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FINGERPRINT BASED SMART ATTENDANCE SYSTEM USING IOT

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***Abstract*:** Proper attendance record-keeping is critical in schools for tracking student participation and performance. Conventional approaches, including manual registers and RFID-based systems, are prone to errors, tampering, and inefficiencies. This research proposes a Fingerprint-Based Smart Attendance Management System Using IoT, which tracks attendance automatically using biometric verification. The system utilizes an ESP32 microcontroller coupled with a fingerprint sensor to scan and authenticate student identities. Attendance records are stored and analyzed in a Python-based system with real-time tracking through a web-based interface. Additionally, when a student has an attendance level of less than 75%, an automatic warning message is sent to their parents. The proposed system improves the accuracy, stops proxy attendance, and enhances overall efficiency in handling attendance. With the integration of IoT and biometric authentication, the system guarantees a secure, scalable, and user-friendly process for tracking attendance.

Keyword: Attendance Monitoring System (AMS), Automated Attendance Tracking, Cloud-based Systems, Fingerprint Recognition, Internet of Things (IoT).

I.INTRODUCTION

Efficient attendance management is crucial for educational institutions, ensuring accurate student tracking and compliance with academic policies. Traditional methods like paper-based registers and roll calls are time- consuming and prone to errors. As institutions grow, these outdated systems become inefficient, leading to inaccurate records, administrative burdens, and data loss. The lack of real-time communication also prevents timely updates for administrators and parents, making it difficult to address attendance issues.

To solve these challenges, this project proposes a fingerprint smart attendance system integrating biometric fingerprint recognition, an ESP32 microcontroller, and a Python-based web application. The fingerprint module ensures secure student identification and prevents proxy attendance. The ESP32, with low power consumption and Wi-Fi capabilities, processes fingerprint data and enables real-time data transfer.

An LED display provides instant attendance feedback, reducing confusion. The Twilio API enhances communication by sending automated WhatsApp notifications when attendance drops below a set threshold. Attendance records are securely stored in Neon Cloud with a MySQL database, ensuring real-time updates, easy access, and enhanced security. The web application provides an interactive dashboard for administrators and faculty to monitor trends, generate reports, and manage attendance efficiently.Designed for scalability, this system integrates advanced hardware and cloud storage to improve accuracy, efficiency, and security while minimizing administrative burdens. It modernizes attendance tracking, ensuring better student participation and engagement.

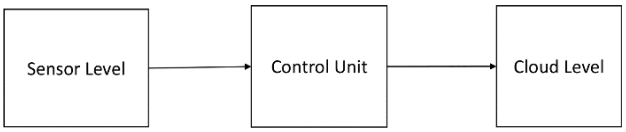

Fig.1 Basic Block Diagram of the Syste

The block diagram presents a Fingerprint-Based Smart Attendance System structured into three levels. At the sensor level, a fingerprint sensor captures biometric data, and an LED display provides immediate feedback. The control unit processes this data using an ESP32 microcontroller, manages attendance through a Python-based application, and automates notifications via the Twilio API. In the cloud level, a MySQL database securely stores attendance records, accessible through a web dashboard, while data analytics help analyze attendance trends. This system ensures automated, secure, and real-time attendance monitoring for educational institutions.

II. PROPOSED SYSTEM

The proposed fingerprint-based attendance system is structured into three main levels: Sensor Level (Input), Control Unit, and Output, ensuring efficient data processing, secure storage, and real-time communication..

