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Low-Cost Class Room Attendance System using STM32 Microcontroller

T Vijay, Dr. D Sandeep

Department of Electronics and Communication Engineering, Sree Rama Engineering College, Tirupati, India

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ABSTRACT: This paper presents the design and implementation of a low-cost, portable classroom attendance system using the STM32 Blue Pill Development Board and biometric fingerprint technology. Traditional attendance methods are time-consuming and prone to proxy attendance. To address these issues, a compact handheld device is developed using the STM32 microcontroller, R305 Fingerprint Sensor, and a 16×2 LCD display. The system ensures accurate and secure attendance recording while maintaining affordability. The device is powered using a power bank, making it portable and convenient for classroom use. Experimental results show improved efficiency and reliability compared to manual methods.

KEYWORDS: STM32, Fingerprint Recognition, Attendance System, Embedded Systems, Biometrics, Low-Cost Device

I. INTRODUCTION

Attendance monitoring plays a vital role in academic institutions for evaluating student participation and academic performance. Traditional attendance methods, such as manual roll calls and paper-based registers, are time-consuming, prone to human error, and susceptible to proxy attendance. These limitations reduce efficiency and compromise the authenticity of attendance records.

With advancements in embedded systems and biometric technologies, automated attendance systems have gained significant attention. Among various biometric methods, fingerprint recognition is widely preferred due to its uniqueness, reliability, and cost-effectiveness. Unlike RFID cards or PIN-based systems, fingerprint-based systems eliminate the possibility of duplication or misuse.

In this paper, a **low-cost and portable classroom attendance system** is proposed using the STM32 Blue Pill Development Board and the R305 Fingerprint Sensor. The system is designed as a handheld device powered by a power bank, making it suitable for flexible classroom environments. A 16×2 LCD is used to display user information and attendance status in real time.

The proposed system aims to provide a **secure, efficient, and affordable solution** for attendance management while reducing manual effort and preventing fraudulent practices. The use of the STM32 microcontroller ensures fast processing and low power consumption, making the system suitable for real-time applications.

II. LITERATURE SURVEY

Several automated attendance systems have been proposed in recent years to overcome the limitations of traditional manual methods. These systems primarily utilize technologies such as RFID, face recognition, and biometric authentication.

RFID-based attendance systems are widely used due to their simplicity and fast operation. In these systems, students carry RFID cards that are scanned to record attendance. However, RFID systems are vulnerable to misuse, as cards can be exchanged among students, leading to proxy attendance.

Face recognition-based systems have gained popularity with advancements in image processing and machine learning. These systems automatically detect and recognize faces using cameras. While they reduce manual effort, their performance is affected by lighting conditions, facial variations, and require higher computational resources.

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Fingerprint-based systems are considered one of the most reliable biometric methods due to the uniqueness of fingerprints. Modules such as the R305 Fingerprint Sensor provide accurate and secure identification. These systems effectively eliminate proxy attendance and are suitable for embedded applications.

Microcontroller platforms like the STM32 Blue Pill Development Board offer a cost-effective and efficient solution for implementing such biometric systems, providing high performance with low power consumption.

A. Comparison of Attendance Technologies

Table 1

Parameter	RFID System	Face Recognition System	Fingerprint System (Proposed)
Cost	Low	High	Low
Accuracy	Medium	High (depends on conditions)	High
Proxy Attendance	Possible	Difficult	Not Possible
Hardware Required	RFID Card & Reader	Camera + High Processing Unit	Fingerprint Sensor
Processing Speed	Fast	Moderate	Fast
Environmental Impact	Not affected	Affected by lighting	Not affected
Security Level	Low	Medium to High	High
Ease of Use	Easy	Moderate	Easy

B. Discussion

From the comparison, it is evident that fingerprint-based systems provide the best balance between **cost, accuracy, and security**. Unlike RFID systems, they eliminate proxy attendance, and compared to face recognition systems, they require less computational power and are less sensitive to environmental conditions.

Therefore, the proposed system adopts fingerprint-based authentication to ensure a **reliable, secure, and cost-effective attendance solution**.

III. PROPOSED SYSTEM

The proposed system is a **low-cost, portable biometric attendance system** that uses fingerprint authentication to ensure secure and accurate attendance recording. It integrates embedded hardware and efficient software design for real-time operation.

C. System Design

The system is designed using a modular approach consisting of input, processing, and output units. The STM32 Blue Pill Development Board acts as the core controller, interfacing with the R305 Fingerprint Sensor and a 16×2 LCD display.

