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STUDENT ATTENDANCE TRACKING USING AI

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***Abstract*—** This project introduces a smart and efficient attendance management system that utilizes face recognition technology to automate the process of student identification and attendance marking. Traditional attendance systems, whether manual or biometric (e.g., fingerprint), are often time-consuming, prone to human error, and susceptible to proxy attendance. To overcome these challenges, this system employs computer vision and machine learning techniques to recognize faces accurately and in real time.[5,6] The system captures the facial image of a student through a live camera feed and compares it against a database of pre-registered facial data using advanced facial recognition algorithms such as Haar Cascades or deep learning models like CNNs. Once a match is found, the student's details—including name, ID, and profile information—are displayed on the screen, and their attendance is automatically marked and stored in a secure database. The system ensures a contactless and quick process, which is especially beneficial in large classrooms or institutions. Additional features may include timestamp logging, generation of attendance reports, and integration with Learning Management Systems (LMS) or school ERP software. [7,8]
***Keywords*—** Face Recognition, Attendance System, CNN, Computer Vision, Automation, ML

INTRODUCTION

Attendance management is a critical aspect of academic administration, directly influencing student performance tracking, classroom discipline, and overall institutional efficiency. Accurate attendance records are essential not only for evaluating student engagement and academic progression but also for meeting regulatory requirements, enabling timely interventions, and generating data-driven insights for curriculum planning and resource allocation.

Traditional attendance methods, often reliant on manual entry, paper-based registers, or card-swiping systems, are increasingly viewed as inefficient and outdated. These approaches are time-consuming, especially in large classrooms, and prone to human error or deliberate manipulation—most notably in the form of proxy attendance, where one student records attendance on behalf of another. Such issues can lead to inaccurate data, unfair assessments, and compromised academic integrity.

With the rapid advancement of biometric technologies, facial recognition has emerged as a powerful and practical solution to these challenges. As a form of biometric authentication, facial recognition analyses unique facial features—such as the distance between the eyes, jawline shape, and nose structure—to accurately identify individuals. It offers a secure, contactless, and automated method for verifying identity, making it highly suitable for high traffic environments like classrooms, where speed and convenience are critical. [1,2]

This project introduces a facial recognition-based attendance system aimed at modernizing and streamlining the attendance process within educational institutions. Leveraging realtime image capture and machine learning algorithms, the system automatically detects and identifies students as they enter the classroom, recording their attendance with high accuracy and minimal disruption. The solution is designed to reduce administrative overhead, enhance record reliability, and discourage fraudulent practices.

Beyond simple attendance logging, the system can be integrated with academic databases and student information systems to generate detailed reports, track attendance trends, and trigger alerts for irregular patterns.[4] It can also support remote learning environments, hybrid classrooms, and campus-wide implementation. As educational institutions continue to embrace digital

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transformation, this approach represents a step forward in building intelligent, data-driven, and efficient academic ecosystems

BACKGROUND&OVERVIEW

Attendance tracking has long been an essential administrative task in educational institutions, serving as a measure of student participation, academic responsibility, and compliance with institutional and governmental regulations. Historically, attendance was recorded using manual methods such as roll calls or sign-in sheets, which, while simple to implement, proved inefficient in terms of time and reliability—especially in large-scale classroom settings. As educational systems grew in complexity and student populations increased, institutions began adopting slightly more advanced techniques like barcode or RFID-based card systems. While these methods offered some level of automation, they still required student interaction and remained vulnerable to misuse, including buddy punching and proxy attendance

LITERATURE REVIEW

The development of an automated attendance system using face recognition is inspired by the growing need for accuracy, efficiency, and security in student attendance tracking. Several studies and systems have explored the use of biometric and computer vision technologies to improve traditional attendance methods. This chapter presents a survey of relevant literature, highlighting key techniques, findings, and their relevance to the current project.[1,3]

SYSTEM ARCHITECTURE

1. Face Registration Module:

o Students' facial data is captured and stored during an initial registration process.

o Each face is linked with the student's metadata including name, student ID, course, and contact information.

o Facial features are extracted using deep learning models (e.g., **CNN-based encoders** such as FaceNet or OpenFace) and stored in an encrypted vector format in a database.

2. Live Face Detection and Recognition: o A live camera feed continuously monitors and captures images of individuals entering the classroom.

o Detected faces are processed in real time using algorithms like **Haar Cascades** for detection and **CNN-based models** (e.g., ResNet-50, MTCNN) for recognition.

o The system compares the live face embeddings against the database to find a match.

