee performance. Indonesia's electricity demand is growing rapidly, driven by robust economic growth combined with unprecedented urbanization and industrialization (Akbar dkk., 2019). One crucial approach to evaluate employee performance is by monitoring their attendance. Manual attendance systems, whereby employees fill out attendance forms, are deemed ineffective due to their susceptibility to manipulation, leading to a loss of authenticity in workplace attendance data. Accurate and specific attendance records form a critical foundation that underpins the successful operation of employee activities and performance, particularly in an industrial setting. Managing employee absenteeism poses a significant challenge for companies, particularly given the various

factors such as tardiness, permission and absenteeism that may impact productivity and efficiency. Moreover, the need for ensuring fairness and accuracy in salary calculations has become increasingly pressing. Fingerprint attendance technology has emerged as a commonly utilised solution to address this issue; however, it requires a smart approach when analysing attendance data (Siskandar, Indrawan, dkk., 2020).

In Industry 4.0, the Internet of Things (IoT) is a prevalent technological concept promoting object connectivity. Internet of Things (IoT) is a system that connects devices directly or indirectly to the internet (Siskandar, Fadhil, dkk., 2020). Attendance serves as a tool for monitoring employee performance, automatically controlled through a website. This study aims to develop an IoT concept that utilises fingerprint technology to provide both an attendance tool and employee performance monitoring. The Internet of Things (IoT) is one of the five key technologies facilitating the progress of Industry 4.0. It embodies the notion of connecting machinery or objects, and humans among themselves and with each other via the Internet (Riskiono dkk., 2020). IoT ecosystems can be implemented in limited spaces, such as buildings, or expanded to larger areas, such as cities. IoT is revolutionising the way we interact, communicate, and carry out daily activities. (Paolone dkk., 2022)

At present, the system records attendance-related data for employees absent due to illness, permission, or external duties, and calculates absence summaries by scrutinising the attendance data of each employee individually. The payroll calculation process is impeded by the inefficiencies and time consumption of the current system, as control over employees' work entry and exit hours is difficult. Employing manual systems can increase the likelihood of errors in the recording process (Roosdianto dkk., 2021). Furthermore, retrieving previous archive data can be a time-consuming task, and data from previous periods may be lost or inaccessible (Romindo, Novia Amelyia Ganesha Medan, 2019).

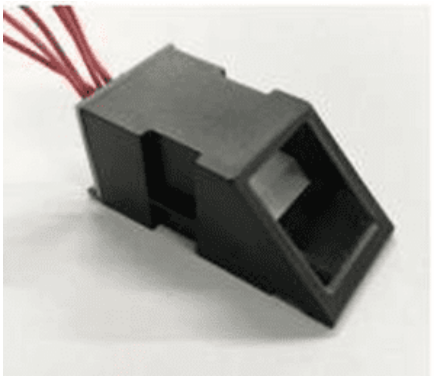


Figure 1. Fingerprint Module

According to (Khairuman dkk., 2022), a fingerprint is an electronic device equipped with a fingerprint scanning sensor that can identify the type of a person's fingerprint and verify their attendance data. The use of fingerprint technology has emerged as a solution that simplifies the attendance process and prevents potential data manipulation. A fingerprint-based employee attendance monitoring system is one of the strategies employed to enhance employee performance. The use of fingerprint technology for attendance tracking is rapidly growing in popularity due to its simplicity and affordability, which significantly improves the efficiency and accuracy of employee attendance management.

The fuzzy logic approach can be developed into a flexible programming model because the fuzzy membership set was developed objectively to be able to assess with certainty the fuzzy input and output variables, making it easier to make decisions (Hidayat dkk., 2021). Fuzzy logic is an integral component of artificial intelligence systems that emulate human thinking using algorithms to process data. Fuzzy logic is an integral component of artificial intelligence systems that emulate human thinking using algorithms to process data. This method is adept at dealing with complex and uncertain data. Fuzzy logic is a suitable method to map the input space into an output space, providing

continuous value (Raga Djara dkk., 2019). Fuzzy logic is a suitable method to map the input space into an output space, providing continuous value (Raga Djara dkk., 2019). Hence, integrating fuzzy logic is a compelling approach in this context. With the integration of fuzzy logic, we can obtain precise categorisation of employee attendance, resulting in salary calculations that are more equitable and consistent with actual attendance levels.

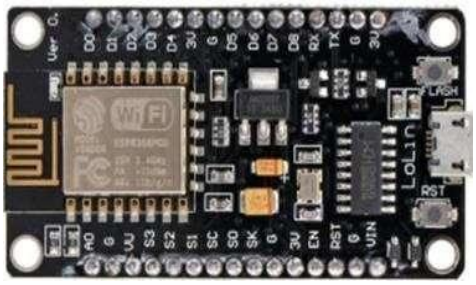


Figure 2. ESP 32

Selecting the appropriate module is crucial for the effective operationalization of the Internet of Things (IoT). In previous research, multiple performance tests were undertaken on IoT supporting modules with communication media. Among these is the ESP32, a product developed by Espressif that boasts two communication media on its chip, namely Bluetooth and Wi-Fi. ESP32 is a cost-effective and energy-efficient range of camera module systems that feature integration with a microcontroller, Wi-Fi, and Bluetooth dual-model on a single board (Noerifanza, 2022). It serves as a successor to the ESP8266 microcontroller, introduced by Espressif Systems. With an inbuilt WiFi module, it is particularly conducive for developing internet of things applications (L. Sari Raena, 2021).

Organic Light Emitting Diodes (OLED) are photonic devices that consist of a cathode as the negative side, an anode as the positive side, and an emissive layer of organic material that produces light when a current is applied. OLEDs are advantageous for use in flat displays with low voltage. The most basic OLED structure is a single Organic Light Emitting Diode (OLED) structure that comprises only a cathode, an anode, and an emissive layer.

