BINDURA UNIVERSITY OF SCIENCE EDUCATION

FACULTY OF SCIENCES AND ENGINEERING

Fingerprint based attendance System

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A Project Submitted to the Department of Engineering and Physics in partial fulfilment to the requirements for the Bachelor of Science Honors in Physics with specialization in (Electronics)

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Acknowledgement

First and foremost, I would like to thank God for giving me the courage and will to pursue this project. It is through His mercy that I was able to complete this project successfully without facing too many obstacles. I would also like to express my sincere gratitude to my mother who is no longer with us in flesh but in spirit. She has always been an inspiration and the main reason why I aspire to achieve greatness in whatever it is I pursue. I also thank my father greatly for providing the vast financial support and for giving me motivation to successfully complete this project. I cannot write this acknowledgement without expressing my gratitude to my Supervisor Dr H Danga. I thank her for the great amount of knowledge she has given me and all the assistance she gave me during the period of this project. I also would like to thank my school mates and friends which include Simbarashe Nyamukapa, Tafara Mateyo, Brighton Nyadongo who were always encouraging even when things seemed a bit heavy

Abstract

This project presents the development and implementation of a fingerprint-based attendance system using Arduino Uno, the AS608 fingerprint module, a Breadboard, and an RTC (Real-Time Clock) module. The aim of the system is to provide a reliable, efficient, and secure method for tracking attendance in various domains, such as educational institutions and workplaces. The project utilizes Arduino Uno, a versatile microcontroller board, which acts as the central control unit for the attendance system. The AS608 fingerprint module is integrated to capture and analyze fingerprint patterns, ensuring accurate identification and authentication of individuals. The Breadboard facilitates easy connection and organization of various components, while the RTC module ensures accurate timekeeping for attendance records.

The project follows a step-by-step methodology, including hardware setup, software programming, testing, and evaluation. The developed system is evaluated for its functionality, accuracy, and user-friendliness. The report provides an in-depth analysis of the advantages, limitations, and scalability of the fingerprint-based attendance system.

The results of the project demonstrate the successful implementation of the fingerprint-based attendance system using Arduino Uno, the AS608 fingerprint module, Breadboard, and RTC module. The system proves to be an effective solution for attendance management, offering reliable identification, streamlined processes, and improved organizational efficiency.

This project contributes to the growing field of biometric identification technology, particularly in the context of attendance tracking. The findings and recommendations from the project serve as valuable insights for future research and development in the field, promoting the adoption of advanced attendance systems in various domains. Through the integration of hardware components and software programming, the developed system demonstrates the practical application of biometric identification technology for attendance management.

Table of Contents

Abbreviations

LCD	-	Liquid Crystal Display.
RTC	-	Real-Time Clock.
IC	-	Integrated Circuit.
PCB	-	Printed Circuit Board.
IOT	-	Internet of Things.
RFID	-	Radio Frequency Identification.
PC	-	Personal Computer.
UART	-	Universal Asynchronous receiver- transmitter.
USB	-	Universal Serial Bus.
TIR	-	Total Internal Reflection.
LED	-	Light Emitting Diode.
DEL	-	Delete.
ID	-	Individual Details.

Chapter 1: Introduction

1.1 Background

Most organizations nowadays, whatever type they may be are somewhat vulnerable to security risks if they don't keep a record of attendance of students or staff. They are also prone to mismanagement due to false records and impersonations. Since there are a lot of practical issues involved in paper-based manual attendance methods, nowadays almost all companies have automated their process of attendance management.

Manual attendance tracking systems are no longer efficient and accurate, as they are prone to errors, time-consuming and lack reliability. The advent of biometric technology offers a more dependable and automated solution to manage employee attendance records. Fingerprint-based attendance systems have gained significant popularity in recent years as they offer a reliable, secure, and easy-to-use option for tracking employee attendance.

In the past 10 years alone, research in biometric technology has continued to advance at a rapid rate. Biometrics have gone from a novelty technology to a part of everyday life. As biometrics become more common, the use of identification proxies may cease to exist. When you can use yourself as proof of your own identity, you don't have to carry around keys, or card anymore.

1.2 Objectives

The objective of this project is to develop a fingerprint-based attendance system using Arduino Uno, the AS608 fingerprint module, a Breadboard, and an RTC (Real-Time Clock) module and other materials. This project aims to design and implement a fingerprint-based attendance system that will replace the traditional paper-based attendance system and enhance organization productivity. The system will utilize fingerprint recognition technology to identify employees and record their attendance data with high accuracy in real-time. The system's effectiveness and efficiency in managing employee attendance data will be evaluated, and recommendations for future improvements will be made. The project is expected to benefit organizations by significantly reducing errors, time, and costs associated with employee attendance management. It also ensures accuracy in that it will not give the person recording themselves any troubles. It should prove to be reliable whilst also providing security against fraudulent activities such as buddy punching or impersonation.

1.3 Scope of the Project

The project utilizes Arduino Uno, a popular microcontroller board known for its versatility and ease of use. The AS608 fingerprint module is employed to capture and analyze fingerprint patterns, ensuring the uniqueness and identity of each individual. Additionally, a Breadboard is used for easy connection of various components and the RTC module is integrated to maintain accurate timekeeping for attendance records. By combining these hardware components and utilizing appropriate software programming, the developed fingerprint-based attendance system will offer several advantages over traditional attendance tracking methods. These advantages include real-time identification and recording of attendance, elimination of manual errors, improved efficiency, reduced administrative tasks, enhanced security, and cost-effectiveness in the long term.

1.4 Conclusion

The implementation of the fingerprint-based attendance system using Arduino Uno and the AS608 fingerprint module will provide an opportunity to explore the practical aspects of biometric identification, hardware interfacing, and programming. The project aims to serve as an effective solution for attendance management in various settings, contributing to improved efficiency and overall organizational performance. This report will document the step-by-step process of developing the fingerprint-based attendance system, including the hardware setup, software programming, testing, and evaluation. Furthermore, the report will discuss the advantages and limitations of the system and provide recommendations for scalability and further improvements.

Chapter 2: Literature review

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2.1 Introduction

In industrial and domestic applications attendance registering is important at each and every moment. Many face a lot of problems due to lack of proper attendance monitoring systems. Most organizations have been known to resort to the use of registers. If the number of workers is very small the attendance of each worker is recorded in a register as he enters the factory gate. In such a case probably there will be no need for a separate timekeeper and the work will be done by the Forman concerned. This is prone to security risks as workers could make deals with the timekeeper and input false information into the register. In other institutions there's no timekeeper or Foreman attending to the register so workers or students could write false information. The FBAS takes care of those two flaws in that it will be able to know exactly who you are through fingerprint capturing and thanks to the RTC module, the exact time you placed your finger on the system will be recorded. This makes it difficult for workers to undermine punctuality and attendance.

Another method often used by educational institutions is calling out the roll numbers of students or asking the students to manually sign the attendance sheet, which is passed around during the lecture. The process of manually taking and maintaining the attendance records becomes highly cumbersome. Other downsides to this is its time consuming and students could also sign for their absent friends. Fingerprint sensors take less than a second to capture an image and match it with others already saved.

2.2 Biometric Identification

Biometric identification is a type of technology that manages to utilize unique physical features or behavioral characteristics of individuals for authentication and identification purposes. It is used for a lot of various security implementations and since recently it has been widely used in attendance systems to prevent fraudulent activities such as buddy punching. Biometric identification techniques are still being introduced and developed but currently the main ones include fingerprint recognition, iris recognition, facial recognition, and voice recognition.

