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MARKBASE: AI-ASSISTED WEB-BASED ATTENDANCE MANAGEMENT SYSTEM

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ABSTRACT

Attendance management is a critical operational process in educational institutions; however, conventional manual registers and loosely controlled digital systems often suffer from proxy attendance, delayed updates, and lack of institutional control. This paper presents Markbase, a staff-controlled, AI-assisted, web-based attendance management system designed to replicate real-world academic workflows through a timetable-driven operational model. In the proposed system, attendance sessions are dynamically activated based on division-specific academic timetables and can be initiated only by authorized staff members, ensuring strict procedural governance.

The system integrates artificial intelligence–based facial recognition for secure student authentication during login and attendance marking, significantly reducing identity fraud and proxy attempts. A rule-based attendance engine automatically assigns Present, Late, or Absent status using time-bound session validation, eliminating manual manipulation. Markbase implements role-based access control supporting Administrator, Staff, Student, and Parent roles, each provided with role-specific dashboards, analytics, and reporting interfaces.

The backend is implemented using a Python-based RESTful architecture with SQLite database support, while the frontend utilizes ReactJS to provide a responsive, browser-based interface suitable for both desktop and mobile devices. The proposed architecture ensures scalability, reliability, and transparency while maintaining administrative authority over attendance processes. The system is designed for realistic institutional deployment and serves as a comprehensive final-year engineering or diploma-level academic project demonstrating the integration of artificial intelligence, web technologies, and automated academic workflow management.

KEY WORDS — *Attendance Management System, Facial Recognition, Timetable-Driven Attendance, Role-Based Access Control, FastAPI, Educational Web Application.*

1. INTRODUCTION

Attendance monitoring is an essential academic process used by educational institutions to evaluate student participation, maintain discipline, and ensure compliance with institutional regulations. Traditional attendance recording methods, such as manual registers and basic digital entry systems, are often time-consuming, prone to human error, and vulnerable to proxy attendance. Even several modern digital systems allow students to independently mark attendance or rely on static scheduling mechanisms, which fail to accurately represent real-world academic workflows where attendance is conducted under direct staff supervision during scheduled lecture or laboratory sessions.

With the rapid advancement of artificial intelligence, web technologies, and biometric authentication systems, there is a growing demand for intelligent attendance solutions that provide accuracy, automation, and administrative control. Facial recognition technology has emerged as a reliable biometric approach for identity verification due to its non-intrusive operation and high recognition accuracy when integrated with modern deep learning models. However, many existing implementations focus only on biometric verification without incorporating institutional requirements such as timetable-driven attendance activation, staff-controlled session initiation, and automated rule-based attendance status assignment.

To address these limitations, this paper proposes Markbase, an AI-assisted, web-based attendance management system designed specifically around realistic academic institutional workflows. The proposed system introduces a timetable-driven session architecture in which attendance sessions are dynamically activated based on division-level academic schedules and can be initiated only by authorized staff members. Students authenticate their presence using facial recognition within active sessions, while automated time-based rules assign attendance status as Present, Late, or Absent without manual intervention.

Markbase further implements role-based access control supporting administrators, staff, students, and parents, enabling secure access to attendance records, analytics dashboards, and institutional reporting tools. The system is developed using a Python-based RESTful backend architecture with a relational

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database for centralized data management, and a responsive web-based frontend to ensure accessibility across devices. By combining biometric authentication, timetable-driven automation, and institutional administrative control, the proposed system offers a secure, scalable, and practical solution suitable for deployment in educational environments as well as for final-year engineering or diploma-level academic projects.

2. SYSTEM OVERVIEW

Markbase is a fully web-based, AI-assisted attendance management system designed to operate according to real academic institutional workflows. The system follows a centralized, timetable-driven operational model in which attendance sessions are dynamically activated based on predefined academic schedules and can be initiated only by authorized staff members. This ensures that attendance is conducted strictly during valid lecture or laboratory sessions, preventing unauthorized or self-marked entries by students.

The platform is implemented using a layered client–server architecture consisting of a web-based frontend, a RESTful backend service layer, a relational database, and an artificial intelligence–based facial recognition module. The frontend provides responsive browser-based access for administrators, staff, students, and parents through role-specific dashboards and navigation interfaces. The backend manages authentication, timetable processing, attendance rule enforcement, and system logic, while the database layer stores institutional structures, user accounts, timetable sessions, and attendance records.