Figure 3. OLED

OLED is a display media commonly used for Arduino modules or other controllers. It has a size of 0.96 inches and a resolution of 128x64, providing sharp pixel contrast without requiring a backlight, thus saving power consumption. The quality of OLED can be determined by its current and voltage characteristics, which should be in line with diode characteristics, allowing the OLED to emit light. (Khoerun & Udhiarto, 2019)

A database is a system designed for organizing, storing, and easily retrieving data. It comprises a collection of data that is organized in digital format for one or more uses. A Database Management System (DBMS) is utilized to manage digital databases, storing the contents, and allowing for data creation and maintenance, along with facilitating search and access. Available databases include Mysql, Sql Server, Ms.Access, Oracle, and PostgreSql (Ramadhan & Mukhaiyar, 2020). In the present study, the SQL operating system of choice is MySQL. The developers of this

system aimed to create a fast, reliable, and user-friendly database service. MySQL is a multi-user system that employs Structured Query Language (SQL) (Syah Putra & Novembrianto, 2021). Widely recognized as a leading database server, MySQL employs SQL to manage its stored data. Additionally, users may choose to abide by a FOSS License Exception or opt for a commercial license. MySQL is available on several platforms, including Windows and Linux. To simplify MySQL administration, you can use software such as PHP MyAdmin and MySQL.

PHP is a programming language designed for creating website programs that compile and execute program code on the server side to generate dynamic website pages. PHP was initially developed for Personal Home Pages. Due to its numerous benefits and strong development capabilities, PHP is commonly referred to as a hypertext preprocessor (Gusmaliza Debi, 2019). PhpMyAdmin is an open-source application that allows us to freely perform programming and administrative tasks on MySQL databases. Additionally, phpMyAdmin utilizes the PHP language for programming and supports a variety of MySQL operations such as managing databases, tables, fields, relations, indexes, users, and permissions. It can be concluded that there is a distinction between phpMyAdmin and MySQL. phpMyAdmin serves as an aid in navigating the MySQL database, while MySQL primarily functions as a database for data storage.

This article differs from previous studies. The research supports prior research and was conducted through a literature review involving the analysis and understanding of several studies.

- Prior research by (Setyawan dkk., 2021) involved the creation of a website-based fingerprint attendance tool utilizing the ESP8266 NodeMCU, which still utilizes the ESP8266 WiFi module. Espressif Systems developed both the ESP8266 and ESP32 WiFi modules. However, the ESP8266 only has one CPU core and does not support Bluetooth, while the ESP32 features two CPU cores, supports WiFi, Bluetooth Classic, and BLE. Additionally, the ESP32 provides more RAM and Flash, a greater number of GPIO pins, and more comprehensive peripheral interfaces. While the ESP8266 is usually a more cost-effective option, the decision between the two rests on particular project requirements, including performance, Bluetooth connectivity, and resource accessibility. Therefore, in terms of microcontrollers, ESP32 is a better choice for improvement.
- Previous research conducted by the Telecommunications Study Program (Rizki Fauzi, 2020) has also produced an innovative solution for recording attendance using a displayed QR code. This innovation cannot be carried out for research now, because it is not efficient to do it continuously, employees could forget to bring the QR Code or the QR Code is damaged and lost, so an efficient fingerprint system is needed, namely fingerprint biometrics. Every human being has fingerprints, and these fingerprints are different, making this a development of previous research.
- Previous research on Bicycle Security (Pinem dkk., 2021) used a primary circuit consisting of a fingerprint sensor as a reader, an LCD display for information, and a buzzer to indicate tool errors. For further development, a buzzer or speaker should be included to signal when fingerprints are successfully registered or not, or when the absence is successful or unsuccessfull.

This study employs a fingerprint-based attendance system utilizing fuzzy logic, with the primary aim of enhancing employee attendance monitoring efficiency and preventing attendance fraud, thereby mitigating instances of data theft and double absenteeism. This technology is anticipated to be a groundbreaking and proficient remedy to surmount predicaments linked to monitoring employee attendance. This, in turn, will endorse the company's pursuit to enhance its efficiency and operational Data collection techniques.

METHODS

The construction of this tool will be carried out over 5 months, from 1 August to 31 December 2023, with daily implementation. The manufacturing of this tool will be carried out at the IPB Vocational School Hardware Lab, as well as in partnership with PT. Nirwana Tirta, Kp. Nyalindung RT 03 RW 03 Kel. Sukamantri, Tamansari District, Bogor - Indonesia.

1. Data collection techniques

Data collection techniques used during the implementation of field work practices and the production of tools according to the needs of partners include several approaches, including

- Conducting a literature review to explore information on the latest developments in IoT technology, hardware and software that are essential for creating IoT tools, as well as examples of similar implementations that can serve as references for the tools being developed.
- Conduct interviews with companies or potential users of the IoT tools to be developed. The purpose of these interviews is to obtain valuable input on the specifications, features and needs desired by the users of the tool.
- Make direct observations of the object or situation that is the focus of the IoT tool to be developed. It is hoped that direct observation will provide detailed information about how the tool works and the specific needs to overcome the problems faced.

2. Data Analysis

In analysing the data collected during the fieldwork exercises and the development of the Fingerprint Attendance tool, the following analysis was carried out:

- Fingerprint reliability analysis: Evaluate the extent to which the Fingerprint Attendance system works in identifying employees' fingerprints. Measure the level of accuracy of fingerprint recognition and analyse the error rate in the identification process.
- Analyse the efficiency of tool usage: Analyse the patterns of use of the attendance tools, including the regularity and timeliness of attendance recording.
- System security and vulnerability analysis: Assess potential security risks associated with fingerprint attendance technology. Identify potential vulnerabilities in employee attendance data storage systems and ensure information security.

3. Procedures

1. Data analysis

The initial phase of the implementation of this placement involves two main aspects, namely problem analysis and needs analysis in relation to tool development. In problem analysis, the focus is on collecting information related to existing problems in the management of electronic devices that are being developed. Meanwhile, requirements analysis focuses on identifying the tools and materials needed to design and build a new system. These needs are then determined based on the problems identified during the problem analysis phase.

2. Design

In the tool design stage, the manufacturing process will follow a series of block diagrams and flowcharts that have been previously planned. Block diagrams are used to visualise the function and flow of the whole system, while flowcharts detail the operational processes step by step. In addition, an electronic circuit design is carried out at this stage to determine the placement and relationships between electronic components. Mechanical design is also considered to describe the physical and ergonomic aspects of the tool to be produced.

3. System integration

This stage is concerned with the integration of software and hardware. It involves connecting hardware to software, configuring parameters on both hardware and software, and ensuring that stable communication is established between the various components.