Among these, fingerprint recognition has gained popularity due to its reliability, accessibility, and ease of use.

2.3 Principle of Fingerprint Recognition

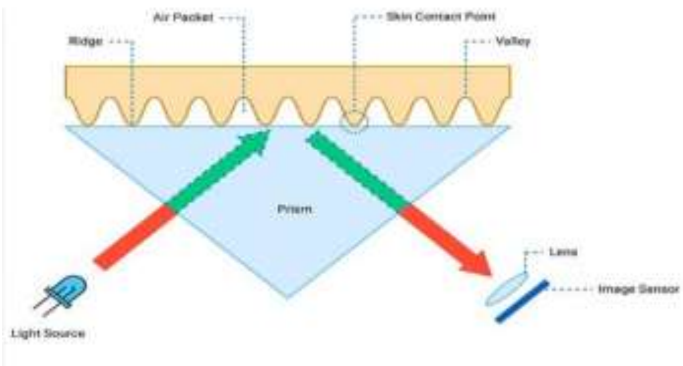

FIGURE 1. OPTICAL FINGERPRINT WORKING PRINCIPLE (How2 Corperation, n.d.)

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Fingerprints are formed by the pattern of ridges and valleys on the surface of the finger. The most common recognition technique used is minutiae-based recognition, which compares specific minutiae points on a fingerprint, such as loop, arch, and whorl patterns, to those in a database. The number of minutiae points, their location, orientation, and distance from each other are used to create a unique fingerprint template that can be used for matching and identification purposes. This means that there are no two identical fingerprints in the world which make this one of the best security features. The recognition process involves capturing an image of the fingerprint, extracting its features, which are the patterns of ridges and valleys, and comparing these features with the database to determine if a match exists.

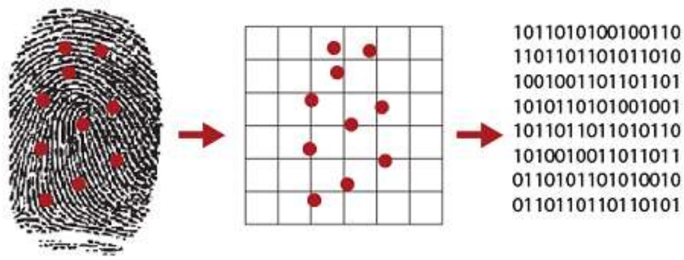

FIGURE 2. BIOMETRIC ACCEPTANCE BY UNIT (Jain & Tomar, 2020)

This whole process is done in under a second which makes the matching process quite easier and faster than most if not all attendance recording methods

There are two types of sensors used in fingerprint recognition: optical and capacitance. Optical sensors capture an image of the fingerprint's surface using a digital camera, while capacitance sensors measure the electrical current generated by the ridges and valleys on a fingertip. Each type of sensor works differently and has its advantages and disadvantages.

An optical fingerprint scanner works based on the principle of Total Internal Reflection (TIR). In an optical fingerprint scanner, a glass prism is used to facilitate TIR. Light from an LED (usually blue color) is allowed to enter through one face of the prism at a certain angle for the TIR to occur. The reflected light exits the prism through the other face where a lens and an image sensor are placed.

When there's no finger on the prism, the light will be completely reflected off from the surface, producing a plain image in the image sensor. When TIR occurs, a small amount of light leaked to the external medium and it is called the Evanescent Wave. Materials with different refractive indexes (RI) interact with the evanescent wave differently. When we touch a glass surface, only the ridges make good contact with it. The valleys remain separated from the surface by air packets. Our skin and air have different RIs and thus affect the evanescent field differently. This effect is called Frustrated Total Internal Reflection (FTIR)

Capacitance sensors use an array of micro-cells to capture the electrical current generated by the ridges and valleys on a fingertip. The sensor analyzes the changes in the current to build a 2D or 3D map of the fingerprint's surface. This technique is more reliable than optical sensors as it is not impacted by dirty or worn-out fingertips and can work in wet or dry conditions. Capacitance sensors are commonly found in high-security applications such as biometric access control and time attendance systems

2.2 Fingerprint-Based Attendance System

Fingerprint-based attendance systems can be widely used in various fields such as education, organizations, and government institutions without encountering difficulties due to their accuracy and reliability. They offer numerous advantages such as high accuracy, reliability, and ease of use. The uniqueness and permanence of fingerprints make them an ideal biometric modality for identification. These systems utilize the unique pattern of ridges and furrows on an individual's finger to recognize and authenticate them with the help of a fingerprint sensor, which in our case is the AS608 fingerprint module. The primary component of a fingerprint-based attendance system is the fingerprint sensor, which captures the fingerprint image of a user and converts it into a digital format that can be comprehended by human beings.

2.3 Arduino Platform

Arduino is an open source prototyping platform based in Italy, that provides a simple and flexible and software environment for helping its users gain an understanding of building interactive electronic projects. It consists of a microcontroller board and a development environment, which is both the hardware and software required to make functional projects. This makes it an excellent choice for developing fingerprint-based attendance systems due to its easy to use interface and readily available microcontrollers. Arduino offers easy integration with various sensors, including the AS608 fingerprint module which we will be using. It also provides easy integration with other modules such as the RTC or i2c module.

2.4 Arduino Uno

Arduino Uno is an open-source microcontroller board that provides a platform for building and constructing various electronic projects. It's mainly used for temporary projects or not too complicated circuits. It is widely used due to its ease of use, compatibility, and availability of numerous libraries and resources. These resources are easy to access and they can be found inside the Arduino IDE platform. Arduino Uno can be easily connected to different modules and sensors, making it very suitable for implementing fingerprint-based attendance systems. The board is also able to execute commands at fast speeds due to its impressive ATMega328p processor. This means it would register information faster than any trained conventional timekeeper who are usually used when recording attendances manually

2.5 AS608 Fingerprint Module

The fingerprint sensor is responsible for capturing high-resolution images of the fingerprint. Different types of fingerprint sensors are available, such as optical sensors, capacitive sensors, and ultrasonic sensors. Each sensor type has its own advantages and limitations, such as image quality, speed, and cost-effectiveness. In this project we will be using the well-known AS608 fingerprint module. It is a widely used fingerprint sensor that provides an integrated solution for fingerprint recognition capabilities. It offers high image quality, fast recognition speed, and convenient UART communication. The module's compact size, low power consumption, and compatibility with Arduino make it suitable for integrating into the attendance systems.

2.6 Existing Systems

Existing attendance systems include manual tracking through paper registers or sign-in sheets, barcode scanning systems, magnetic strip systems, RFID systems, and facial recognition systems.

Manual tracking through paper registers or sign-in sheets require employees to physically sign in and out, which can be very time-consuming for large companies with many employees. This is also prone to errors as employees can forget to sign in or out, and the data can be easily manipulated.

Barcode scanning systems use barcodes on employee ID cards which are then scanned by a device to log attendance. This method is more efficient than manual tracking, but it is also prone to technical difficulties like non-scanning or unreliable scanners.

Magnetic strip systems also use employee ID cards which are then swiped on a magnetic strip reader. This is generally more reliable than barcode systems, but it can also be prone to technical difficulties.

RFID systems use radio frequency to track employee identification cards and can log attendance even without physical contact between the card and the reader. This reduces friction and is more efficient than the previous systems.