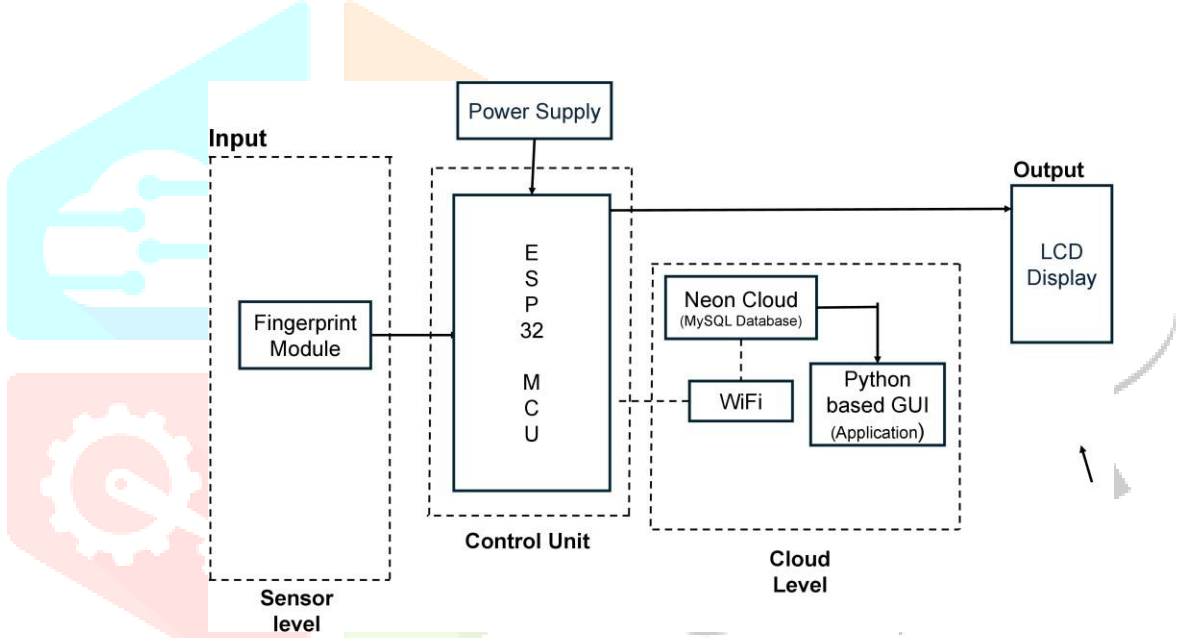

Fig.1 Block Diagram of Fingerprint Based Smart Attendence System Using an IOT

The system consists of three levels: sensor, control, and output. At the sensor level, a fingerprint module captures and verifies student biometrics, sending the data to the ESP32 microcontroller for authentication.

The control unit, powered by ESP32, processes fingerprint data, communicates with the cloud, and provides real-time feedback via an LCD display with messages like “Attendance Marked” or “Access Denied.” It connects to Wi-Fi, transmitting attendance records to a MySQL database on Neon Cloud, managed by a Python-based GUI.For automation, the system integrates the Twilio API, sending SMS or WhatsApp alerts when attendance falls below 75%. The output level includes an LCD display for instant feedback and a web- based interface for administrators and parents to track records and receive notifications. This system enhances accuracy, reduces manual work, and ensures transparency in attendance tracking.

III.SYSTEM IMPLEMENTATION

The implementation of the fingerprint-based smart attendance system follows a step-by-step approach from development to deployment. It begins with requirement analysis and component selection, where hardware like the ESP32 microcontroller, fingerprint sensor, LED display, and power supply unit are chosen, along with software tools such as Arduino IDE, Python (Flask), and Neon Cloud MySQL for data storage. The hardware setup is then completed, ensuring proper connections and WiFi configuration for real-time data transmission.In the software development phase, the ESP32 is programmed using Arduino IDE with necessary libraries for fingerprint scanning and database communication. A Python-based web application is developed using Flask to interface with the Neon Cloud MySQL database, enabling administrators to manage attendance records efficiently. The system then moves to the attendance process, where a student scans their fingerprint, and upon verification, the attendance is recorded in the cloud. An LED display provides real- time feedback, and if attendance falls below 75%, the Twilio API sends automated WhatsApp alerts to students, parents, and administrators.Finally, the system undergoes testing and debugging to ensure smooth operation and is then deployed for real-time attendance tracking and automated reporting, making attendance management efficient, secure, and scalable.