4. System testing

This stage is carried out after the integration process has been completed. The attendance system is thoroughly tested to ensure that all components function according to the design specifications. Testing includes a series of tests specifically designed to identify and resolve errors, evaluate performance and verify that the attendance system meets all specified requirements. Testing is conducted in a variety of usage scenarios, including standard operating cases as well as extreme or marginal conditions. The testing process includes functional, integration and security testing of the attendance system.

RESULTS AND DISCUSSION

1. Data analysis

1.1 Problem Analysis

Problem analysis is the first step in developing a manual attendance management security system at PT. Nirvana Tirta. This problem analysis process was conducted through interviews with field supervisors and review of system requirements at PT. Nirvana Tirta . The problem identified was that the manual recording of absences was not optimal and attendance data was often manipulated. Therefore, a suitable solution was designed in the form of an IoT-based safety management system using ESP32.

1.2 Needs analysis

In the process of creating an IoT-based system, hardware and software play a very important role. Each component has a specific function that supports the whole process from design concept to physical realisation of the tool.

Table 1. Software Requirements

No	Name	Information
1	Arduino IDE	Used to create sketch programs on microcontrollers
2	Fritzing	To create electronic circuits
3	Fusion 360	Used to create 3D designs
4	Visual Studio Code	Used to create an inventory website

Table 2. Hardware Requirements

No	Tool and Materials	Information	Quantity
1	ESP 32 DEF Kit	ESP32 ESP-32 DEVKITC V4 WROOM-32D *WIFI BLUETOOTH PLUS* KABEL *MICRO USB*	1
2	*Fingerprint* Sensor Sidik Jari *Module Reader* Adafruit Arduino	FPM10A *Fingerprint* Sensor Sidik Jari *Module Reader* Adafruit Arduino	1
3	*OLED*	*OLED LCD BLUE* 0.96" I2C 128X64 DISPLAY MODULE BIRU	1
4	*Jumper*	10CM *FOR BREADBOARD BASE PLATE EXTENSION*	1
5	*Extention board* ESP	ESP32 *SHIELD ESP32 DOIT V1 30P PLUS*	1
6	Adaptor	ADAPTOR 9V 1A Adaptor 1A 12V	1
7	*Mini bredboard*	*MINI BREADBOARD* 400P N	1

Each component in the table above will be used in the system design, each component has a function description as follows:

- ESP 32 DEF Kit, functions as a microcontroller in a system designed to process sensor input data and issue instructions to the output device according to the conditions described by the input device.
- Fingerprint Sensor Fingerprint Reader Module Adafruit Arduino, as input or sensor. used to detect fingerprint patterns. One of the technologies developed to capture fingerprints is the Fibre Optic Plate (FOP) technique, which consists of an optical fibre array.
- OLED, functions to display messages sent by the ESP32 to the user. The message is an absence message.
- Jumper, functions to transfer electrical current from one component to another connected component.
- ESP expansion board, acts as a holder for a compatible rapid prototyping microcontroller or shield.
- Adapter, acts as a power source for the circuit that converts AC current to DC current.
- Mini Breadboard, functions to design a simple electronic circuit.

2. Design results

2.1 Hardware design

2.1.1. Block Diagrams

The system block diagram illustrates the flow of input, processing, and output in attendance design. Specifically, it pertains to the use of fingerprint technology for

employee performance monitoring at PT. Nirvana Tirta. The block diagram of the system is shown in the following picture.

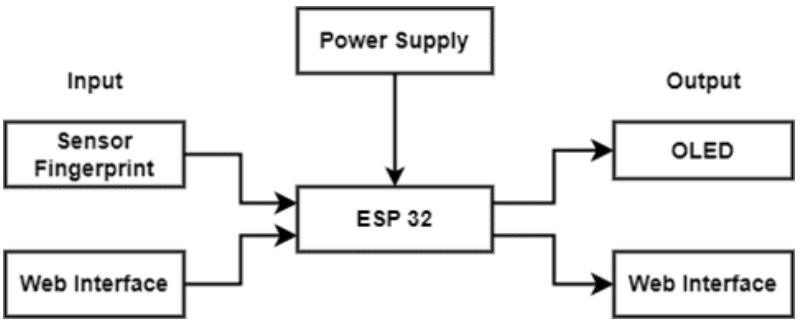


Figure 4. Block Diagrams

The system block diagram comprises an input, namely the fingerprint sensor, which captures fingerprint signals to be processed by the ESP32 microcontroller. The output stage sends a message to the web interface using IoT communication.

2.1.2. Flowchart

A flowchart is a diagram that illustrates the operation of a system as a whole and explains the sequence of procedures within it. The accompanying figure displays the flowchart.

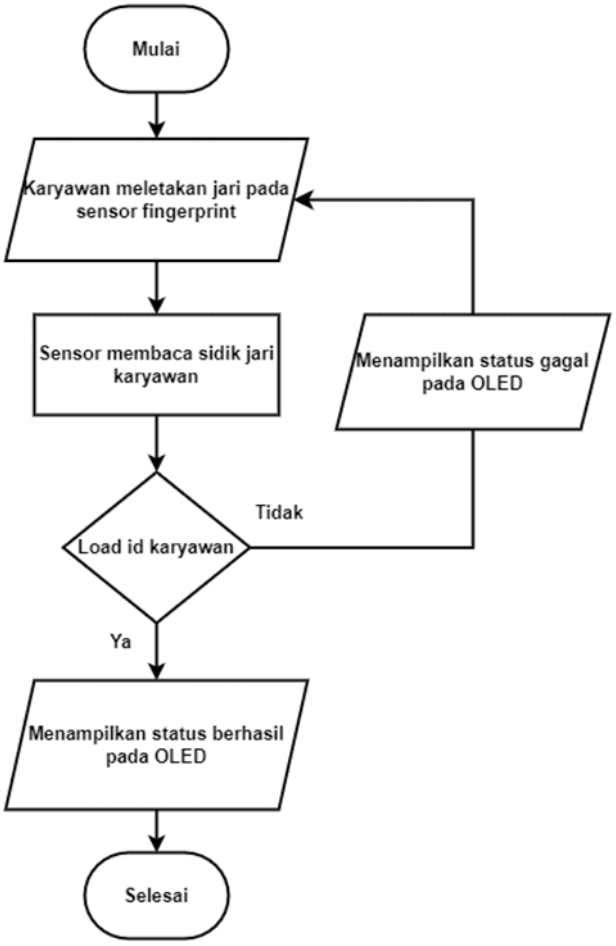


Figure 5. Flowchart

The tool will initiate if the employee has been absent. It will then read the registered fingerprint. If successful, a success status will appear on the OLED.