Facial recognition systems take photographs of employees' faces and compare it against a database of employee pictures. This is generally fast and does not require any physical contact between the employee and the reader.

Finally, fingerprint-based attendance systems use a biometric algorithm to scan the employee's fingerprint to log attendance. This is the most secure and reliable attendance system and eliminates the chances of fraudulent practices like buddy punching.

2.6 Conclusion

Although previous studies have developed fingerprint-based attendance systems, there is still a gap in the research. Most of the previous studies focus on the implementation and functionality of the systems, neglecting the evaluation of system performance and user experience. Therefore, this proposed project aims to bridge this gap by developing a comprehensive fingerprint-based attendance system. The system will not only focus on accurate attendance recording but will also consider factors such as system reliability, scalability, usability, and integration with existing attendance management systems.

In this literature review, the different components required for developing a fingerprint-based attendance system, including the AS608 fingerprint module, Arduino Uno, breadboard, and RTC module, have been discussed. Existing studies in the field have been reviewed, highlighting the gap in research. The proposed project intends to address the limitations and provide a comprehensive and efficient solution to attendance management using fingerprint recognition technology.

Chapter 3: Experimental Procedure

3.1 Introduction

The fingerprint-based attendance system project is a biometric authentication system that is able to utilize fingerprints to register and check attendance records, and also for identification purposes in some cases. This system ensures that only authorized or enrolled individuals can gain access to secured facilities, thus improving security measures within organizations. In a school like setting, this means that students and staff will not have to carry their IDs, rather they just have to use their fingerprint at every entrance point at the institution

This chapter outlines the experimental procedure which were employed to design and develop a fingerprint-based attendance system. The essential materials needed included an Arduino Uno, AS608 fingerprint module, Breadboard, 16x2 LCD, I2C module, RTC module, and SD Card module. The chapter provides a step-by-step description of the hardware setup, software implementation, and system configuration. The procedures detailed below were followed in order to achieve an accurate and functional attendance system

3.2 System Architecture

The fingerprint based attendance system revolves around the integration of different components, the Arduino Uno being the central processing unit of the project. It also involves the interaction of various components for instance the 16×2 liquid crystal display and i2c module which need to be connected prior initializing their connection to the Arduino board.

The system's architecture includes the following components:

- Arduino Uno Board
- Arduino IDE
- AS608 Fingerprint Module
- 16x2 LCD with I2C Module
- RTC Module
- Potentiometer

- 3 x Pushbuttons
- SD Card Module
- 2 x LEDs
- Buzzer
- 2 x 10K Ohm Resistors
- Breadboard and Wires

3.2.1 Arduino UNO

The Arduino Uno is a circuit board based on the ATmega328P microprocessor. The processor has AVR CPU at up to 16 MHz, 32KB Flash, 2KB SRAM and 1KB EEPROM. The board then offers 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator (CSTCE16M0V53-R0), a USB connection, a power jack, an ICSP header and a reset button. It can be programmed using the Arduino IDE software. It serves as the main processing unit of the fingerprint-based attendance system. It provides the necessary computation and storage capability that the system requires to function correctly. The board controls the sensors and the display unit and manages the communication process between the fingerprint module, RTC module, and SD card module.

The main specifications of the board include:

- Microcontroller: ATmega328p
- Input voltage: 7 – 12V
- Operating voltage: 5V
- DC current per I/O Pin: 20mA
- DC current for 3.3V Pin: 50mA
- Flash Memory: 32KB
- LED Built-in: 13
- Length: 68.6 mm
- Width: 58.4 mm
- Weight: 25 g

3.2.3 AS608 fingerprint Module

FIGURE 4. AS608 FINGERPRINT SENSOR MODULE (Phipps Electronics, 2023)

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For the fingerprint module we will be using the AS608 fingerprint sensor which is the best contender for this project because of its price and availability. The sensor can be used to scan fingerprints and it can send the processed data to a microcontroller via serial communication as well. The device uses a DSP chip that does image rendering, feature finding, calculation and searching. It has an in-built flash memory that stores the data of fingerprint and enrolls new fingerprints. It interfaces with the controller or any other system with TTL serial and sends packets of data to take photos, detects print, hash, and search. The device has a red and green LED light indication for the wrong and right prints. The module can be easily tested with a window software as well as user can enroll using the software and can see the image of the fingerprint on the computer. All registered fingerprints are stored in this module. The AS608 is capable of storing up to 127 individual fingerprints.

For connection it has 4 main pins which are

* V+: Module power supply (3.3v)
* GND: Ground
* TX: Serial transmitter
* RX: Serial Receiver

The main specifications include:

~ Voltage supply range: 3.6V to 6V
~ Maximum operating current: 120mA
~ Peak current: 150mA
~ Max Prints imaging time: 1s
~ False accept rate (FAR): <0.001%
~ False reject rate(FRR): <1.0%
~ Interface: UART or TTL serial
~ Storage capacity: 162 fingerprints
~ Signature file: 256 bytes
~ Template file: 512 bytes
~ Default baud rate: 57600
~ Window area: 14mm x 18mm

~ Working temperature: -20℃ to 50℃

3.2.2 Arduino IDE

FIGURE 5. ARDUINO IDE INTERFACE (Jain & Tomar, 2020)

The Arduino Integrated Development Environment (IDE) is software application that contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. Its main function is to connect to the Arduino hardware to upload programs and communicate with them. Programs written using Arduino Software (IDE) are called sketches. These sketches are written in the text editor and are saved with the file extension ino.

The main buttons include:

- ~ Verify: Checks your code for errors compiling it.
- ~ Upload: Compiles your code and uploads it to the configured board.
- ~ New: Creates a new sketch.
- ~ Open: Presents a menu of all the sketches in your sketchbook.

~ Save: Saves your sketch.

~ Serial Monitor: Opens the serial monitor

3.2.4 16x2 LCD and I2C Module

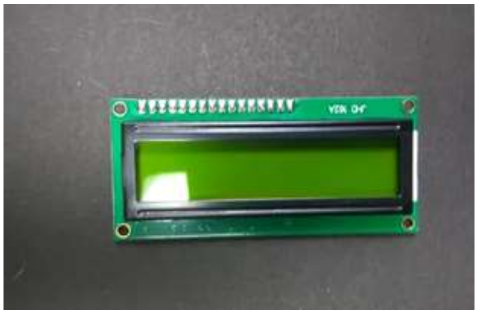

FIGURE 7. 16X2 LCD MODULE

For the display I'm going to be using the basic 16x2 Liquid Crystal Display in conjunction with an I2C module to help simplify the connections. The serial interface adapter (I2C Module) can be connected to a 16x2 LCD and provides two signal output pins (SDA and SCL) which can be used to communicate with an MCU/MPUT. These two will be connected pin for pin and soldered together to work as one.

The 16x2 LCD can display up to 32 characters at a time. Each character segment is made up of 40 pixels that are arranged in a 5x8 matrix. The 16x2 has a 16-pin connector and the module can be used either in 4-bit mode or in 8-bit mode. In 4-bit mode, 4 of the data pins are not used and in 8-bit mode, all the pins are used.