Markbase supports four primary user roles: Administrator, Staff, Student, and Parent. Administrators manage academic structures such as departments, divisions, batches, subjects, and user accounts, as well as monitor analytics and institutional attendance reports. Staff members initiate attendance sessions and supervise attendance marking during active timetable periods. Students authenticate their presence using facial recognition during staff-initiated sessions and can later view their attendance statistics, while parents are provided with read-only access to attendance summaries and performance trends.

Attendance processing is governed by an automated rule engine that assigns attendance status based on session timing, ensuring consistent classification of Present, Late, or Absent records. Once recorded, attendance entries are locked to maintain integrity, with limited same-day administrative override authority for institutional corrections. The modular and loosely coupled system architecture ensures scalability, maintainability, and ease of deployment in academic institutions.

3. OBJECTIVES

The primary objective of this work is to design and implement an **AI-assisted, web-based attendance management system** that ensures accuracy, security, and institutional control. The specific technical objectives are as follows:

1. **To design a timetable-driven attendance framework** that activates attendance sessions based on predefined academic schedules and enforces strict time-based validation rules.
2. **To implement AI-based facial recognition using deep learning techniques** for real-time student identification and authentication during attendance marking.
3. **To develop a staff-controlled attendance initiation mechanism** that prevents unauthorized or self-marked attendance by students.
4. **To integrate liveness detection techniques** to mitigate spoofing attacks such as photograph or video-based proxy attempts.
5. **To design and deploy a RESTful backend architecture** that supports secure communication, modular scalability, and efficient data handling.
6. **To implement role-based access control (RBAC)** ensuring secure data access for administrators, faculty, students, and parents.
7. **To store and manage attendance data in a centralized database** with support for consistency, integrity, and long-term record maintenance.
8. **To develop real-time analytics and reporting modules** for session-wise, subject-wise, and student-wise attendance monitoring.
9. **To ensure system scalability and performance optimization** for handling multiple users, concurrent sessions, and real-time facial recognition tasks.
10. **To design a responsive and user-friendly web interface** that enables seamless interaction across different devices and user roles.

4. METHODOLOGY

The proposed Markbase: AI-Assisted Web-Based Attendance Management System follows a structured and modular development methodology integrating web technologies, artificial intelligence, and institutional workflow automation to ensure accuracy, security, and scalability.

4.1 System Architecture Design

The system is designed using a client–server architecture where the frontend operates as a responsive web application and communicates with the backend through RESTful API services. This architectural separation ensures modular development, secure data exchange, and scalability for handling multiple concurrent users and attendance sessions. The backend is responsible for authentication, timetable processing, attendance rule enforcement, and database operations, while the frontend manages role-specific user interfaces and visualization dashboards.

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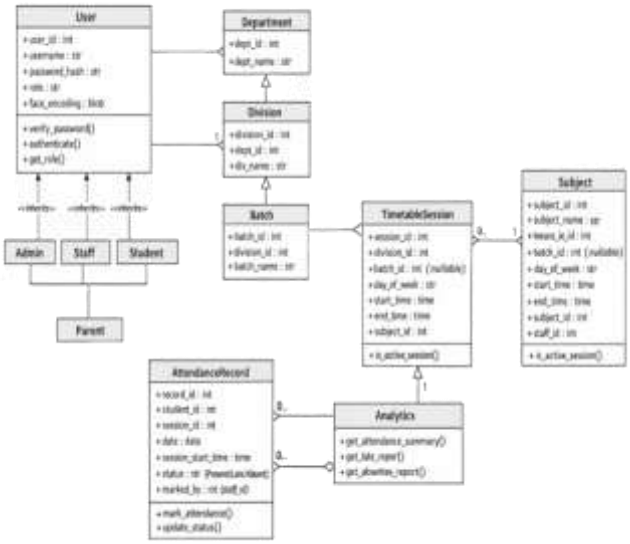

Figure 1 – Class Diagram

4.2 Role Definition and Access Control

Multiple user roles including Administrator, Staff, Student, and Parent are defined within the system. Role-Based Access Control (RBAC) is implemented to ensure that system functionalities are restricted according to authorization levels. Administrators manage academic structures, user accounts, and analytics; staff members initiate attendance sessions; students authenticate their presence using facial recognition; and parents access attendance reports through read-only dashboards.

4.3 Timetable-Driven Attendance Activation

Attendance sessions are dynamically activated using a timetable-driven mechanism rather than fixed scheduling. Weekly academic timetables are stored as session-level entries containing division, batch (if applicable), subject, staff, day, and time information. The system continuously evaluates the current system time and identifies whether an active session exists for a logged-in staff member. Attendance can be initiated only when a valid timetable match is detected, ensuring strict adherence to institutional schedules.

