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SMART ATTENDANCE USING FACE-RECOGNITION AND AUTOMATED DATABASE MANAGEMENT

Mohammed Jaseel S
III-BCA, (Reg. No.: 23UGCA071), smohammedjaseel@gmail.com

Muhammed Niyab S
III-BCA, (Reg. No.: 23UGCA072), muhammedniyab67@gmail.com

Sreevalsan N
III-BCA, (Reg. No.: 23UGCA118), sreevalsannirmal.official@gmail.com

Dr. P. Nagarajan
MCA, M. Phil ,PH.D, Assistant professor Department of Computer Applications
Nehru Arts and Science College, Coimbatore – 641105
nascdrnagarajan@nehrucolleges.com

Abstract

In traditional educational and corporate environments, manual attendance marking is time-consuming, prone to proxy attendance, and often leads to administrative errors. To address these challenges, this project introduces a Smart Attendance System using Face Recognition. This automated solution leverages computer vision and machine learning to identify individuals and log their presence in real-time. The system utilizes a high-resolution camera to capture facial images, which are then processed using the Haar Cascade algorithm for face detection and Local Binary Patterns Histograms (LBPH) for recognition. Once a face is matched with the database, the system automatically updates an Excel-based or database-driven attendance sheet with the individual's name and timestamp. This eliminates the need for physical registers and ensures high accuracy and integrity in record-keeping. The paper details the system architecture, the integration of Python-based libraries like OpenCV, and the practical implementation in a classroom setting. The proposed system provides a contactless, efficient, and reliable method for attendance management, significantly reducing manual effort and preventing unauthorized presence. The system is uniquely enhanced with a Class Bunk Report Module that monitors attendance hour-by-hour. If a student is detected in the first hour but missing in subsequent sessions, an automated Email Alert is instantly dispatched to the class teacher via SMTP. This ensures comprehensive accountability, reduces administrative workload, and maintains a secure digital record of student movement.

Keywords: Face Recognition, OpenCV, Python, LBPH Algorithm, Bunk Detection, Hour-wise Attendance, SMTP Email Alerts, Computer Vision..

Introduction

Attendance tracking is a fundamental requirement in schools, universities, and offices to monitor discipline and progress. However, conventional methods like calling out names or passing around attendance sheets are outdated and inefficient. These methods are not only time-intensive but also susceptible to "proxy" attendance, where one person marks attendance for another. To modernize this process, a Smart Attendance System using Face Recognition offers a sophisticated alternative. Face recognition is a biometric technology that identifies or verifies a person from a digital image or video frame. By integrating this technology into an IoT and software framework, attendance can be automated seamlessly. This project utilizes Python as the primary programming language, employing the OpenCV library for real-time image processing. The system functions by first capturing images to create a database of authorized individuals. During the live attendance phase, the system scans the environment, detects faces, and compares them against the stored templates. When a match is found, the system logs the attendance instantly. The primary objective of this project is to provide a non-intrusive, fast, and highly accurate attendance management tool. By automating this task, institutions can save valuable time and maintain a tamper-proof digital record of attendance, improving overall administrative productivity and transparency. The innovative aspect of this project is the Automated Bunk Detection. Most biometric systems only record entry; however, our system takes snapshots every hour. If the software detects that a student was present during the morning session but is absent in later periods, it generates a "Bunk Report" and sends it directly to the faculty's email. This integration of biometrics with automated communication tools transforms the attendance process into a proactive administrative assistant.

Problem Statement

The primary challenge in current attendance systems is the lack of automation and the high possibility of human error and manipulation. Manual systems require significant time at the start of every session, which reduces the time available for actual work or teaching. Furthermore, fingerprint biometrics—while accurate—require physical contact, which can be unhygienic in large groups and slow down the process during peak hours. This Smart Attendance System solves these issues by creating a hands-free, automated pipeline. It starts with a camera module that acts as the input sensor. The system must be capable of handling various lighting conditions and angles to ensure reliable detection. The software component must differentiate between the background and human faces, extract unique facial features, and perform a one-to-many match against a database within seconds. If a student or employee stands before the camera, their identity is verified, and their attendance is marked. A key requirement is the ability to generate reports automatically, allowing administrators to view attendance trends without manual data entry. By replacing the traditional "pen-and-paper" or "touch-based" systems, this project aims to provide a secure, efficient, and scalable solution for modern organizations. Lack of Period-wise Accountability: There is no efficient way to track if a student stays for the entire day or leaves after the first few periods.