The main specifications of the I2C module includes:

- Operating voltage of 5V DC
- I2C control using PCF8574
- Can have 8 modules on a single I2C bus
- has an I2C Address: 0X20~0X27
- Up to 8 devices can be connected on a single I2C bus.
- The address of each can be changed using the solder points provided on the board (A0, A1, A2)

The Pin Configurations are as follows:

- GND (Ground): Power
- VCC (Voltage Input): Power
- SDA (Serial Data): I2C Data
- SCL (Serial Clock): I2C Clock
- A0 (I2C Address Selection 1): Jumper
- A1 (I2C Address Selection 2): Jumper
- A2 (I2C Address Selection 3): Jumper

The pin configuration of the 16x2 LCD in fig 3 are as follows from left to right:

- Ground

- Supply Voltage (4.7v – 5.3v)
- Contrast adjustment
- Command and Data register
- Read/Write
- Enable
- 8 data pins (D0……D7)
- LED backlight VCC (5v)
- LED backlight ground (0v)

3.2.5 RTC Module

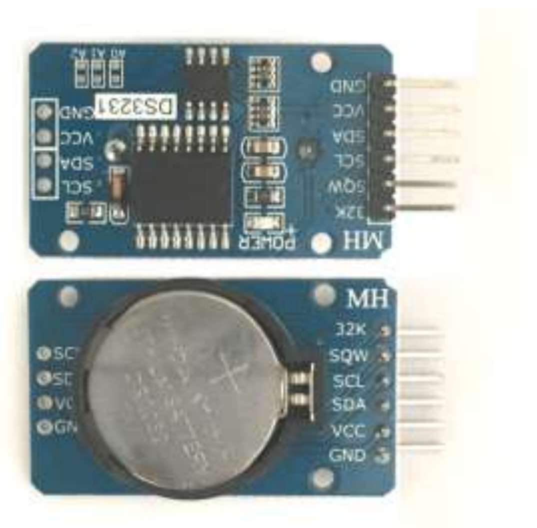

FIGURE 8. RTC MODULE (Rajguru electronics web site, n.d.)

To help keep track of time and date of fingerprint enrollments I'm going to be using an RTC Module. RTC module is an electronic device that is a single packaged module with integrated RTC IC, oscillator circuit and master clock. "RTC" is an acronym for Real Time Clock. Its primary function is to keep accurate track of time even when a power supply is turned off or a device is placed in low power mode. It operates on 2.3V – 5.5V and can also operate on LOW voltages. It also consumes 500nA on battery backup, has a maximum voltage at SDA, SCL: VCC + 0.3V and operating temperature are -45ºC to +80ºC

It comprises of is six terminals, out of them, two pins are not compulsory to use. So we have mainly four pin in use. The pin descriptions are as follows

- VCC: Connected to positive of power source.
- GND: Connected to ground.
- SDA: Serial Data pin (I2C interface)
- SCL: Serial Clock pin (I2C interface)
- SQW: Square Wave output pin
- 32K oscillator output

3.2.6 SD Card Module

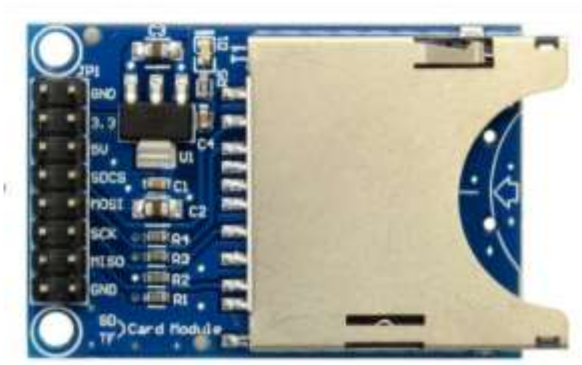

FIGURE 9. SD CARD MODULE (Rajguru electronics web site, n.d.)

In order to do functions such as reading, writing with a microcontroller and storing log information we need an SD Card Module, which is a breakout board used for SD card processes. The board is compatible with microcontroller systems like Arduino. A standard SD card can be directly inserted into the board, but to use micro SD cards, you need to use an adapter. The board has two main components, built in 3.3V voltage regulator and a 74LVC125A logic level shifter chip, allowing for safe and easy communication with a 3.3V or 5V microcontroller without damaging the SD card.

The SD Card Module has six main pins which include:

- VCC: pin provides power to the module and should be connected to the Arduino's 5V pin.
- GND: Ground pin
- MISO (Master In Slave Out): is the SPI output from the micro SD card module
- MISO (Master OUT Slave In): is the SPI input to the micro SD card module.
- SCK (Serial Clock): pin accepts clock pulses from the master (an Arduino in our case) to synchronize data transmission.
- CS (Chip Select): pin is a control pin that is used to select one (or a set) of slave devices on the SPI bus.

3.2.7 Breadboard & Connectors

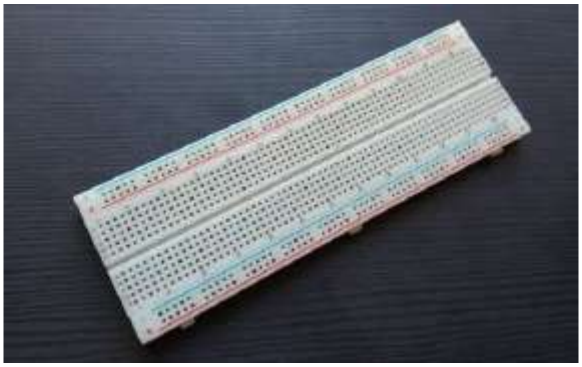

FIGURE 10. BREADBOARD & CABLES (Circuit Bread, 2023)

In order to create a circuit for the system, I'll need a board that supports basic connections and this is when the breadboard comes to play. The breadboard is simply a board for prototyping or building circuits on. It allows you to place components and connections on the board to make circuits without soldering. The holes in the breadboard take care of your connections by physically holding onto parts or wires where you put them and electrically connecting them inside the board

3.2.8 Potentiometer & Resistor

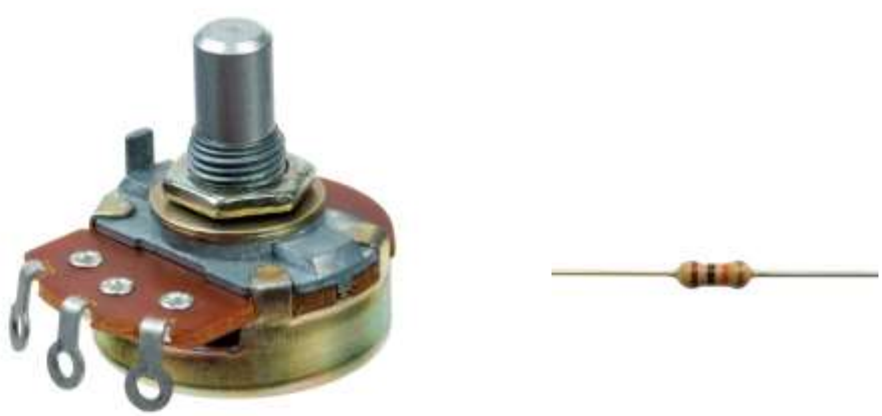

FIGURE 11. POTENTIOMETER & RESISTOR (Wikipedia, 2023)

For the circuit I'll be designing, I'll need to repeatedly adjust the current going through the circuit, and for this I'll need a potentiometer and some fixed resistor. A potentiometer is a type of variable resistor which is designed to control electrical resistance. Potentiometers work by picking up an input Voltage and transferring different amounts to a circuit. This amount is determined by the position of the wiper (sometimes also known as a slide) on a resistive track. Potentiometers can be used as voltage regulators, but they can also be used to introduce different levels of resistance, to compare the electromotive force (EMF) of two cells, or to regulate the power in a circuit.