4.4 Facial Data Enrollment and Preprocessing

During the enrollment phase, student facial data is captured using webcam interfaces. Multiple facial images are collected under varying lighting conditions and viewing angles to improve recognition accuracy. The images undergo preprocessing operations including face detection, normalization, grayscale conversion, and noise reduction before being converted into numerical facial embeddings stored securely in the database.

4.5 Facial Recognition and Identity Verification

Artificial intelligence–based facial recognition models are used to extract distinguishing facial features and generate numerical encodings. During attendance marking, real-time facial input is captured and matched against stored embeddings using similarity threshold algorithms. Identity verification is granted only when the similarity score satisfies the defined threshold, ensuring reliable and secure authentication.

4.6 Liveness Detection and Anti-Spoofing

To prevent proxy attendance and spoofing attempts using photographs or recorded media, liveness detection techniques such as facial motion analysis and blink detection are incorporated. These techniques verify the presence of a live human face before authentication is approved, enhancing the overall security of the system.

4.7 Automated Attendance Rule Engine

Attendance status is determined automatically using a rule-based engine linked to session timing. Students marked within the first fifteen minutes of session start are classified as Present, students marked afterward but before session completion are classified as Late, and students not marked by session completion are automatically recorded as Absent. Once attendance is recorded, entries are locked to prevent unauthorized modification, with administrative override permitted only within the same operational day.

4.8 Attendance Recording and Data Storage

Upon successful identity verification, attendance is automatically recorded along with student identifier, subject identifier, session details, timestamp, and marking authority. All records are stored in a centralized relational database designed with referential integrity constraints to ensure consistency between timetable sessions and attendance entries.

4.9 Dashboard Analytics and Reporting

Role-specific dashboards provide real-time attendance monitoring and analytical reporting. Faculty dashboards display live session attendance status, while administrative dashboards present absentee trends, late-comer analysis, and institutional attendance summaries using graphical visualizations. Student and parent dashboards provide subject-wise attendance percentages and historical attendance records for performance monitoring.

4.10 System Testing and Validation

The system is evaluated through functional testing, performance testing, and biometric recognition accuracy assessment under controlled academic scenarios. Validation metrics include recognition accuracy, processing latency, session activation reliability, and resistance to proxy attendance attempts. The evaluation confirms that the proposed methodology provides a secure, scalable, and institution-ready attendance management solution.

5. ATTENDANCE RULE ENGINE

The Markbase system incorporates an automated Attendance Rule Engine designed to ensure consistent, tamper-resistant, and institution-compliant attendance recording. The rule engine operates at the session level and is tightly integrated with the timetable-driven session management module, ensuring that attendance marking occurs only during valid academic sessions.

5.1 Session-Based Attendance Processing

Attendance is recorded separately for each lecture or laboratory session defined in the timetable. When a staff member initiates an attendance session, the rule engine automatically retrieves the corresponding timetable entry, including session start time,

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end time, subject, division, and batch information. All attendance operations are validated against this session context to prevent marking outside authorized time windows.

5.2 Automated Time-Based Status Assignment

Attendance status is assigned automatically based on the time at which a student successfully completes facial authentication during an active session. The classification rules are defined as follows:

- Present (P): Attendance marked within the first fifteen minutes from the official session start time.
- Late (L): Attendance marked after fifteen minutes but before the official session end time.
- Absent (A): Attendance not marked by the end of the session. Absence is automatically recorded by the system once the session closes.

These rules are enforced programmatically and cannot be manually overridden by staff members, ensuring fairness and standardization across all academic divisions.

5.3 Record Locking and Integrity Control

Once attendance is recorded for a session, the corresponding entries are automatically locked to prevent modification or duplication. Staff users are restricted to attendance initiation and monitoring functions only and do not possess editing privileges. Administrative users retain limited override authority, allowing corrections only within the same operational day for exceptional institutional requirements. All administrative modifications are logged to maintain transparency and auditability.

Figure 2 – Flow Chart

5.4 Duplicate and Eligibility Validation

Before recording attendance, the rule engine verifies multiple validation conditions including active session status, student eligibility within the assigned division or batch, and confirmation that the student has not already marked attendance for the same session. These validation mechanisms prevent duplicate entries, cross-division marking, and unauthorized attendance recording.

Through automated enforcement of time-based classification, eligibility verification, and record-locking mechanisms, the Attendance Rule Engine ensures reliable, secure, and institution-ready attendance management aligned with real academic workflows.