3. Attendance Marking System:

Once a face is recognized with a confidence score above a predefined threshold the system:

- Marks attendance.
- Logs the current **timestamp**.
- Updates the attendance record in the database.

o The system prevents duplicate entries for the same session and handles multi-session recognition (e.g., morning/evening classes). [4,8]

4. Database and Storage:

o Stores registered facial embeddings, student profiles, and attendance logs.

o Implements **data encryption and access control** to protect sensitive biometric data.

5. Admin Dashboard and Reporting:

Provides an intuitive UI for administrators to:

- View and manage student data.
- Monitor live attendance activity.
- Generate and export attendance reports (PDF/Excel).

Offers visualization tools to analyze attendance trends over time.

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UML DIAGRAMS

Unified Modeling Language (UML) diagrams are used to visualize, specify, construct, and document the components of the project . These diagrams help in understanding system structure, behavior, and interaction between modules. The class diagram, represents the static structure of the system by illustrating classes, their attributes, methods, and relationships.

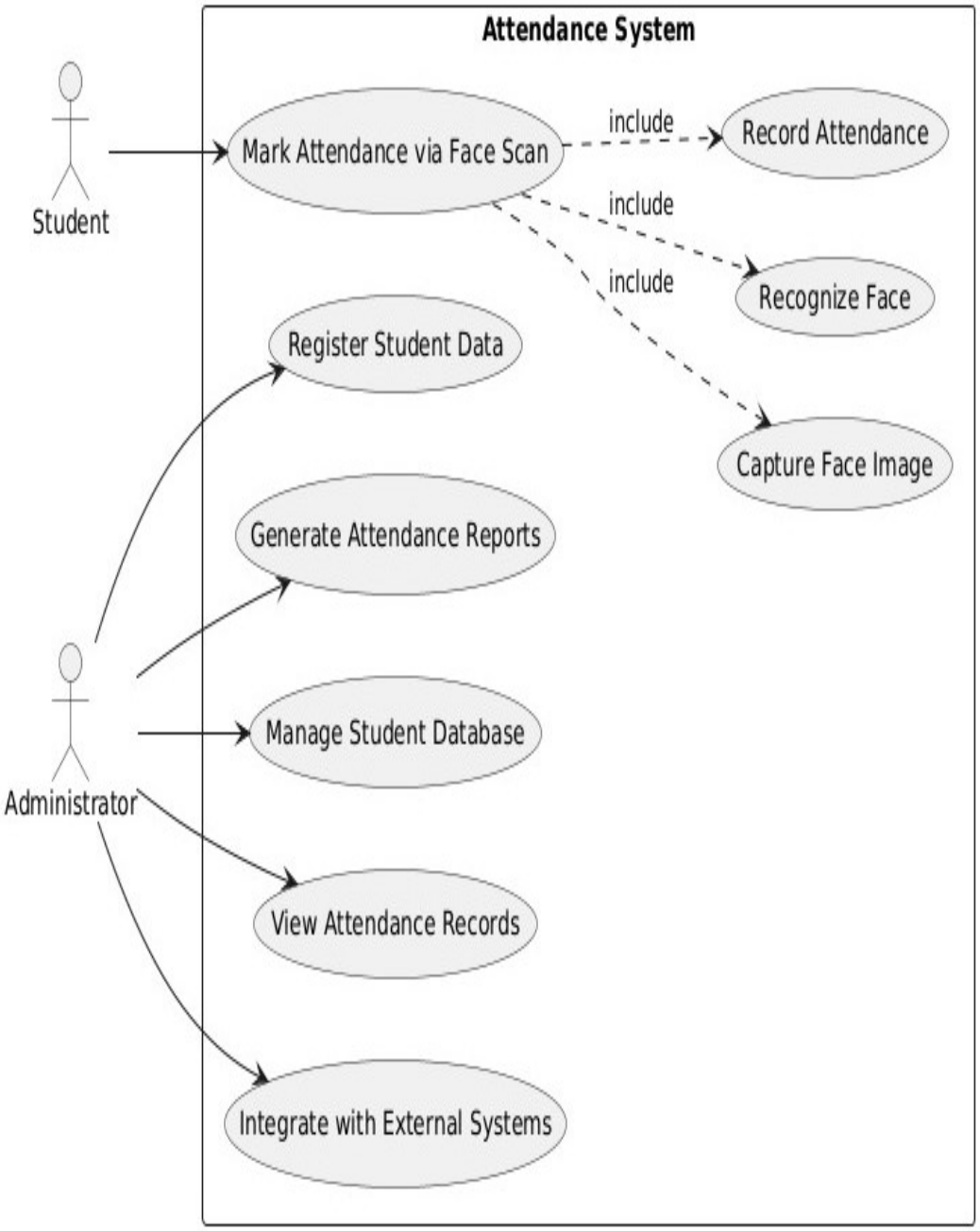

FIG 1: Use case Diagram

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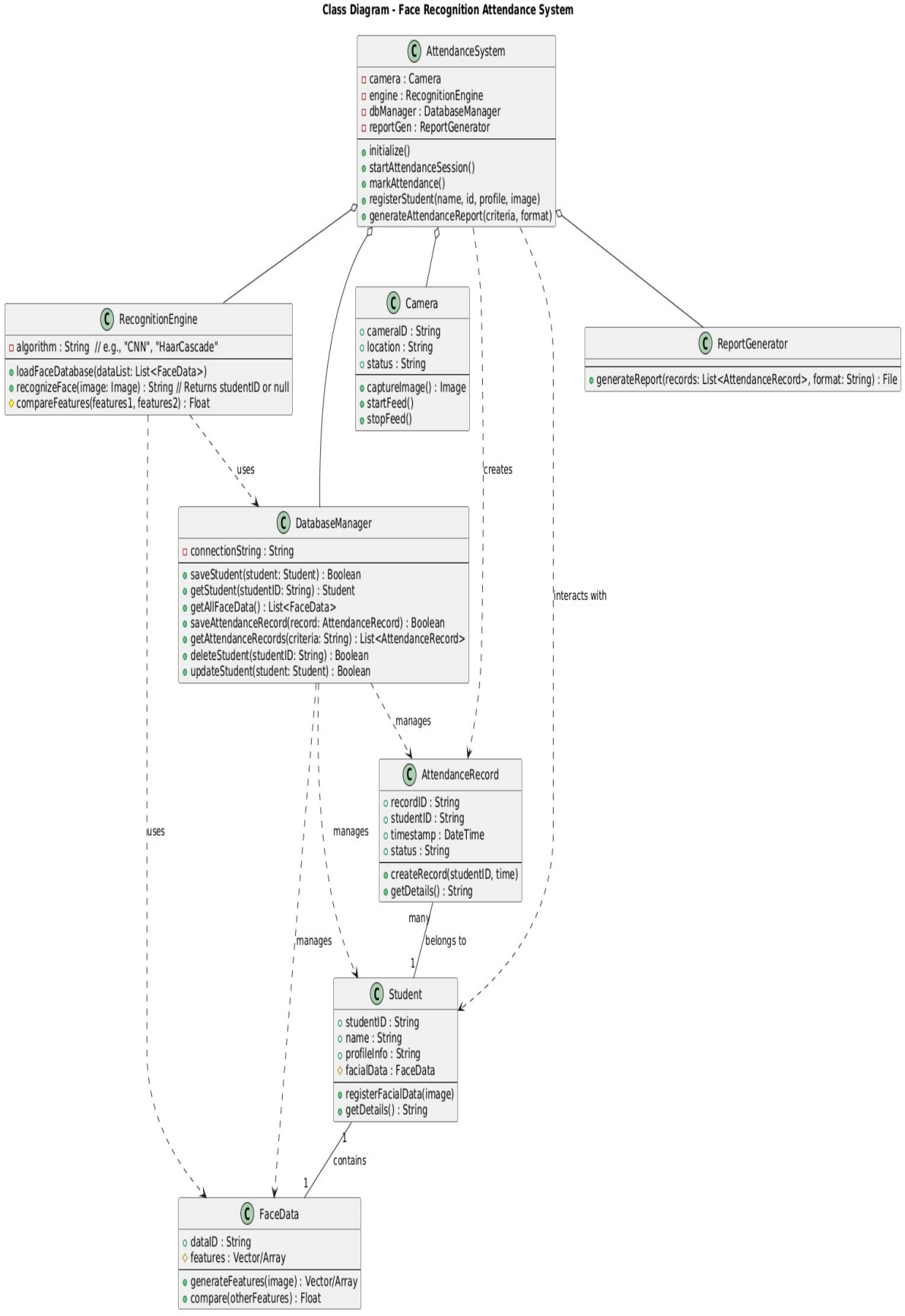