However, if it fails, employees will need to repeat attendance by placing their finger on the sensor to register their fingerprints.

2.1.3. Mechanical Design and Results

The mechanical design plan related to the tool management system with fingerprint recognition and IoT is based on the image below:

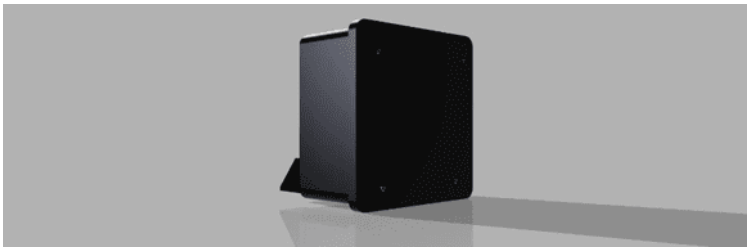


Figure 6. Rear View Design

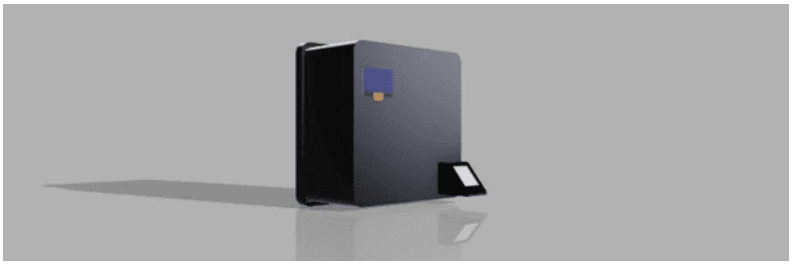


Figure 7. Front View Design

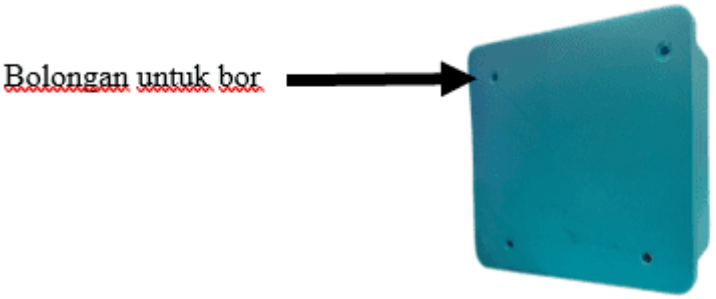


Figure 8. Back View Results

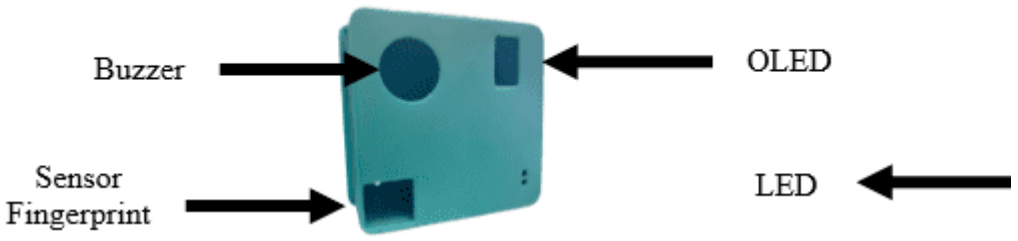


Figure 9. Front View Results

This is the design of the tool created by the researchers. The design prioritises ergonomics, with dimensions of 5 cm in length, 10 cm in width, and 10 cm in height. The tool was constructed using 3 millimetre-thick fla filament.

2.1.4 Tool Schematic Circuit

The system includes a fingerprint sensor module for reading and identifying employee fingerprints. The microcontroller processes data from the sensor and connects it with fuzzy logic to provide presence assessment based on specified conditions.

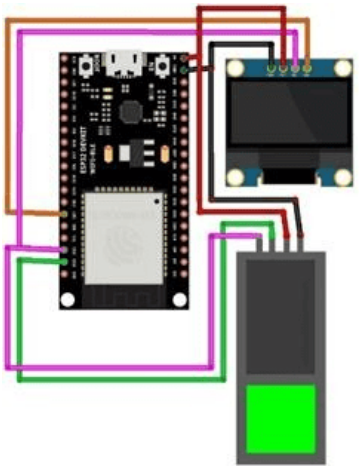


Figure 10. Tool schematic

The system is connected to the internet to transfer data to the server and access the web platform, where employee attendance data is stored and managed. This is a database designed to store attendance data, employee information, and results from fuzzy logic processing. It also includes a web interface that enables users to access employee performance monitoring and data management.

3. Software Design

3.1 Use Cases

This Use Case diagram explains the functional rights between actors regarding the system to be designed or built . The actors in this Use Case are directors and employees. The website creation process is based on the Use Case diagram below.