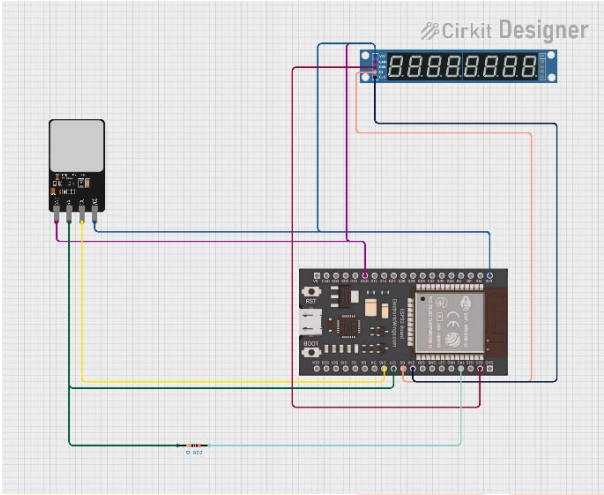

Fig. 3. Circuit Diagram of the System

The flowchart illustrates the working of a fingerprint-based smart attendance system. It starts with scanning a fingerprint, where the system verifies the identity. If the verification fails, access is denied; otherwise, attendance is successfully recorded. After marking attendance, the data is transmitted to a web application and updated in the Neon Cloud MySQL database. The system then checks if the student's attendance percentage is below 75%. If attendance is sufficient, the process ends. Otherwise, a notification is sent via the Twilio API to inform students and parents.Lastly, the system provides a real-time dashboard for admins and faculty to monitor attendance records efficiently. The process concludes at this stage, ensuring automated, secure, and real-time attendance tracking.

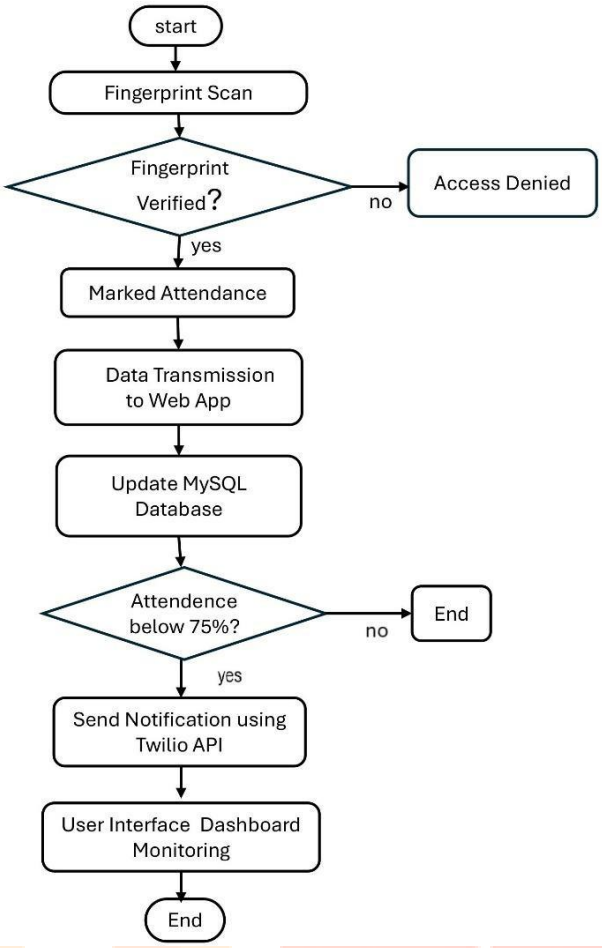

Fig.4 Flowchart of the System

IV. RESULTS AND DISCUSSION

The fingerprint-based smart attendance system successfully automates attendance tracking, ensuring accuracy and security. The system efficiently verifies student identity using a fingerprint sensor and records attendance in the **Neon Cloud MySQL** database through the ESP32 microcontroller. Real-time feedback is provided via an LED display, and automated **WhatsApp alerts** are sent using the Twilio API when attendance drops below **75%**. The Python web application enables administrators to monitor records and generate reports. This implementation minimizes proxy attendance, enhances data security, and improves communication between students, parents, and administrators.