FIG 2: Class Diagram

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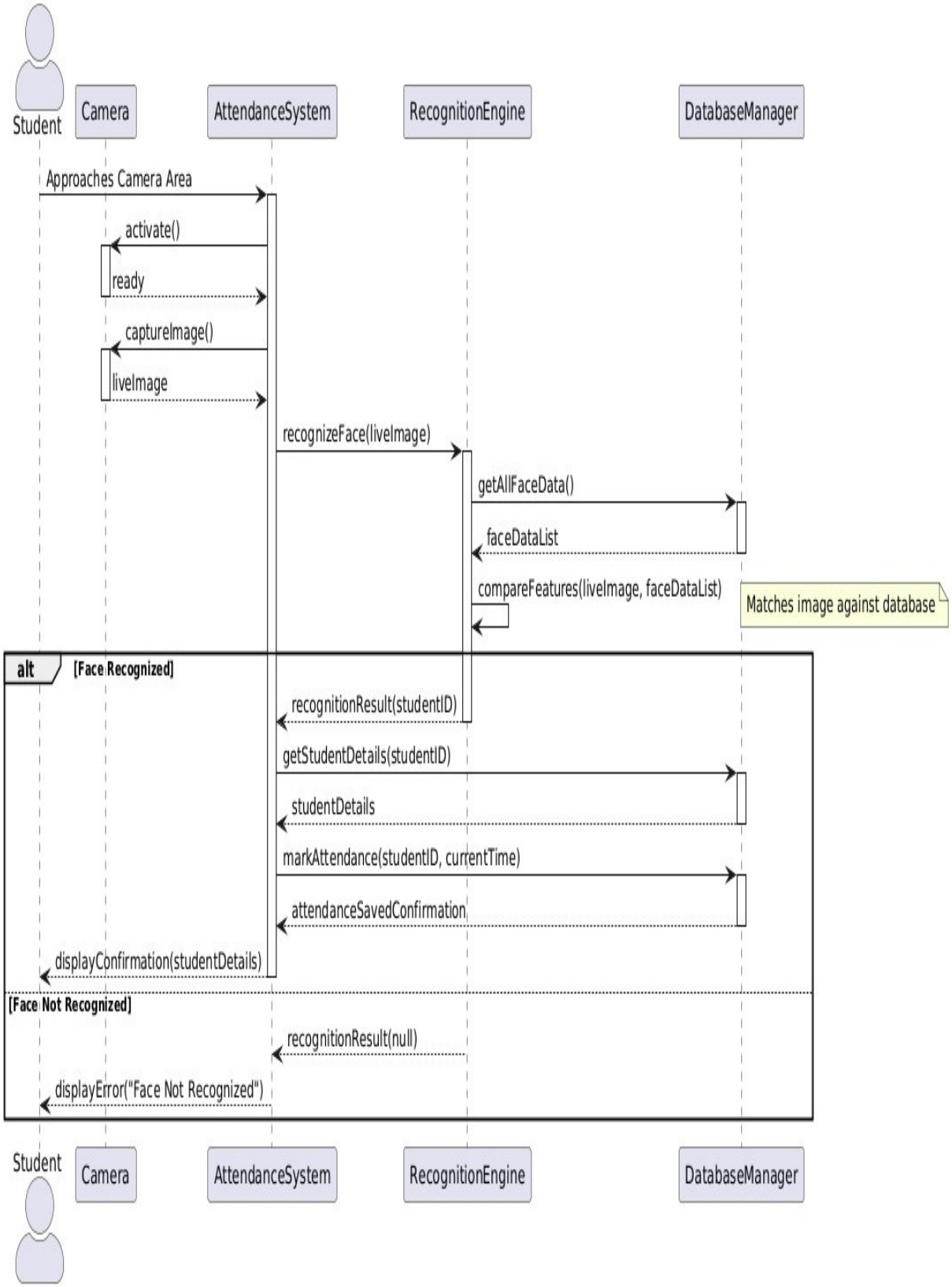

FIG 3: Sequence Diagram

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SOFTWARE ENVIRONMENT

Backend & Server-Side Python 3.x:

Core programming language used for API logic, AI interaction, and data processing.[3,4]

Flask:

Lightweight Python web framework for handling routes, user sessions, and RESTful API endpoints

Face Recognition Technologies

- **OpenCV**: For image capture, face detection (Haar Cascades), and processing. [13,12,18]
- **Face Recognition Library** *(built on Dlib)*: For real-time face recognition and comparison.

Database

MySQL:

Stores student data (ID, name, profile image path).

Attendance logs with timestamp and recognition results.