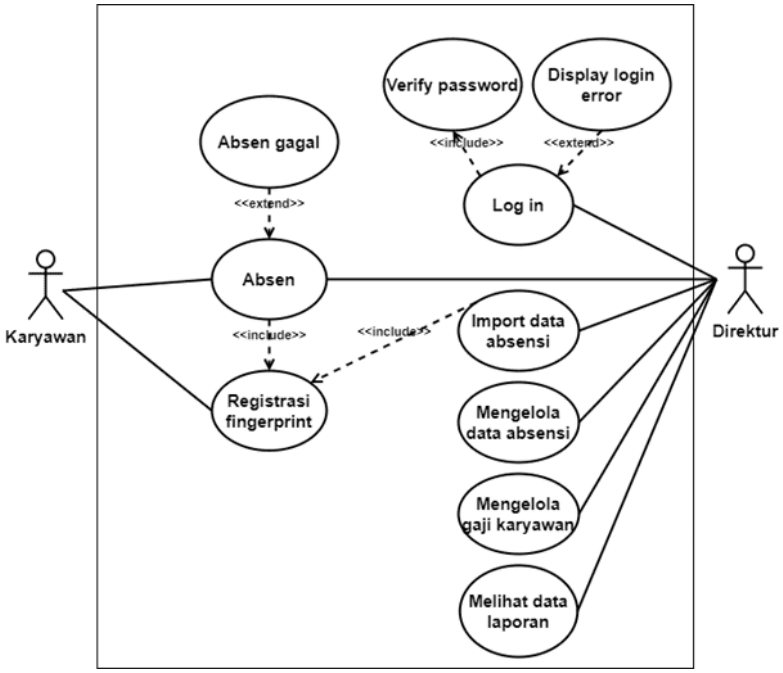


Figure 11. Use case

The image above illustrates the login process that a director must complete before accessing the required data. Once logged in, the director can import employee absence data, manage absence data, manage employee salaries, and view attendance report data. Prior to taking an absence, employees are required to register their attendance on the fingerprint machine. The director will then import employee data from the system database to the machine database, allowing for employee attendance data to be accessed on the website. Subsequently, employees can record their attendance using their fingerprints after registering on the fingerprint machine.

In the analysis of creating this tool, it is necessary to prepare several items, including the hardware listed in Table 3 and the software listed in Table 4.

4. Implementation Results

4.1 Software Implementation

This section relates to the implementation of the website, which will serve as the user interface for the tool.

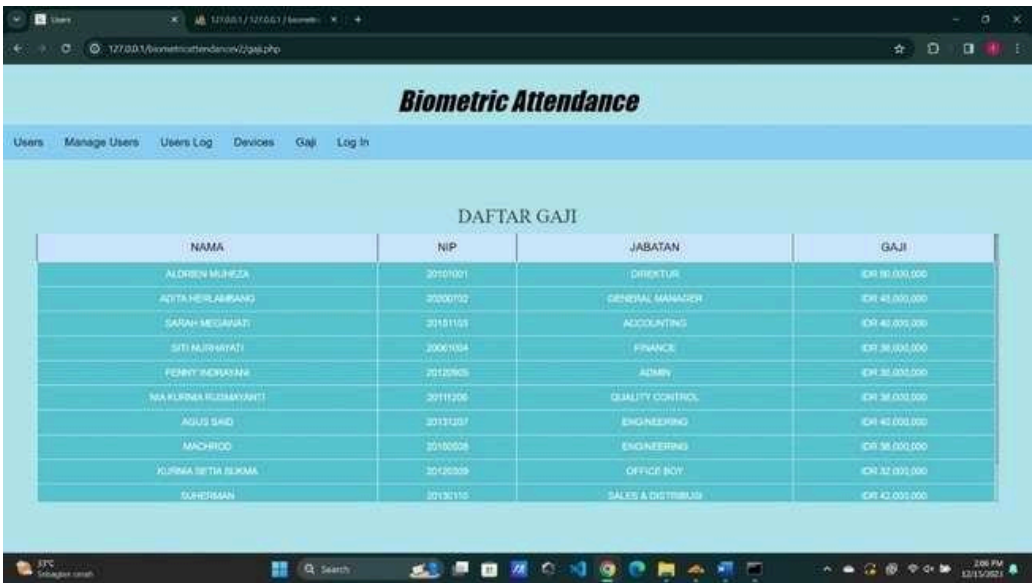


Figure 12. Salary Page

This page provides information on salary estimates that are calculated using fuzzy logic based on attendance and position data.

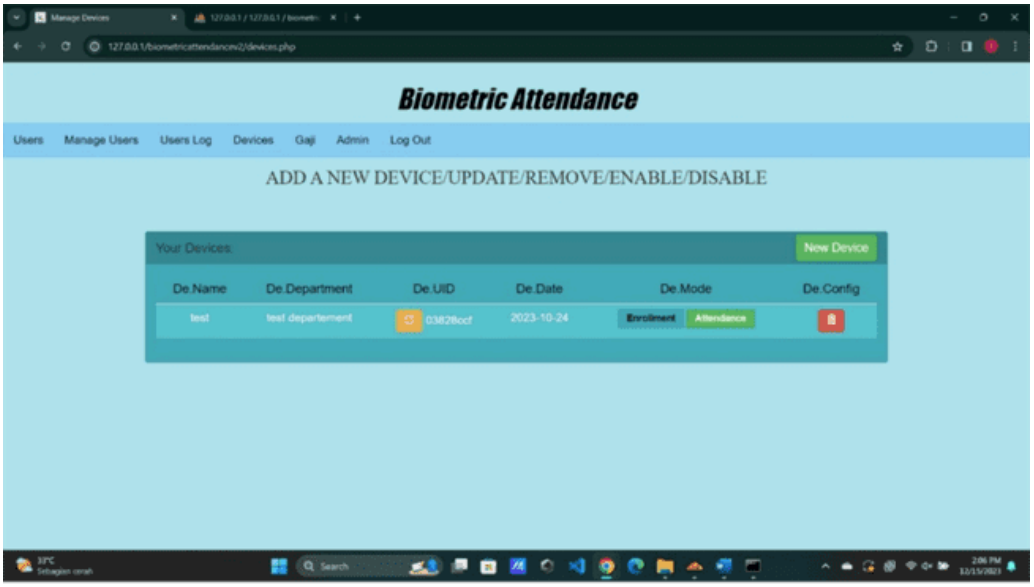


Figure 13. Devices Page

This page provides a list of available fingerprint devices. The user can add or delete existing fingerprint devices.