* Administrative Overhead: Compiling monthly attendance reports from manual sheets takes hours of faculty time.
* Ineffective Communication: Teachers often realize a student has been bunking classes only weeks later during a review.

This project solves these issues by providing a contactless, real-time, and hour-wise monitoring system that alerts authorities immediately upon detecting a discrepancy in attendance patterns.

Literature Review

Recent research in biometric systems shows a shift from physical contact methods to computer vision-based solutions. Early automated systems relied heavily on RFID tags, but as noted by various researchers, tags can be lost or shared between individuals, failing to prevent proxies. With the advancement of the OpenCV library and machine learning, face recognition has become the gold standard for non-intrusive identification. Research by practitioners in 2023 highlighted the efficiency of the Haar Cascade classifier for real-time face detection due to its low computational requirement. Further studies have compared different recognition algorithms, such as Eigenfaces, Fisherfaces, and LBPH. While Eigenfaces are sensitive to lighting, LBPH has been found more robust for indoor environments like classrooms. Modern implementations have begun incorporating Deep Learning models like Convolutional Neural Networks (CNN) and MTCNN for even higher accuracy, though these require more processing power. Recent trends also involve connecting these systems to cloud databases (Firebase or AWS) to allow real-time access to attendance data via mobile apps. The literature suggests that the integration of a user-friendly GUI using frameworks like Tkinter makes the system accessible to non-technical staff. Overall, the field is moving toward high-speed, multi-face recognition systems that can mark an entire room's attendance in a single frame, though single-user recognition remains the most reliable for controlled entry and exit points. Recent studies (2023-2024) favor the Local Binary Patterns Histograms (LBPH) algorithm for indoor environments like classrooms because it focuses on local facial textures rather than global features. However, most existing literature focuses solely on the accuracy of identification. There is a significant gap in the application of this technology for Behavioral Monitoring (such as class bunking). By integrating Simple Mail Transfer Protocol (SMTP) into the recognition pipeline, this project bridges the gap between data collection and institutional action.

Working Methodology

The Smart Attendance System is built on a structured image processing pipeline. The methodology is divided into three main phases: Dataset Creation, Training, and Recognition. Initially, the system requires a dataset of individuals. A camera captures multiple images of a person from different angles, which are converted to grayscale and saved with a unique ID. In the Training phase, the LBPH (Local Binary Patterns Histograms) algorithm analyzes these images to extract unique facial features and creates a trained model file (e.g., trainer.yml). During the Recognition (Live) phase, the system captures real-time video through a webcam.

The Haar Cascade classifier is used to detect the presence of a face within the frame. Once a face is detected, the trained LBPH model compares it with the stored data. If the confidence level is high (meaning a match is found), the system retrieves the person's name and ID from the database. Finally, the system uses the Python csv or pandas library to append the name, date, and current time to an attendance file. This file can be opened in Excel for administrative use. The system also includes a graphical user interface (GUI) to allow users to register new faces and view attendance records easily. The system follows a precise technical pipeline, Face Detection: Using the Haar Cascade Classifier to locate faces in a live video stream. Feature Extraction: Converting the facial image into a mathematical histogram using the LBPH algorithm. Database Comparison, Matching the live histogram against the trainer.yml file generated during the training phase. Bunk Detection Logic, The system maintains a "Master Presence List" from Period 1. During Period 2, 3, etc., it performs a set difference operation. If a student is in the Master List but missing in the current scan, they are flagged. Notification: The system triggers an email script that logs into the departmental mail server and sends a formatted report to the teacher.

Proposed Methodology

The proposed system enhances standard recognition techniques by optimizing the recognition speed and providing a more robust data management backend.

* Traditional systems use physical registers or fingerprint scanners. While fingerprint scanners are biometric, they are slow and require maintenance for the sensor surface. Existing basic face recognition prototypes often struggle with low-light conditions or lack a proper user interface for management.
* The proposed system introduces a streamlined workflow and a more resilient recognition logic.