3.3 Hardware Design

To set up the circuit for the system, I had to begin by assembling most of the hardware components on a breadboard. The major steps included connecting the Arduino Uno to the AS608 fingerprint module, 16x2 LCD, I2C module, RTC module, and SD Card module according to their respective pin configurations and manufacturer's instructions.

3.3.1 Arduino Uno integration with breadboard

To simplify connections and make the connections of the system less tedious I used a breadboard. The 5v pin from Arduino I connected to any positive hole on the breadboard and the ground pin on the Arduino is connected to any negative hole on the breadboard. This means that any component that needs a %v power supply o below can get it from the breadboard

3.3.2 Arduino Uno Integration with AS608 fingerprint

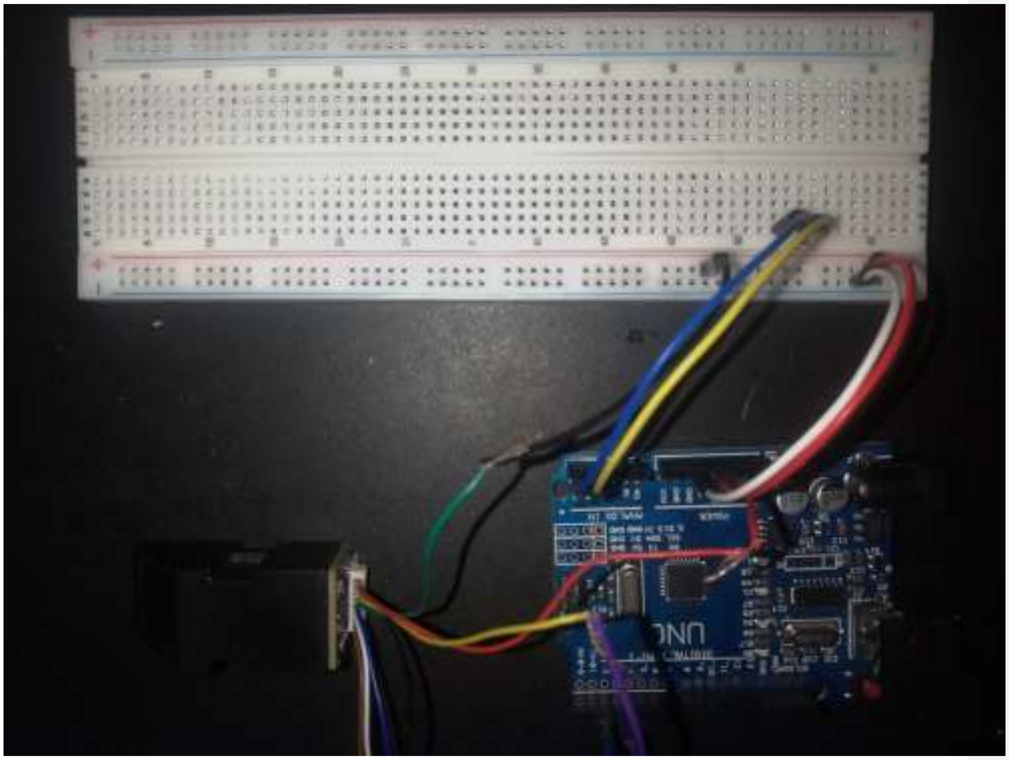

FIGURE 13. ARDUINO UNO INTEGRATION WITH AS608 FINGERPRINT

The AS608 fingerprint module is responsible for capturing and recognizing individual fingerprints. It can store multiple fingerprints in its internal memory and compare them with newly scanned fingerprints. In this projected I connected it to the Arduino through the breadboard for power supply

It has four main pins:

- VCC to 5V on Arduino Uno via a breadboard
- GND to GND on Arduino Uno via a breadboard
- Receiver RX to Digital Pin 2 on Arduino Uno
- Transmitter TX to Digital Pin 3 on Arduino Uno

3.3.2 16x2 LCD with I2C module integration

The 16x2 LCD with I2C module provides a user-friendly interface for displaying relevant information. It uses the I2C protocol for communication with the Arduino Uno, reducing the number of required wires and simplifying the connection.

The I2C Module has 4 main pins on it:

- VCC to 5V on Arduino Uno via a breadboard
- GND to GND on Arduino Uno through a breadboard
- SDA to Analog Pin 4 on Arduino Uno directly
- SCL to Analog Pin 5 on Arduino Uno directly

3.3.3 RTC Module integration

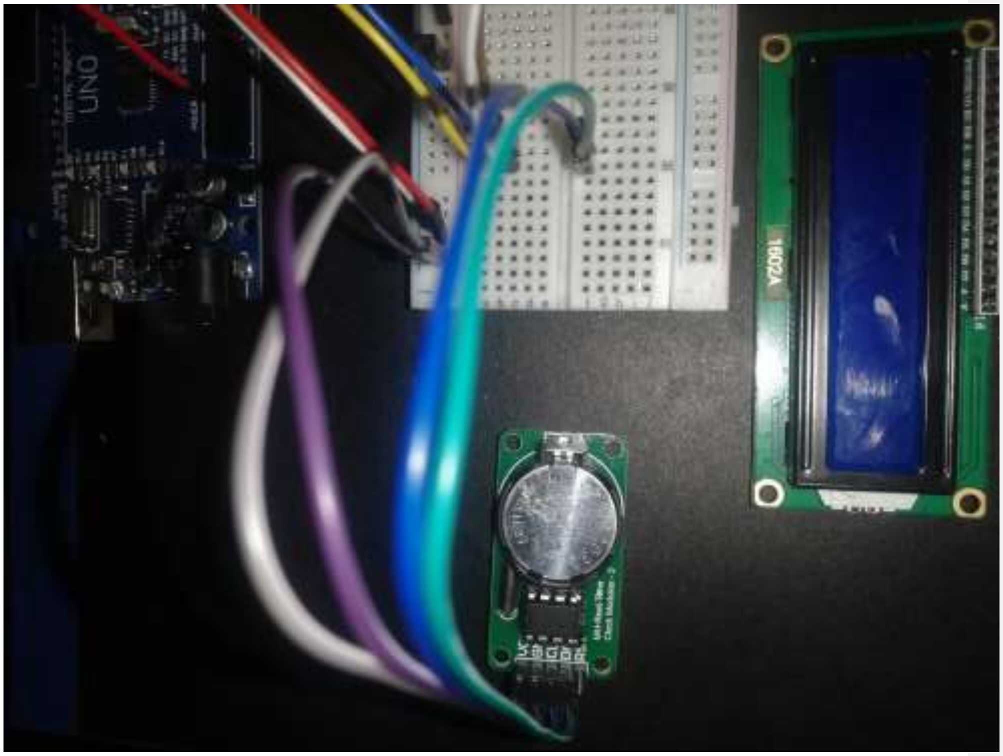

FIGURE 15. RTC MODULE INTEGRATION WITH BREADBOARD

The RTC module is crucial for maintaining accurate time and date even when the system is powered off. It ensures that the attendance records are timestamped correctly. It is connected to the Arduino board, which receives a continuous stream of time and date information through a serial interface.