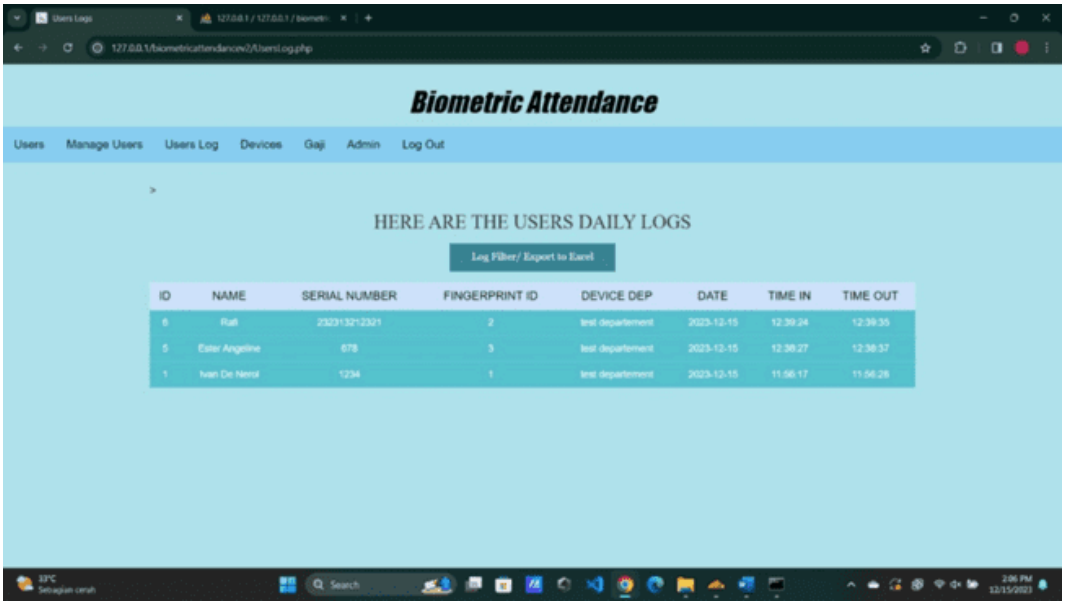


Figure 14. User Log page

This page displays activity logs of users on the same day as the user's access.

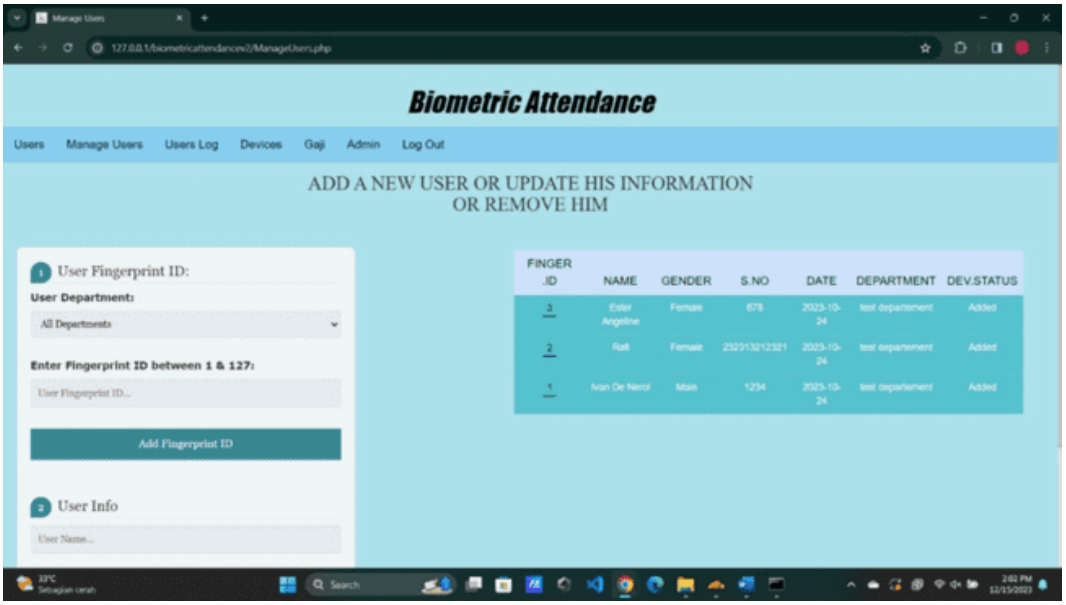


Figure 15. Manage User page

This page is used for adding and deleting users, as well as storing fingerprints and controlling the fingerprint sensor.

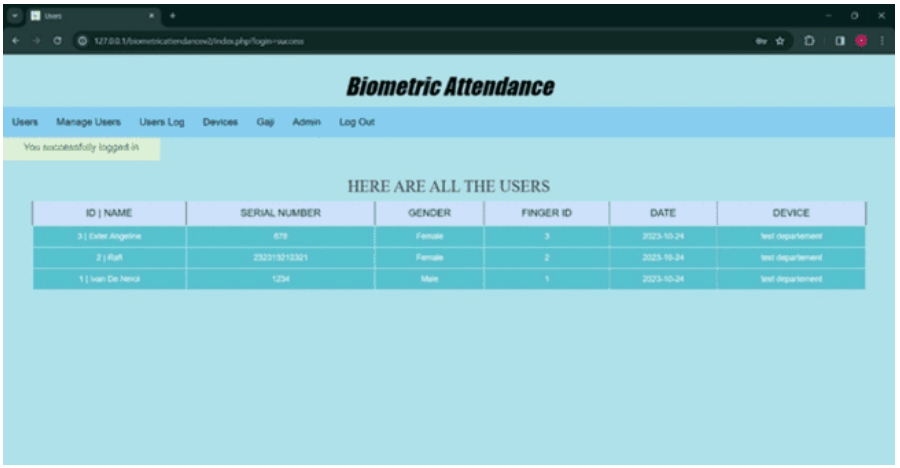


Figure 16. User Page

This page presents a list of registered users and their associated information.

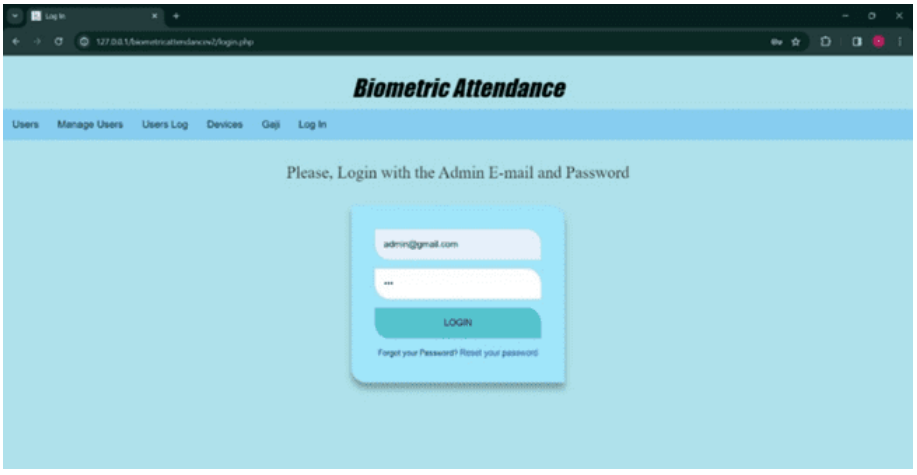


Figure 17. Login Page

Upon accessing the website, this page serves as an administrator login.