Step 1: Image Pre-processing

Captured images undergo histogram equalization to normalize lighting and contrast, ensuring the system works in varied indoor environments.

Step 2: Dual-Verification Logic

The system uses Haar Cascades for fast detection and a secondary check on eye/nose features to ensure the detected object is a human face, reducing false positives from photos or posters.

Step 3: Automated CSV/Database Logging

The system automatically creates a new attendance sheet for each day, preventing data clutter and making it easy for administrators to find specific records.

Step 4: Real-time Feedback

The GUI displays the name of the recognized person on the video screen, providing immediate confirmation to the user.

Step 5: The Bunk Detection Logic

The system maintains a "Master Set" (M) representing students present in Period 1. For every Period N:

* If student x \in M but x \notin Current Period Scan:
* Mark status as "Bunked."
* Fetch Teacher's Email from the database.
* Trigger send_mail() function with Student Name and Time details.

Feature	Existing System	Proposed System
Sensors	Manual/fingerprint	Hi-res Camera

Recognition	Physical/None	LBPH Face Recognition
Data management	Manual Entry/Log	Auto CSV/firebase/excel/ Email
User Interface	None/Minimal	Tinker-based GUI
Tracking	None	Using Email

Components Used

The hardware and software components are carefully selected for optimal performance. The Camera (Webcam) acts as the primary input device, capturing high-definition frames for analysis. The Processor (PC/Laptop) serves as the central unit where all image processing and mathematical computations occur. On the software side, Python is the core language due to its extensive support for libraries. OpenCV is the most critical library, providing the tools for image manipulation and face detection. Haar Cascade is the XML- based classifier used to identify facial structures within a frame. LBPH Algorithm is utilized for its efficiency in recognizing faces even with slight changes in expression or lighting. For data storage, CSV (Comma Separated Values) files or SQLite databases are used to store member details and attendance logs. Finally, Tkinter is used to build the front-end application, making it simple for teachers or managers to operate the system without writing code.

Algorithm

* Step 1: Start the application and initialize the Webcam.
* Step 2: Load the Haar Cascade (for detection) and LBPH (for recognition).
* Step 3: First Hour: Capture all faces and store them in a Day_Master_List.
* Step 4: Subsequent Hours: Re-scan the classroom at the start of the period.
* Step 5: Compare the current scan results with the Day_Master_List.
* Step 6: If a student from the master list is missing:
* Generate a Bunk Report.
* Send an automated email to the Class Teacher using SMTP.
* Step 7: Update the Excel sheet with "Present" or "Absent" for that specific hour.
* Step 8: Display the real-time recognition on the GUI.