Frontend (HTML + CSS)

Tools Used:

o **HTML5**: Forms for login, image uploads, and attendance display.

o **CSS3**: Styling for a clean, responsive interface.

o **Jinja2 (Flask templating)**: Dynamically inject student info and attendance results into HTML pages. **Tensor Flow**

o Open-source ML framework by Google.

o Excellent for building and training **Convolutional Neural Networks (CNNs)**.

o Compatible with GPU acceleration for faster training. o Rich ecosystem (Keras, TensorBoard, TF Lite) for model development, visualization, and deployment

IMPLEMENTATION

USER INPUT HANDLING

The system provides an interactive interface for faculty to log in, register, and manage attendance using face detection. The frontend interacts with Flask routes to collect user credentials and class details.

Input Collection

The application allows users to provide:

o **Login Credentials** (username, password)

o **Registration Details** (name, username, password)

o **Class Selection Inputs**

o Year (1–4)

o Department

o section

Face Image Input

o Captured via webcam and sent as Base64 encoded image

Form Validation

The frontend ensures:

1. Required fields are not empty
2. Proper format for username and password
3. Avoids duplicate usernames during registration

Backend Request Validation

On the server side:

- Validates login credentials using hashed passwords
- Ensures JSON structure for image input (image field required)
- Checks if image decoding is successful
- Ensures at least one face is detected before processing

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DATA PROCESSING & IMAGE PREPARATION

The system processes captured images before feeding them into the deep learning model.

Input Preprocessing

- Base64 image is decoded into an OpenCV frame
- Image is converted to grayscale
- Face regions are extracted using Haar Cascade

Face Detection

- Uses OpenCV Haar Cascade (haarcascade_frontalface_default.xml)
- Detects bounding boxes for faces in the image

Image Transformation

- Face region resized to **224×224 pixels**
- Pixel values normalized (scaled to 0–1)
- Converted to 3-channel format (for model compatibility)

MODEL & FEATURE REPRESENTATION

The system uses a deep learning model for face recognition.

Model Loading

- Pre-trained model loaded from model_split.h5
- Built using TensorFlow/Keras

Feature Representation

- Each face is converted into a numerical tensor
- Model outputs probability scores for each known identity

Prediction Output

- Highest probability class is selected
- Confidence score determines validity (threshold: 0.4)

RECOGNITION & ATTENDANCE ENGINE

This is the core component responsible for identifying students and marking attendance.

Face Recognition

- Model predicts identity of detected face
- Matches prediction with predefined labels

Database Lookup

- Retrieves student details (ID, roll, year, department, section)

Attendance Marking

- Checks if attendance already exists for the day
- If not, inserts a new attendance record

Detection Output

Each detected face returns:

- Name
- Confidence score
- Roll number
- Year, Department, Section

DATABASE MANAGEMENT

The system uses MySQL for storing user and student data.

Tables Used

1. **Users Table**
   - Stores faculty login credentials (hashed passwords)
2. **Students Table**
   - Stores student details
3. **Attendance Table**

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- Stores daily attendance records

Security Measures

- Passwords stored using hashing (werkzeug.security)
- SQL queries use parameterized inputs to prevent injection

API IMPLEMENTATION

The system exposes Flask-based endpoints for frontend-backend communication.

Main Routes

- /login – Faculty login
- /register – New user registration
- /select-class – Class selection interface
- /attendance – View attendance data
- /face-detect – Face detection UI page
- /detect-face – Face recognition API

Request Handling

- Receives JSON image data from frontend
- Processes through detection and recognition pipeline
- Returns structured JSON response

Response Format

```
{
 "success": true,
 "detections": [
  {
   "name": "Student Name",
   "confidence": 0.95,
   "roll": "123",
   "year": "3",
   "department": "CSE",
   "section": "A"
  }
 ]
}
```

SAMPLE INPUT/OUTPUT

Sample Input

User Inputs

- **Username:** faculty1
- **Password:** ********
- **Year:** 3
- **Department:** CSE
- **Section:** A
- **Image:** Base64 encoded webcam image containing student faces

Sample Output

Detections (Recognized Faces)

1. nidhi – 92.4%
2. gopi – 88.7%

Attendance Status

- Attendance marked successfully for detected students

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Total Recognized Faces:2

SYSTEM TESTING

System testing is performed to ensure that the **Face Recognition Attendance System** functions correctly and meets its intended objectives. The testing process focuses on verifying system behavior under various conditions, ensuring accurate face recognition, and validating real-time attendance marking.