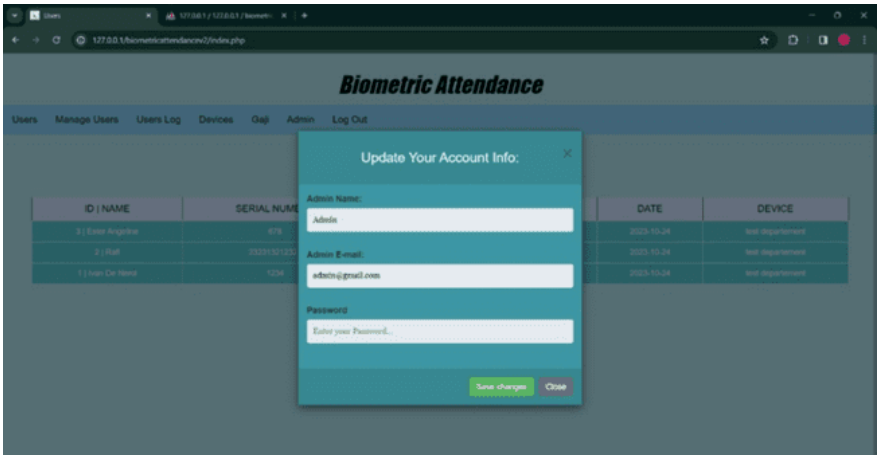
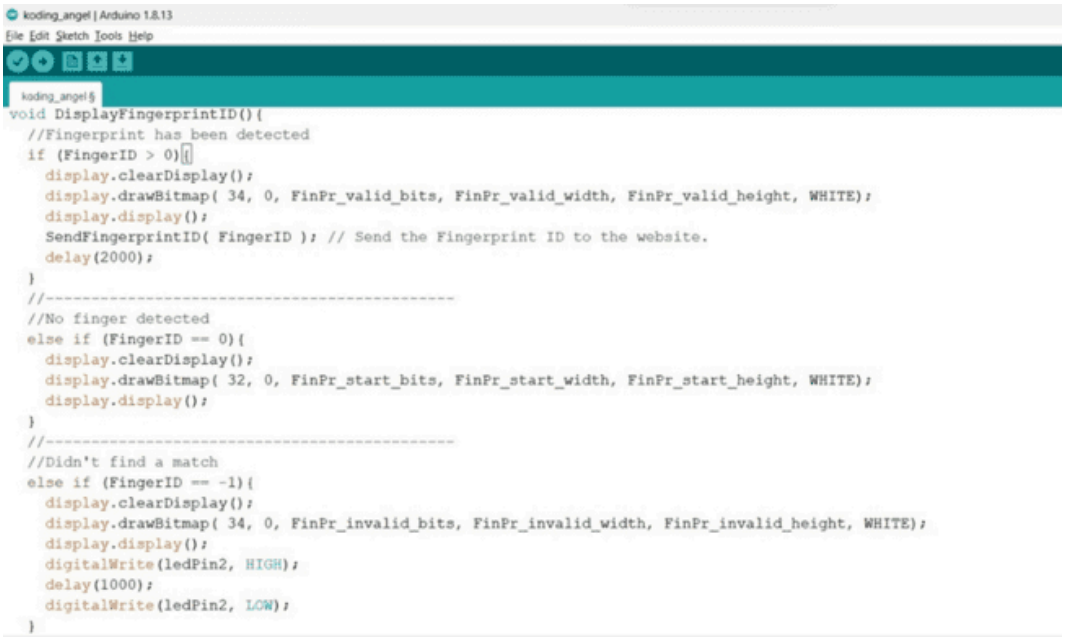


Figure 18. Reset Password page

This page is designed to enable the changing of the password for the admin account.

4.2 Implementation of Source Code

The implementation phase involves writing program lines using the Arduino IDE software. Below is an example of the program:




```
void DisplayFingerprintID(){
  //Fingerprint has been detected
  if (FingerID > 0){
    display.clearDisplay();
    display.drawBitmap( 34, 0, FinPr_valid_bits, FinPr_valid_width, FinPr_valid_height, WHITE);
    display.display();
    SendFingerprintID( FingerID ); // Send the Fingerprint ID to the website.
    delay(2000);
  }
  //-------------------------------------------
  //No finger detected
  else if (FingerID == 0){
    display.clearDisplay();
    display.drawBitmap( 32, 0, FinPr_start_bits, FinPr_start_width, FinPr_start_height, WHITE);
    display.display();
  }
  //-------------------------------------------
  //Didn't find a match
  else if (FingerID == -1){
    display.clearDisplay();
    display.drawBitmap( 34, 0, FinPr_invalid_bits, FinPr_invalid_width, FinPr_invalid_height, WHITE);
    display.display();
    digitalWrite(ledPin2, HIGH);
    delay(1000);
    digitalWrite(ledPin2, LOW);
  }
```

Figure 19. Void Display Fingerprint ID

This code checks the fingerprint sensor to determine if the scanned finger is registered. If the finger is registered, the function displays a success status on the OLED.

```
//************send the fingerprint ID to the website*************
void SendFingerprintID( int finger ){
  Serial.println("Sending the Fingerprint ID");
  if(WiFi.isConnected()){
    HTTPClient http;    //Declare object of class HTTPClient
    //GET Data
    getData = "?FingerID=" + String(finger) + "&device_token=" + device_token; // Add the Fingerprint ID to the Post array in order to send it
    //GET methode
    Link = URL + getData;
    http.begin(Link); //initiate HTTP request   //Specify content-type header

    int httpCode = http.GET();   //Send the request
    String payload = http.getString();    //Get the response payload

    Serial.println(httpCode);   //Print HTTP return code
    Serial.println(payload);    //Print request response payload
    Serial.println(finger);     //Print fingerprint ID

    if (payload.substring(0, 5) == "login") {
      String user_name = payload.substring(5);
  //  Serial.println(user_name);

      display.clearDisplay();
      display.setTextSize(2);             // Normal 2:2 pixel scale
      display.setTextColor(WHITE);        // Draw white text
      display.setCursor(15,0);             // Start at top-left corner
```