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Figure 3 – Mark Attendence

6. FACIAL RECOGNITION MODULE

The Markbase system integrates an artificial intelligence–based facial recognition module to ensure secure student authentication during login and attendance marking. During the enrollment phase, multiple facial images of each student are captured using a webcam interface and processed to extract unique facial embeddings, which are securely stored in the database.

During authentication, live facial input is captured and compared with the stored embeddings using similarity threshold matching. Attendance is recorded only when a valid match is detected within an active staff-initiated session, ensuring that only authorized students can mark attendance. Basic liveness detection techniques, such as facial motion and blink verification, are incorporated to reduce spoofing attempts using photographs or prerecorded media. This biometric authentication mechanism significantly minimizes proxy attendance and enhances the reliability of the attendance management process.

7. DASHBOARDS AND ANALYTICS

Each user role is provided with a dedicated dashboard:

- Admin Dashboard: Overall attendance statistics, absentee trends, late-comer analysis
- Staff Dashboard: Active sessions and live attendance status
- Student Dashboard: Subject-wise attendance and percentage
- Parent Dashboard: Daily, weekly, and monthly attendance reports

Charts such as bar graphs and pie charts are used for data visualization.

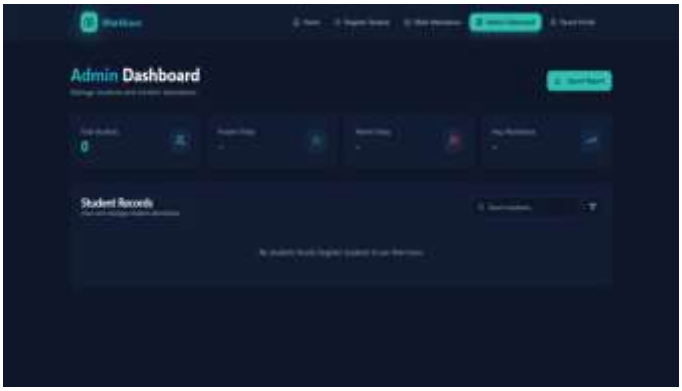

Figure 4 – Admin Dashboard

8. DATABASE DESIGN

The Markbase system uses a relational database designed to maintain structured academic and attendance records with referential integrity. Core tables include Users, Students, Staff, Parents, Divisions, Batches, Subjects, Timetable Sessions, and Attendance Records. Each attendance entry stores student identifier, subject identifier, session date, session start time, attendance status (Present, Late, Absent), and marking authority (staff identifier). Foreign key constraints ensure consistency between timetable sessions, academic entities, and attendance data, enabling efficient querying for analytics and reporting while preventing duplicate or invalid records.

9. RESULTS

The implemented system demonstrates accurate and secure attendance recording through timetable-driven session activation and AI-based facial recognition authentication. Automated rule-based status assignment eliminates manual intervention and reduces administrative errors. Experimental testing in simulated academic scenarios indicates reliable session detection, successful prevention of duplicate attendance entries, and improved transparency in attendance monitoring. The modular architecture ensures stable performance under concurrent usage and supports scalable deployment across multiple academic divisions.

10. CONCLUSION

Markbase presents a comprehensive, AI-assisted web-based attendance management framework that integrates timetable-driven automation, facial recognition–based authentication, and role-based access control to address the limitations of traditional attendance systems. The system ensures institutional control by enabling staff-initiated attendance sessions, automated rule enforcement, and centralized administrative supervision. Its modular REST-based architecture, relational database design, and responsive web interface make it suitable for real-world academic deployment as well as for final-year engineering or diploma-level academic projects demonstrating the practical integration of artificial intelligence and modern web technologies.

11. FUTURE SCOPE

Although the proposed **Markbase: AI-Assisted Web-Based Attendance Management System** significantly enhances attendance accuracy, security, and administrative control, there remains scope for further improvement. Future enhancements may focus on strengthening facial recognition accuracy under real-world conditions such as low lighting, partial face occlusion, and variations in camera angles to ensure reliable performance in diverse classroom environments.

The system can also be expanded by introducing mobile-based support for faculty members, allowing attendance operations to be performed more conveniently using handheld devices. Mobile integration can improve accessibility, reduce dependency on fixed hardware, and enable quicker attendance verification during classroom sessions.

Additionally, future development may include integration with existing Learning Management Systems (LMS) to enable

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comprehensive academic monitoring. By correlating attendance data with academic performance, institutions can gain deeper insights into student engagement and take proactive measures to improve learning outcomes.

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