The system is tested using **black-box testing techniques**, where emphasis is placed on input-output behavior without considering internal implementation details.

FUNCTIONAL TESTING

User Input Handling Testing

- Verified login with valid and invalid credentials
- Tested registration with new and duplicate usernames
- Checked class selection inputs (year, department, section)
- Tested image input via webcam (Base64 format)

Result:

The system successfully validated user inputs. Invalid login attempts and duplicate registrations were handled properly. Image input was correctly captured and processed.

Image Processing & Face Detection Testing

- Verified decoding of Base64 image input
- Tested grayscale conversion and preprocessing steps
- Checked face detection using Haar Cascade
- Tested cases with multiple faces and no faces

Result:

Faces were detected accurately under normal conditions. The system correctly handled cases with no faces detected.

Model Prediction Testing

- Verified loading of the trained deep learning model (model_split.h5)
- Tested prediction accuracy for known faces
- Checked confidence score generation
- Verified threshold filtering (confidence < 0.4 ignored)

Result:

The model produced consistent predictions with reliable confidence scores. Low-confidence detections were successfully filtered out.

Face Recognition & Matching Testing

- Verified mapping of predicted labels to student records
- Tested recognition for multiple students in a single frame
- Checked handling of unknown faces

Result:

Recognized faces were correctly matched with database records. Unknown or منخفض-confidence faces were ignored.

Attendance Marking Testing

- Verified insertion of attendance records in the database
- Tested duplicate prevention (same student, same date)
- Checked attendance marking for multiple students

Result:

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Attendance was marked accurately and duplicate entries were successfully prevented

Database Interaction Testing

- Tested connection with MySQL database
- Verified queries for users, students, and attendance tables
- Checked data retrieval and insertion operations

Result:

Database operations were executed successfully with correct data storage and retrieval.

API Functionality Testing

- Tested all API endpoints:
  - /login
  - /register
  - /select-class
  - /attendance
  - /detect-face
- Verified request-response handling
- Tested JSON response structure for face detection

Result:

All endpoints responded correctly with proper data. JSON responses were structured and consistent with minimal delay.

Result Display Testing

- Verified display of attendance records
- Tested visualization of detected faces and confidence scores
- Checked UI navigation (login → class selection → attendance)

Result:

Results were displayed clearly with accurate student details and smooth user interaction.

OVERALL TESTING RESULT

The Face Recognition Attendance System performed reliably across all test scenarios. It successfully:

- Detected and recognized faces accurately
- Marked attendance without duplication
- Handled invalid inputs gracefully
- Delivered real-time responses with good performance

RESULT AND OUTPUT SCREENS

USER INTERFACE

The system provides a clean and interactive user interface where users can enter their skills, select interests, and choose difficulty levels. The interface is designed to be responsive and user-friendly, ensuring smooth interaction.

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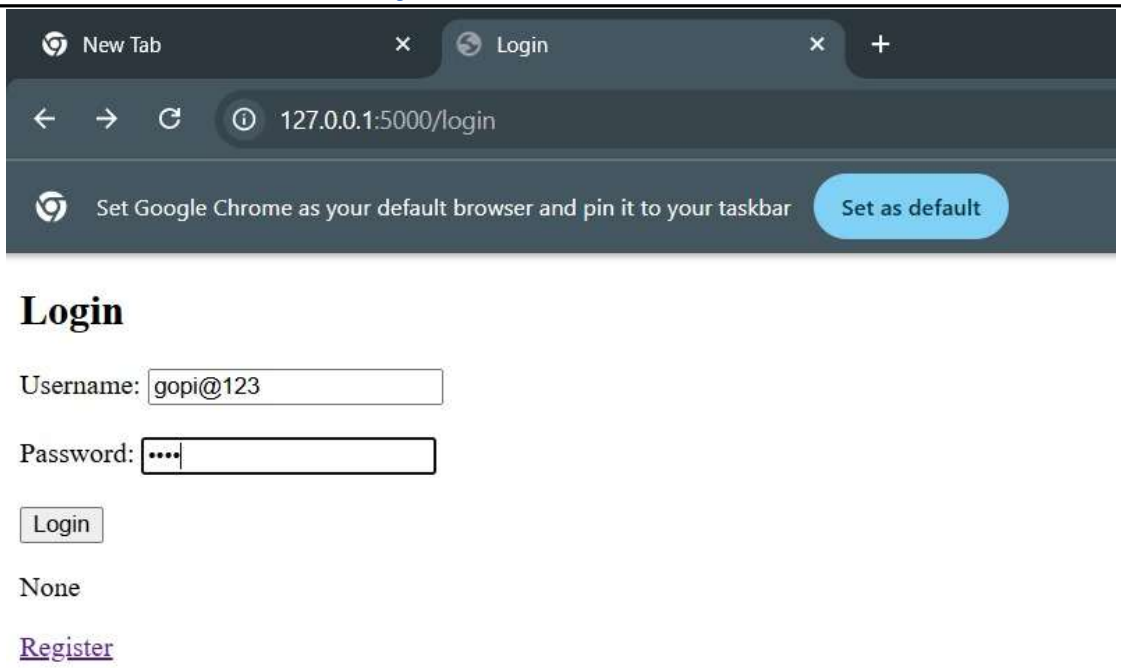