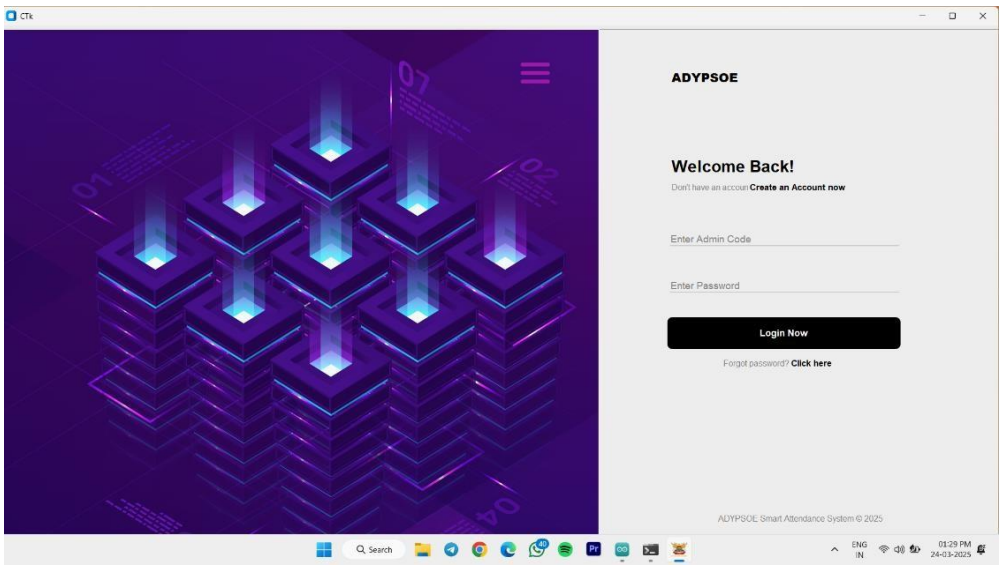

Fig. 4 Admin Login Dashboard

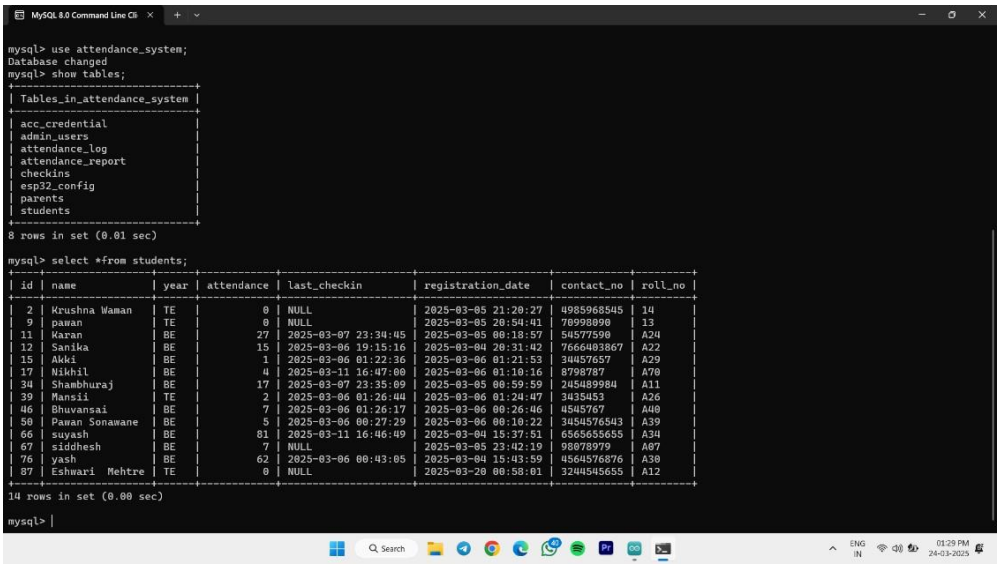

Fig. 4. ID, Date, and Time are inserted into the MySQL database

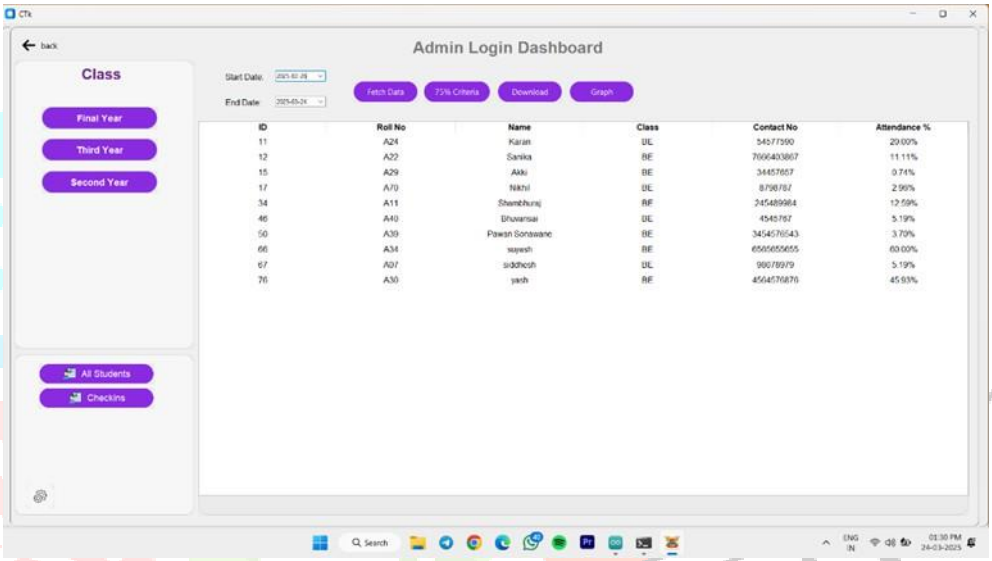

Fig. 4. Application Dashboard

Authors	Data Management	Student Tracking	Attendance Alerts	Achievement Monitoring	Maintenance Records	Information Display
Patel et al. [1]	Yes	No	Yes	No	No	Yes
Zhang et al. [2]	Yes	No	Yes	No	No	Yes
Sinha et al. [3]	Yes	No	Yes	No	No	Yes
Sharma and Dey [4]	Yes	No	Yes	No	Yes	No
Malik et al. [5]	Yes	No	Yes	No	No	Yes
Chen et al. [6]	Yes	Yes	Yes	No	No	Yes
Chavan et al. [7]	Yes	No	Yes	No	Yes	No
Ahmad and Bharti [8]	Yes	No	Yes	No	No	Yes
Farhat et al. [9]	Yes	No	Yes	No	No	Yes

Shankar et al. [10]	Yes	No	Yes	No	No	Yes
Proposed System	Yes	Yes	Yes	Yes	Yes	Yes

Table 1.Comparison of Existing Attendance Systems with the Proposed System

The table presents a comparative analysis of various systems proposed by different researchers in the field of student attendance and management. It evaluates each system based on six key functionalities: Data Management, Student Tracking, Attendance Alerts, Achievement Monitoring, Maintenance Records, and Information Display.Each row corresponds to a different study, listing whether the respective system includes the mentioned functionalities. All reviewed systems support Data Management, but only some incorporate Student Tracking, Attendance Alerts, or other features. Notably, the proposed system integrates all six functionalities, distinguishing it from previous implementations.This comparison highlights the limitations of prior research and emphasizes the comprehensive nature of the proposed system in addressing multiple aspects of student attendance and monitoring.

V. CONCLUSIONS

The Fingerprint Smart Attendance System simplifies attendance tracking by combining fingerprint identification, an ESP32 microcontroller, and a Python-based web application. With an LED display for instant feedback and Twilio API for automated WhatsApp notifications, it improves communication between students, parents, and administrators. A MySQL database ensures secure data storage and easy retrieval of attendance records.Designed to be scalable, the system fits institutions of all sizes, enhancing accuracy and security while reducing proxy attendance and manual errors. Automated alerts help students maintain regular attendance. Future improvements could include facial recognition for added security, multi-factor authentication, a mobile app for better accessibility, and advanced data analytics to track attendance patterns and support at-risk students, making the system more efficient and user-friendly.

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