RTC Module has four main pins:

- Connect VCC to 5V pin on Arduino Uno via a breadboard
- Connect GND to GND pin on Arduino Uno via a breadboard
- Connect SDA (data) to A4 (SDA) pin on Arduino Uno via a breadboard

- Connect SCL (clock) to A5 (SCL) pin on Arduino Uno via a breadboard.

3.3.4 SD Card Module integration

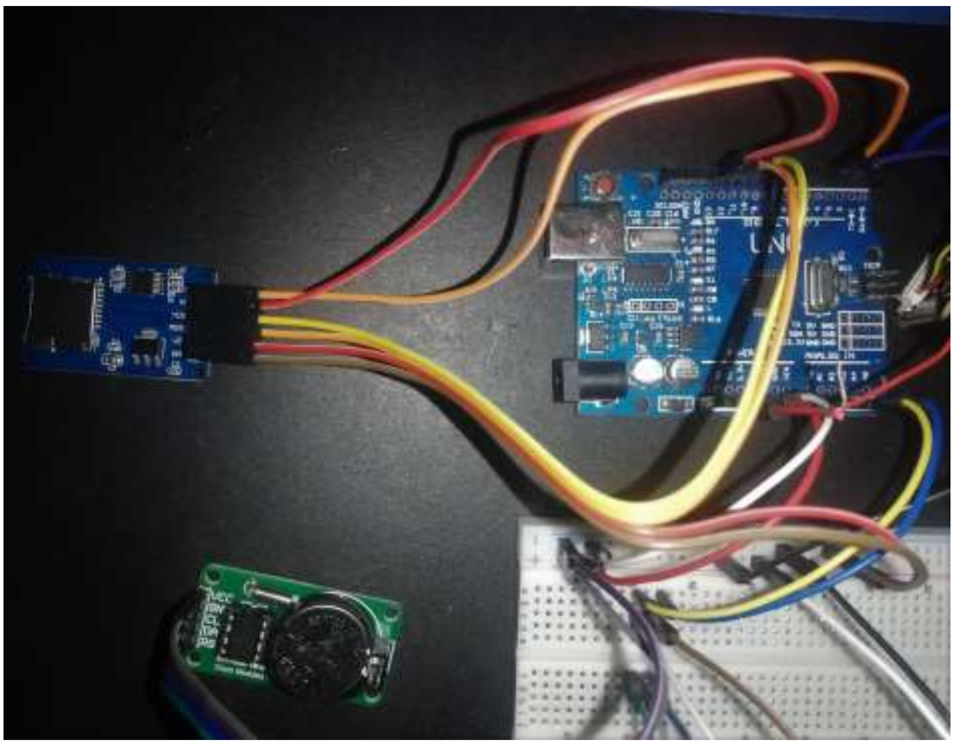

FIGURE 16. SD CARD MODULE INTEGRATION

The fingerprint module on its own can store up to 300 fingerprint images, but It cannot store attendance records. In order to store, read or write an SD Card Module is used. The SD card module stores fingerprint data and attendance records in a secure and organized manner. It provides a convenient method for retrieving and analyzing attendance records. It also happens to receive and store data from the Arduino Uno board via serial communication.

The SD Card Module has 7 main pins:

- Connect VCC to 5V pin on Arduino Uno.
- Connect GND to GND pin on Arduino Uno.
- Connect MISO to digital pin 12 on Arduino Uno.
- Connect MOSI to digital pin 11 on Arduino Uno.
- Connect SCK to digital pin 13 on Arduino Uno.
- Connect CS to digital pin 4 on Arduino Uno.

3.4 Software Design

3.4.1 Introduction

Most of the components which I used in this project require software integration in order to work as a system and they also require individual software initialization. In order to do this task, I had to Install the Arduino IDE software. After this I had to also install the necessary libraries for the AS608 fingerprint module, 16x2 LCD Module, I2C Module, RTC Module, and SD Card module in the Arduino IDE. After this, I had to create a new sketch and define the necessary variables and constants for the system, such as pins assignments and communication protocols. Initialization of the fingerprint module, LCD, I2C, and RTC modules was necessary to ensure proper communication and functionality. Also, implementing the necessary functions for fingerprint enrollment, verification, and attendance recording was a must.

3.4.2 Arduino IDE

The Arduino Integrated Development Environment or Arduino Software (IDE) is a coding application created by the Arduino company. It contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino hardware to upload programs and communicate with them.

FIGURE 17. ARDUINO IDE SKETCH EXAMPLE

Fig is a representation of the Arduino IDE working space where you can compile and run programs. The editor has features for cutting/pasting and for searching/replacing text. The message area gives feedback while saving and exporting and also displays errors. The console displays text output by the Arduino Software (IDE), including complete error messages and other information. The bottom right hand corner of the window displays the configured board and serial port. The toolbar buttons allow you to verify and upload programs, create, open, and save sketches, and open the serial monitor.

3.4.3 Arduino Library

These libraries can be installed in the Arduino IDE by navigating to "Sketch", then "Include Library" and finally "Manage Libraries". I searched for each library name and clicked on "Install", and this option adds them to your Arduino IDE.

The libraries to be installed include:

- For AS608 fingerprint module, install the "Adafruit Fingerprint" library.
- For 16x2 LCD with I2C module, install the "LiquidCrystal_I2C" library.
- For RTC module, install the "RTClib" library.
- For SD Card module, install the "SD" library.

Chapter 4: Application

4.1 Introduction

The purpose of this chapter is to demonstrate the practical application of the fingerprint-based attendance system. The system utilizes an Arduino Uno board, AS608 fingerprint module, 16x2 LCD with I2C module, RTC module, and an SD card module. I will explain the functionality and implementation of each component, and how they work together to create an efficient and reliable attendance system. The fingerprint based attendance system aims to automate the process of tracking and managing attendance. It eliminates the need for traditional paper-based attendance registers and other older methods of marking attendance. It minimizes errors, and provides accurate and real time data. The system consists of multiple hardware components interconnected to an Arduino Uno and programmed using the Arduino IDE.

4.2 Hardware Implementation

The use of fingerprints has been booming ever since mobile phones have adapted to this security feature which most people prefer over traditional passwords. It only makes sense to implement this technology into attendance systems as they avoid a bunch of unwanted problems you would face with conventional attendance methods.

The key hardware components used in this project are as follows:

4.2.1 Arduino Uno

The Arduino Uno is the main microcontroller board which performs the tasks of the central processing unit of the attendance system. It acts as the brain of the system and controls the operation of all other modules. It is responsible for receiving inputs from the AS608 fingerprint module, handling the 16x2 LCD display, managing real-time clock (RTC), and storing data onto an SD card Module. The Arduino Uno is equipped with an ATmega328P microcontroller capable of executing the necessary functions to regulate the flow of data within the system.

4.2.2 AS608 Fingerprint Module

The AS608 fingerprint module is responsible for capturing and recognizing individual fingerprints. It can store multiple fingerprints in its internal memory and compare them with newly scanned fingerprints. It happens to utilize a high-resolution optical sensor to extract unique biometric data from an individual's fingerprint. This module communicates with the Arduino Uno via a serial connection. It allows users to register their fingerprints, and the stored templates are compared during attendance verification.

4.2.3 16x2 LCD with I2C Module

The 16x2 LCD with I2C module provides a user-friendly interface for displaying relevant information to the user. It uses the I2C protocol for communication with the Arduino Uno, reducing the number of required wires and simplifying the connection. The LCD screen displays prompts and messages relating to attendance status, user acknowledgment, and system errors.