Figure 20. Http Client

This code connects the fingerprint sensor to the website and displays the collected data.

```
//**************************************************************************
void setup() {
  Serial.begin(115200);
  delay(1000);
  pinMode(ledPin1, OUTPUT);
  pinMode(ledPin2, OUTPUT);
  //----------initiate OLED display-------------
  if(!display.begin(SSD1306_SWITCHCAPVCC, 0x3C)) { // Address 0x3D for 128x64
    Serial.println(F("SSD1306 allocation failed"));
    for(;;); // Don't proceed, loop forever
  }
  // you can delet these three lines if you don't want to get the Adfruit logo appear
  display.display();
  delay(2000); // Pause for 2 seconds
  display.clearDisplay();
  //-----------------------------------------------
  connectToWiFi();
  //-----------------------------------------------
  // Set the data rate for the sensor serial port
  finger.begin(57600);
  Serial.println("\n\nAdafruit finger detect test");

  if (finger.verifyPassword()) {
    Serial.println("Found fingerprint sensor!");
    display.clearDisplay();
```

Figure 21. Void Setup

This code includes the necessary initial preparations when the device is first turned on, such as connecting to WiFi, defining the pin, and preparing to start the fingerprint sensor and OLED.

```
const uint8_t PROGMEM FinPr_scan_bits[] = {
  0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00
,0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00
,0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00
,0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00
,0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00
,0x00,0x00,0x00,0x1f,0xf8,0x00,0x00,0x00
,0x00,0x00,0x00,0x7f,0xff,0x00,0x00,0x00
,0x00,0x00,0x01,0xfc,0x7f,0xc0,0x00,0x00
,0x00,0x00,0x03,0xc0,0x03,0xe0,0x00,0x00
,0x00,0x00,0x07,0x80,0x00,0xf0,0x00,0x00
,0x00,0x00,0x0e,0x00,0x00,0x3c,0x00,0x00
,0x00,0x00,0x1c,0x1f,0xfc,0x1c,0x00,0x00
,0x00,0x00,0x38,0x7f,0xfe,0x0e,0x00,0x00
,0x00,0x00,0x78,0xf8,0x0f,0x87,0x00,0x00
,0x00,0x00,0x71,0xe0,0x03,0xc7,0x00,0x00
,0x00,0x00,0xe3,0x80,0x01,0xc3,0x80,0x00
,0x00,0x00,0xc3,0x83,0xc0,0xe3,0x80,0x00
,0x00,0x00,0xc7,0x0f,0xf0,0x71,0x80,0x00
,0x00,0x00,0x06,0x1f,0xf8,0x71,0xc0,0x00
,0x00,0x00,0x0e,0x1c,0x3c,0x31,0xc0,0x00
,0x00,0x00,0x1c,0x38,0x1c,0x31,0xc0,0x00
```

Figure 22. Fingerprint Display Code

This code displays images on the OLED to indicate whether attendance has been successful or not.

```
//ESP32---------------------------
#include <WiFi.h>
#include <HTTPClient.h>
#include <SimpleTimer.h>          //https://github.com/jfturcot/SimpleTimer
//OLED----------------------------
#include <SPI.h>
#include <Wire.h>
#include <Adafruit_GFX.h>         //https://github.com/adafruit/Adafruit-GFX-Library
#include <Adafruit_SSD1306.h>     //https://github.com/adafruit/Adafruit_SSD1306
#include <Adafruit_Fingerprint.h> //https://github.com/adafruit/Adafruit-Fingerprint-Sensor-Library
```

Figure 23. Library Code

This code adds libraries for each component used.

5. Testing

5.1 System Testing

The following are the results of the attendance system tests. The system has successfully connected the fingerprint to the website, allowing researchers to add users and save each user's fingerprint.

FINGER .ID	NAME	GENDER	S.NO	DATE	DEPARTMENT	DEV.STATUS
3	Ester Angeline	Female	678	2023-10-24	test departement	Added
2	Rafi	Female	232313212321	2023-10-24	test departement	Added
1	Ivan De Nerol	Male	1234	2023-10-24	test departement	Added

Figure 24. Test Result

5.2 Fuzzy Logic Testing

The test results of fuzzy logic are presented below. The salary estimates displayed are calculated based on employee performance, position, and attendance.

DAFTAR GAJI

NAMA	NIP	JABATAN	GAJI
ALDRIEN MUHEZA	20101001	DIREKTUR	IDR 50,000,000
ADITA HERLAMBANG	20200702	GENERAL MANAGER	IDR 45,000,000
SARAH MEGAWATI	20151103	ACCOUNTING	IDR 40,000,000
SITI NURHAYATI	20061004	FINANCE	IDR 38,000,000
FENNY INDRAYANI	20120905	ADMIN	IDR 35,000,000
NIA KURNIA RUSMAYANTI	20111206	QUALITY CONTROL	IDR 38,000,000
AGUS SAID	20131207	ENGINEERING	IDR 40,000,000
MACHROD	20150508	ENGINEERING	IDR 38,000,000
KURNIA SETIA SUKMA	20120309	OFFICE BOY	IDR 32,000,000

Figure 25. Payroll

CONCLUSION

The attendance management tool developed leverages fuzzy logic and fingerprint sensor technology to provide a more precise evaluation of employee attendance. Its flexibility allows access via mobile devices, making it user-friendly for employees with variable work schedules. Moreover, the incorporation of fuzzy logic in data processing allows for a more adaptive and timely assessment of attendance, considering factors such as tardiness. As we continue to refine and improve this tool, we must ensure our conclusions align with these advancements. This could involve revisiting the effectiveness of fuzzy logic and fingerprint sensor technology in providing accurate attendance evaluations, the ease of accessibility through mobile devices, and the adaptability of the tool in handling variable work schedules. We also need to reassess how the tool handles tardiness and other factors influencing attendance. With these adjustments, our conclusions will remain relevant and accurate in light of the tool's evolution.

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