FIG 5: student login

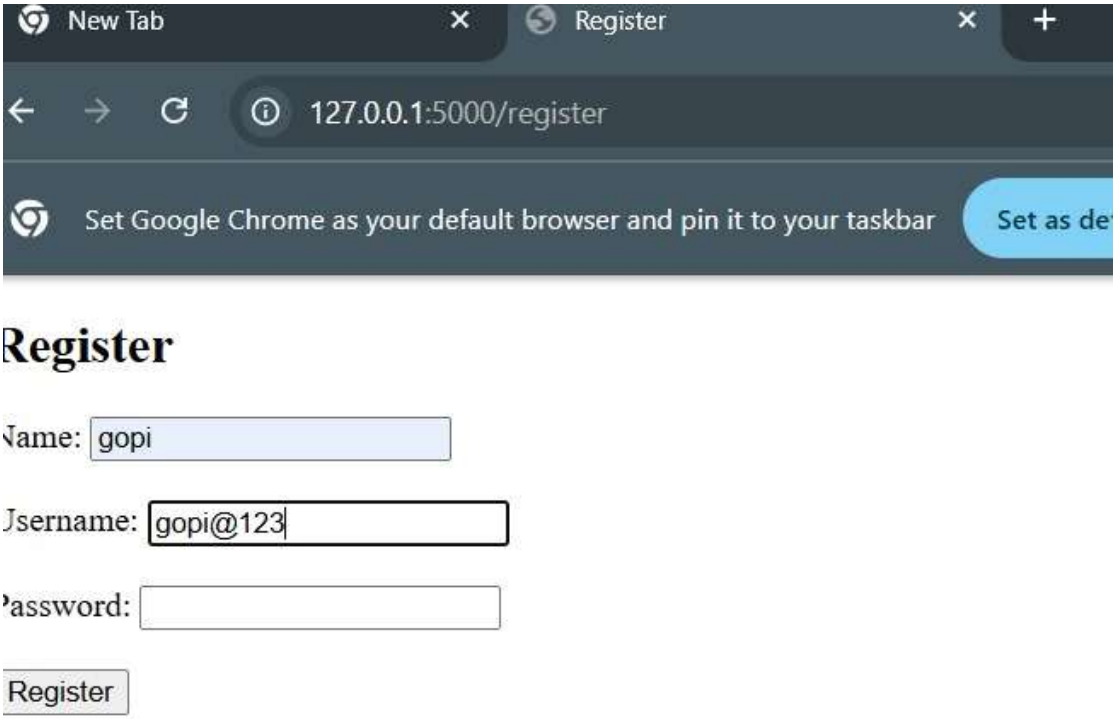

FIG 6: Student registration

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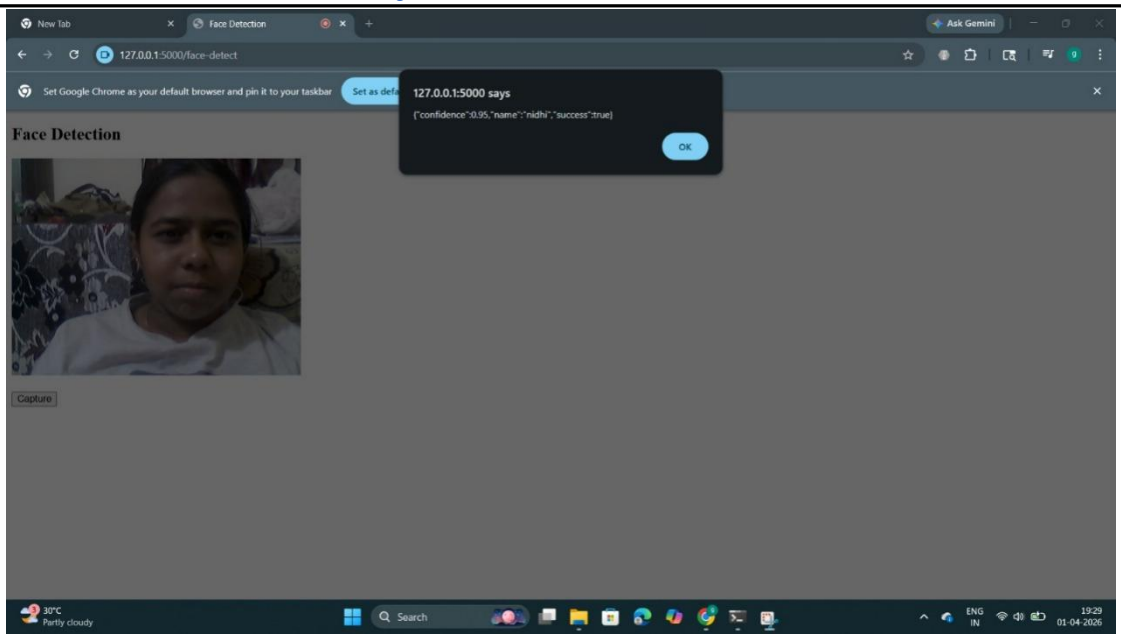

FIG 7: Mark Attendance

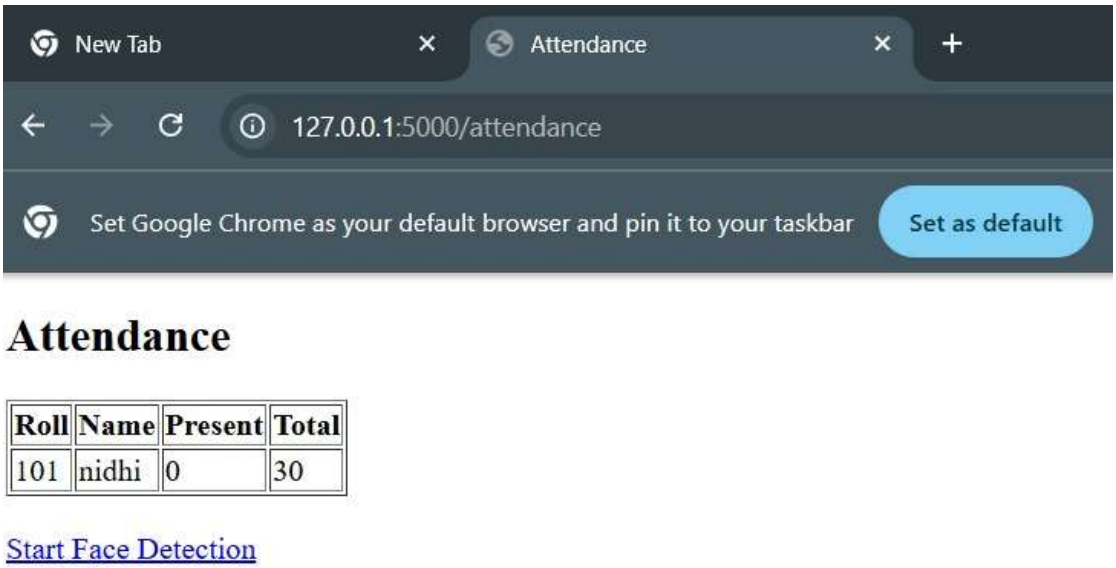

FIG 8: Attendance report

CONCLUSION

The development and implementation of a face recognition-based attendance management system offer a significant advancement over traditional methods of tracking student attendance. By leveraging computer vision and machine learning technologies, the proposed system provides a **fast, accurate, and contactless** solution that addresses key challenges such as human error, proxy attendance, and time inefficiency.

The proposed facial recognition-based attendance management system offers a modern, efficient, and secure alternative to traditional attendance methods. By leveraging computer vision and machine learning, it ensures accurate and real-time identification of students, significantly reducing the risk of proxy attendance and manual errors. The system's contactless nature enhances hygiene and convenience, making it especially suitable for large institutions. With features such as timestamp logging, report generation, and potential integration with LMS or ERP platforms, this

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solution not only simplifies attendance tracking but also contributes to improved administrative efficiency and student accountability. Its scalability and adaptability further make it a valuable tool for educational environments seeking to embrace smart technology.

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