4.2.4 RTC Module

The RTC module is crucial for maintaining accurate time and date even when the system is powered off. The module utilizes a DS3231 RTC chip, which is highly accurate and maintains time in most situation. The RTC module communicates with the Arduino Uno via I2C, providing accurate timestamps for attendance records.

4.2.5 SD Card Module

The SD card module allows for the storage of attendance data in a secure and organized manner. Since it provides a convenient method for retrieving and analyzing attendance records, it enables the system to store a significant amount of data efficiently. This module allows the Arduino Uno to write attendance details, including timestamps and employee identification, onto an SD card. The stored files can later be accessed and analyzed if needed. There are different models from various suppliers, but they all function in a similar manner, using the SPI communication protocol.

4.3 System Workflow

The fingerprint-based attendance system follows the following workflow:

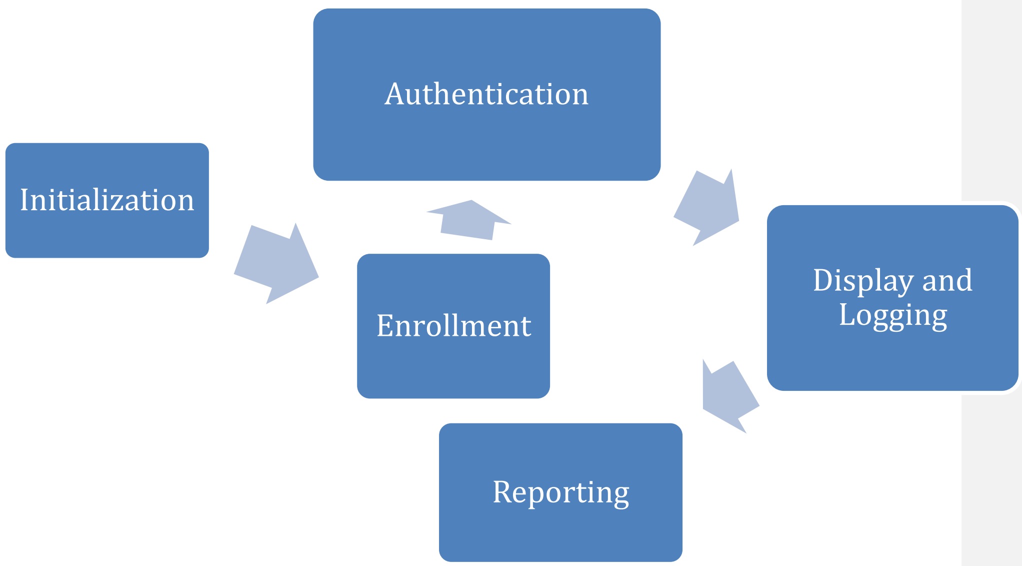

FIGURE 18

Step 1: Initialization

Upon system startup, the Arduino Uno initiates the required modules, including the AS608 fingerprint module, 16x2 LCD with I2C module, RTC module, and SD card module. It sets up necessary configurations and prepares for system operation.

Step 2: Enrollment

To enroll a new user, the AS608 fingerprint module captures and stores their fingerprint in its internal memory. The user is prompted by the LCD for fingerprint scanning until a successful enrollment is achieved. If the user is already enrolled, they can jump this stage and go directly to the Authentication stage

Step 3: Authentication

During the attendance process, the AS608 fingerprint module scans a user's fingerprint and compares it with the stored fingerprints. If a match is found, the user is considered authenticated, and the attendance status is recorded.

Step 4: Display and Logging

The 16x2 LCD with I2C module displays relevant user information, such as their name and attendance status. Simultaneously, the system logs the attendance record on the SD card, along with the timestamp obtained from the RTC module.

Step 5: Reporting

At any point, the attendance data stored on the SD card can be accessed. The data can be used to generate reports, analyze attendance patterns, and monitor productivity.

4.4 Code Implementation

The Arduino IDE serves as a platform for writing and uploading code to the Arduino Uno. The code for the attendance system involves configuring the modules, handling user enrollments, fingerprint authentication, LCD display, RTC synchronization, and SD card operations. Libraries specific to each module can be imported into the Arduino IDE and utilized in the code.

4.5 System Testing

Thorough testing of the system is essential to ensure its functionality and accuracy. The system can be tested by enrolling multiple users, scanning their fingerprints, and verifying the attendance records. The LCD display should provide real-time updates, and the attendance data stored on the SD card should be accessible and organized.

Chapter 5: Conclusion

Presently, attendance of student in most institutes in our country Zimbabwe is taken by the teacher on paper based attendance registers. There are various disadvantages to this approach such as data is not available for analysis because paper based registers are not uploaded to a

Commented [4]: Is this in Zimbabwe or the whole world? I think you need to be specific because some institutions have been using the finger print system for years.

Commented [A5R4]: I meant in Zimbabwe, I corrected it centralized system, time taken for data collection reduces the effective lecture time and fake attendance by students. Some universities also use wall mounted RFID swipe card systems. RFID (Radio Frequency Identification) is a wireless technology which uses electromagnetic waves for communication between RFID reader and RFID tag. Though better than paper based systems, RFID based systems also have certain problems such as the system is complex, costly and absent student’s card can be swiped by other students. Biometric techniques can be used to solve these problems.

In conclusion, the fingerprint-based attendance system project, developed using an Arduino Uno along with the AS608 fingerprint module, 16x2 LCD with i2c module, RTC module, Breadboard, and SD Card module, provides a highly efficient and reliable solution for tracking attendance. This modern system offers numerous advantages over traditional, older methods of attendance tracking.

Firstly, the fingerprint-based attendance system ensures accuracy and eliminates the possibility of any fraudulent actions. Each individual's unique fingerprint is securely stored in the system, making it impossible for anyone to impersonate or cheat the system. This eliminates issues such as proxy attendance, buddy punching, or manual errors in assigning attendance.

Secondly, the system is fast and efficient, saving significant time for both the employees/students and the administration. Traditional methods such as paper-based attendance or manual entry consume considerable time in taking and recording attendance, which can be quite tedious. On the other hand, the fingerprint-based system allows for quick and hassle free attendance recording, as it requires a simple touch of a finger.

Furthermore, the system can be seamlessly integrated with existing databases or payroll systems, making it highly convenient for further analysis and processing. The recorded attendance data can be easily converted to digital formats and seamlessly shared across different platforms, enhancing efficiency in generating attendance reports and ensuring easy accessibility of records.

Moreover, the system offers enhanced security and privacy. As the fingerprints are unique to each individual, this method ensures privacy protection as it does not require personal identification numbers or identity cards that could potentially be misused or stolen. Additionally, the recorded attendance data can be encrypted and stored securely on the SD card module, preventing unauthorized access to sensitive information.

Additionally, the Arduino-based system provides a cost-effective solution as it eliminates the need for expensive attendance systems or biometric devices. The availability of open-source software and the affordability of Arduino boards make this project feasible for implementation in various educational institutions, organizations, or businesses.

In summary, the fingerprint-based attendance system project developed using Arduino Uno along with modules such as AS608 fingerprint module, 16×2 LCD with i2c module, RTC module, Breadboard, and SD Card module provides an efficient, accurate, and secure method for tracking attendance. With its numerous advantages over traditional methods, this system ensures reliability, reduces administrative burden, enhances security, and provides cost-effective attendance management for various settings.