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D. Block Diagram Explanation

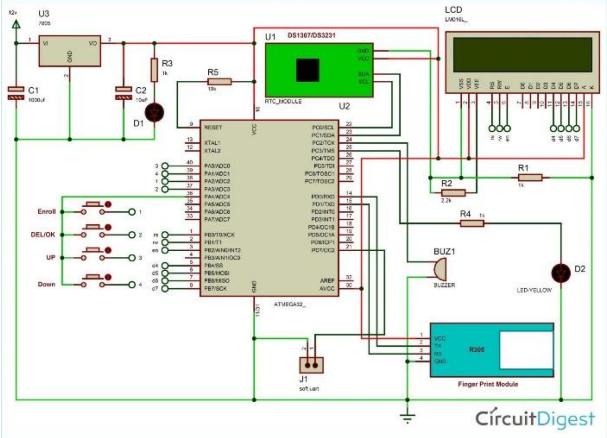

Fig. 1. Block Diagram of Proposed System

The system operates based on the following blocks:

- **Input Block:**

The fingerprint sensor captures the user's fingerprint.

- **Processing Block:**

The STM32 microcontroller processes the received fingerprint data and performs verification.

- **Output Block:**

The LCD displays the authentication result and attendance status.

- **Power Supply Block:**

A power bank provides regulated power to all components.

E. Hardware Circuit Connections

The hardware connections between components are implemented as follows:

- STM32 and R305 Fingerprint Sensor (UART Interface)
- R305 TX → STM32 RX (PA10)
- R305 RX → STM32 TX (PA9)
- VCC → 5V
- GND → GND
- STM32 and 16×2 LCD (4-bit Mode)
- RS → PB0
- EN → PB1
- D4–D7 → PB10–PB13
- VSS → GND
- VDD → 5V
- V0 → Potentiometer (for contrast control)
- Power Supply
- Power bank (5V) connected to STM32 via USB or 5V pin
- Common ground shared across all components

F. Key Design Features

- Compact and handheld device
- Low power consumption
- Fast fingerprint processing
- Simple user interface via LCD
- Secure biometric authentication

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G. Software Design

- The software is developed using Embedded C and follows a modular approach:
- Initialization Module: Initializes UART, GPIO, and LCD
- Fingerprint Module: Handles enrolment and matching
- Display Module: Controls LCD output
- Control Logic: Manages system workflow
- The STM32 communicates with the fingerprint sensor using serial commands and processes responses accordingly.

H. Communication Protocol

- **UART Communication:**

Used between STM32 and R305 fingerprint sensor

- **GPIO Interface:**

Used for LCD communication

- The system ensures fast and reliable data transfer between components.

I. Design Considerations

- **Low Cost**: Use of affordable components like STM32 and R305
- **Portability**: Compact and powered by a power bank
- **Accuracy**: Reliable fingerprint matching
- **Power Efficiency**: Low power consumption design

IMPLEMENTATION

The proposed attendance system is implemented as a compact and portable embedded device integrating biometric authentication with a microcontroller-based platform. The system combines hardware components and embedded software to achieve real-time attendance recording.

J. Hardware Implementation

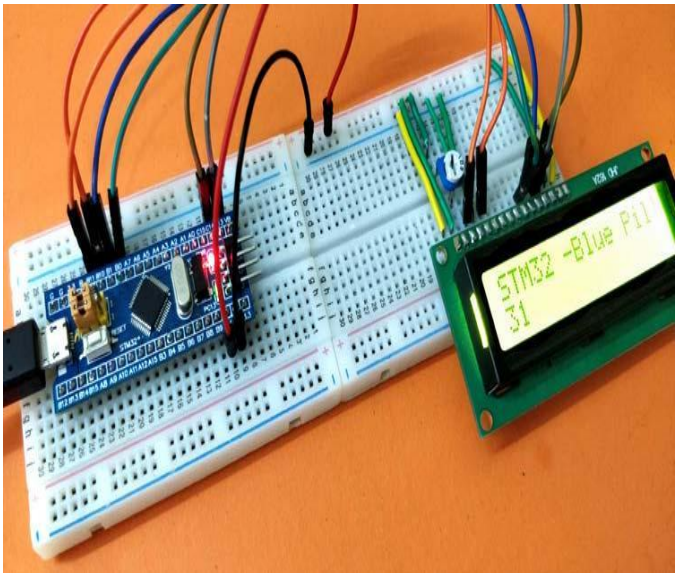

Fig. 2. Hardware Implementation

The hardware components are assembled and interfaced as follows:

- The STM32 Blue Pill Development Board acts as the central controller.
- The R305 Fingerprint Sensor is connected to the STM32 via UART (TX and RX pins) for serial communication.
- The 16×2 LCD is interfaced using GPIO pins in 4-bit mode to reduce pin usage.
- A portable power bank supplies 5V power to the system, ensuring mobility.

All components are mounted in a compact enclosure to form a handheld device suitable for classroom use.

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K. Software Implementation

The software is developed using Embedded C and programmed into the STM32 microcontroller. The firmware is structured into functional modules:

- **Initialization Module:**

Configures UART, GPIO, and LCD for operation.