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Part of The Code Used

```
#include <Wire.h>

#include <LiquidCrystal_I2C.h>

#include <Adafruit_Fingerprint.h>

#if (defined(__AVR__) || defined(ESP8266)) && !defined(__AVR_ATmega2560__)


// For UNO and others without hardware serial, we must use software serial...

// pin #2 is IN from sensor (GREEN wire)

// pin #3 is OUT from Arduino (WHITE wire)

// Set up the serial port to use softwareserial.

SoftwareSerial mySerial(2, 3);


#else

// On Leonardo/M0/etc, others with hardware serial, use hardware serial!

// #0 is green wire, #1 is white

#define mySerial Serial1

#endif

Adafruit_Fingerprint finger = Adafruit_Fingerprint(&mySerial);


uint8_t id=1;

int mode=0;
```

```
LiquidCrystal_I2C lcd(0x27,20,4);  // set the LCD address to 0x27 for a 16 chars and 2 line
display
void setup()
{

  lcd.init();                      // initialize the lcd
  lcd.init();

  Serial.begin(9600);
  while (!Serial);  // For Yun/Leo/Micro/Zero/...
  delay(100);
  Serial.println("\n\nAdafruit Fingerprint sensor enrollment");

  // set the data rate for the sensor serial port
  finger.begin(57600);

  if (finger.verifyPassword()) {

    int i=0;
    Serial.println("Found fingerprint sensor!");
  while(i>-10){
     lcd.backlight();
  lcd.setCursor(i,0);
  lcd.clear();
```

```
  lcd.print("Found sensor");
  i--;
 delay(1000);
  }
  } else {
    Serial.println("Did not find fingerprint sensor :(");
  lcd.backlight();
  lcd.setCursor(0,0);
  lcd.print("Did not find sensor");
    while (1) { delay(1); }
  }
  Serial.println(F("Reading sensor parameters"));
  finger.getParameters();
  Serial.print(F("Status: 0x")); Serial.println(finger.status_reg, HEX);
  Serial.print(F("Sys ID: 0x")); Serial.println(finger.system_id, HEX);
  Serial.print(F("Capacity: ")); Serial.println(finger.capacity);
  Serial.print(F("Security level: ")); Serial.println(finger.security_level);
  Serial.print(F("Device address: ")); Serial.println(finger.device_addr, HEX);
  Serial.print(F("Packet len: ")); Serial.println(finger.packet_len);
  Serial.print(F("Baud rate: ")); Serial.println(finger.baud_rate);
}


void loop()
```

```
{
  if(mode=0){
  displayer();
  delay(1000);
  getFingerprintEnroll();
  id=id+1;
  }
else if(mode=1){
  displaytoscreenauth();
  getFingerprintEnroll();
  }
}
void displayer()
{
    // Print a message to the LCD.
  lcd.clear();
  lcd.backlight();
  lcd.setCursor(0,0);
  lcd.print("Enroll finger");
  lcd.setCursor(0,1);
  lcd.print(id);
  }
  void displaytoscreenauth()
{
```

```
   // Print a message to the LCD.
  lcd.backlight();
  lcd.setCursor(0,0);
  lcd.print("Authenticate");
  lcd.setCursor(2,0);
  lcd.print("student");
   lcd.setCursor(0,2);
  lcd.print("");
  lcd.setCursor(2,3);
  lcd.print("");
  }
uint8_t readnumber(void) {
  uint8_t num = 0;

  while (num == 0) {
    while (! Serial.available());
    num = Serial.parseInt();
  }
  return num;
}

uint8_t getFingerprintEnroll() {
  id=id+1;
  int p = -1;
```

```
Serial.print("Waiting for valid finger to enroll as #"); Serial.println(id);
lcd.clear();
lcd.setCursor(0,0);
lcd.print("waiting....");
delay(1000);
while (p != FINGERPRINT_OK) {
  p = finger.getImage();
  switch (p) {
  case FINGERPRINT_OK:
    Serial.println("Image taken");
    lcd.clear();
    lcd.setCursor(0,0);
    lcd.print("finger placed");
    delay(1000);
    break;
  case FINGERPRINT_NOFINGER:
    Serial.println(".");
    break;
  case FINGERPRINT_PACKETRECIEVEERR:
    Serial.println("Communication error");
    break;
  case FINGERPRINT_IMAGEFAIL:
    Serial.println("Imaging error");
    break;
```

```
    default:
      Serial.println("Unknown error");
      break;
    }
  }
// OK success!
  p = finger.image2Tz(1);
  switch (p) {
    case FINGERPRINT_OK:
      Serial.println("Image converted");
      break;
    case FINGERPRINT_IMAGEMESS:
      Serial.println("Image too messy");
      return p;
    case FINGERPRINT_PACKETRECIEVEERR:
      Serial.println("Communication error");
      return p;
    case FINGERPRINT_FEATUREFAIL:
      Serial.println("Could not find fingerprint features");
      return p;
    case FINGERPRINT_INVALIDIMAGE:
      Serial.println("Could not find fingerprint features");
      return p;
    default:
```

```
    Serial.println("Unknown error");
    return p;
  }
  Serial.println("Remove finger");
  lcd.clear();
  lcd.setCursor(0,0);
  lcd.print("remove finger");
  delay(1000);
  p = 0;
  while (p != FINGERPRINT_NOFINGER) {
    p = finger.getImage();
  }
  Serial.print("ID "); Serial.println(id);
  p = -1;
  Serial.println("Place same finger again");
  lcd.clear();
  lcd.setCursor(0,0);
  lcd.print("place finger");
  lcd.setCursor(0,1);
  lcd.print("again");
  while (p != FINGERPRINT_OK) {
    p = finger.getImage();
    switch (p) {
    case FINGERPRINT_OK:
```

```
    Serial.println("Image taken");

    break;
  case FINGERPRINT_NOFINGER:
    Serial.print(".");
    break;
  case FINGERPRINT_PACKETRECIEVEERR:
    Serial.println("Communication error");
    break;
  case FINGERPRINT_IMAGEFAIL:
    Serial.println("Imaging error");
    break;
  default:
    Serial.println("Unknown error");
    break;
  }
}
p = finger.image2Tz(2);
switch (p) {
  case FINGERPRINT_OK:
    Serial.println("Image converted");
    break;
  case FINGERPRINT_IMAGEMESS:
    Serial.println("Image too messy");
```

```
    return p;
  case FINGERPRINT_PACKETRECIEVEERR:
    Serial.println("Communication error");
    return p;
  case FINGERPRINT_FEATUREFAIL:
    Serial.println("Could not find fingerprint features");
    return p;
  case FINGERPRINT_INVALIDIMAGE:
    Serial.println("Could not find fingerprint features");
    return p;
  default:
    Serial.println("Unknown error");
    return p;
}

// OK converted!
Serial.print("Creating model for #");  Serial.println(id);

p = finger.createModel();
if (p == FINGERPRINT_OK) {
  Serial.println("Prints matched!");
} else if (p == FINGERPRINT_PACKETRECIEVEERR) {
  Serial.println("Communication error");
  return p;
```

```
} else if (p == FINGERPRINT_ENROLLMISMATCH) {
  Serial.println("Fingerprints did not match");

  lcd.clear();
  lcd.setCursor(0,0);
  lcd.print("did not match");
  delay(1000);
  return p;
} else {
  Serial.println("Unknown error");
  return p;
}
```