- **Fingerprint Enrolment Module:**

Allows registration of student fingerprints, which are stored in the sensor's internal memory.

- **Fingerprint Matching Module:**

Captures the fingerprint and compares it with stored templates using the R305 sensor's internal algorithm.

- **Display Module:**

Controls the LCD to show messages such as "Place Finger", "Attendance Marked", or "Access Denied".

- **Control Logic:**

Coordinates all modules and manages system flow.

L. Enrollment Process

Before using the system, each student must enrol their fingerprint:

1. The system enters enrolment mode
2. The user places their finger on the sensor
3. The fingerprint is captured multiple times for accuracy
4. A unique ID is assigned and stored in the sensor memory

M. Attendance Marking Process

The attendance marking process operates as follows:

1) The system prompts the user to place their finger
2) The fingerprint is captured by the sensor
3) The STM32 receives the processed data
4) The sensor compares it with stored templates
5) If matched:

Attendance is recorded
LCD displays confirmation message
If not matched:
Error message is displayed

N. Prototype Development

A working prototype of the system is developed and tested in a classroom environment. The device is designed to be:

- **Portable:** Powered by a power bank
- **Compact:** Easily handheld
- **User-Friendly:** Simple interface using LCD prompts

O. Performance Evaluation

The implemented system demonstrates:

- Fast response time for fingerprint recognition
- High accuracy in attendance marking
- Reliable operation under normal classroom conditions
- Reduced time compared to manual attendance methods

IV. RESULTS & DISCUSSION

The proposed low-cost classroom attendance system was successfully implemented and tested under real-time conditions. The system performance was evaluated based on accuracy, response time, reliability, and usability.

A. Experimental Setup

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Fig. 3. Experimental Setup

The system prototype consists of the STM32 Blue Pill Development Board, R305 Fingerprint Sensor, and a 16×2 LCD integrated into a portable handheld device. The system was tested with multiple users whose fingerprints were pre-enrolled.

B. Performance Analysis

The performance of the system was analysed using the following parameters:

- **Accuracy:**

The system achieved high accuracy in fingerprint recognition. Most enrolled fingerprints were correctly identified, minimizing false acceptance and rejection rates.

- **Response-Time:**

The average time taken to authenticate a fingerprint and display the result was approximately 1–2 seconds, making the system suitable for real-time classroom usage.

- **Reliability:**

The system operated consistently under normal conditions. Minor variations were observed when fingerprints were unclear or improperly placed.

- **Portability:**

The use of a power bank enabled easy movement of the device between classrooms without requiring a fixed power source.

C. Comparative Analysis

Compared to other attendance methods:

- **Manual-Method:**

Time-consuming and prone to human error

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- **RFID-Based-Systems:**

Faster but vulnerable to proxy attendance

- **Face-Recognition-Systems:**

Accurate but require high computational resources and are affected by lighting conditions

- **Proposed-Fingerprint-System:**

Provides a balanced solution with high accuracy, low cost, and minimal processing requirements

D. Observations

- The system significantly reduces attendance time compared to manual methods
- Proxy attendance is effectively eliminated
- The device is simple to use and requires minimal training
- Performance depends on proper fingerprint placement and sensor cleanliness

E. Limitations Identified

- Difficulty in recognizing fingerprints with dirt or moisture
- Limited storage capacity of the fingerprint sensor
- No remote data storage or backup in the current implementation

F. Discussion

The results demonstrate that the proposed system is a **practical and efficient solution** for classroom attendance management. The combination of the STM32 microcontroller and fingerprint sensor provides a good balance between performance and cost. While the system performs well in controlled environments, its functionality can be further enhanced by integrating wireless communication and cloud storage.

V. CONCLUSION

This paper presented the design and implementation of a **low-cost, portable classroom attendance system** based on biometric fingerprint authentication. The system utilizes the STM32 Blue Pill Development Board in combination with the
R305 Fingerprint Sensor to provide a reliable and efficient solution for attendance management.
The proposed system successfully addresses the limitations of traditional attendance methods by eliminating proxy attendance, reducing manual effort, and significantly decreasing the time required for attendance recording. Experimental results demonstrate that the system achieves high accuracy, fast response time, and stable performance under typical classroom conditions.

One of the key contributions of this work is the development of a **portable and cost-effective handheld device**, powered by a power bank, which allows flexible deployment without the need for fixed infrastructure. The system is simple to use, requires minimal training, and can be easily adopted in educational institutions.

Although the current implementation is effective, it has certain limitations such as limited storage capacity and lack of remote data access. These limitations open avenues for future enhancements, including integration with wireless communication technologies, cloud-based data storage, and mobile applications.

In conclusion, the proposed system offers a **practical, scalable, and efficient solution** for modern attendance management and has strong potential for real-world deployment in academic environments.

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