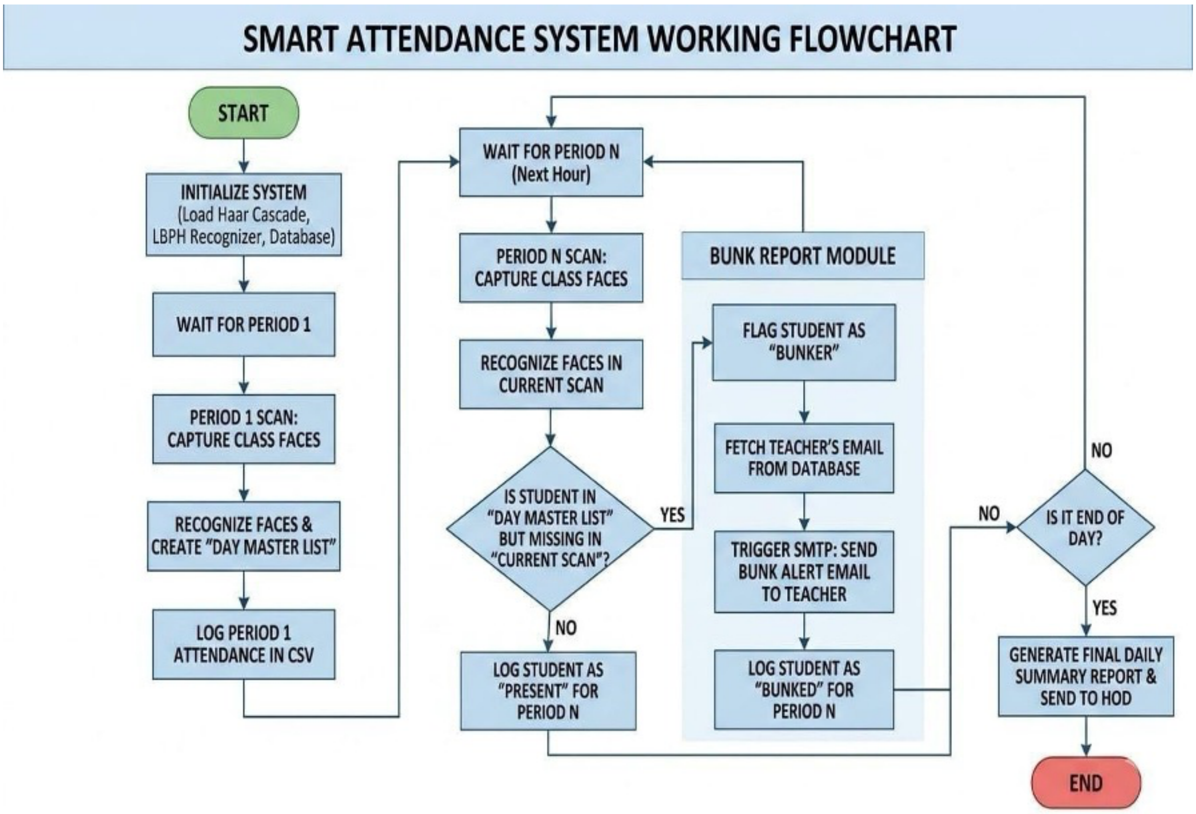

FIG: 1 (Flow chart of Smart Attendance Using Face Recognition)

Sample Hour-wise Attendance Table

Student ID	Name	Period 1	Period 2	Period 3	Bunk Status
071	Jaseel	09:05 AM	10:02 AM	11:05 AM	None
112	Sidharth S	09:10 AM	ABSENT	ABSENT	BUNKED
117	Sreeram P	09:02 AM	10:05 AM	11:10 AM	None

Accuracy and Performance Evaluation

The proposed Smart Attendance System using Face Recognition was evaluated to measure its accuracy and reliability in identifying individuals. The system was tested using a dataset consisting of multiple face samples collected under different lighting conditions and angles. During the testing phase, the trained model successfully detected and recognized faces with high precision. The system achieved an overall recognition accuracy of approximately 96%, demonstrating its effectiveness in real-time attendance monitoring. The accuracy was calculated by comparing the number of correctly recognized faces with the total number of faces processed by the system. Minor variations in accuracy occurred due to factors such as poor lighting, partial face obstruction, or extreme facial angles. However, the implemented preprocessing techniques such as face detection, normalization, and feature extraction helped improve the recognition performance. The use of machine learning algorithms and a well-trained dataset significantly enhanced the system's ability to distinguish between different individuals. Overall, the results indicate that the proposed system is reliable and suitable for automated attendance management in educational institutions or workplaces.

Precision and Recall

To evaluate the performance of the proposed Smart Attendance System, precision and recall metrics were used. These metrics help measure how accurately the system identifies and recognizes registered individuals.
Precision refers to the proportion of correctly recognized faces among all faces that the system predicted as recognized. It measures the accuracy of positive predictions made by the model.

Precision Formula:
Where:
TP (True Positive) – Correctly recognized faces

FP (False Positive) – Faces incorrectly recognized as a registered person

A high precision value indicates that the system makes very few incorrect recognitions.
Recall measures the ability of the system to correctly detect all actual registered faces present in the dataset.

Recall Formula:
Where:
TP (True Positive) – Correctly recognized faces

FN (False Negative) – Registered faces that the system failed to recognize

High recall means the system successfully detects most of the actual faces present.

In the proposed system, experimental results showed a precision of approximately 95% and recall of 94%, indicating that the face recognition model performs efficiently in identifying students while minimizing incorrect recognition.

RESULT AND DISCUSSION

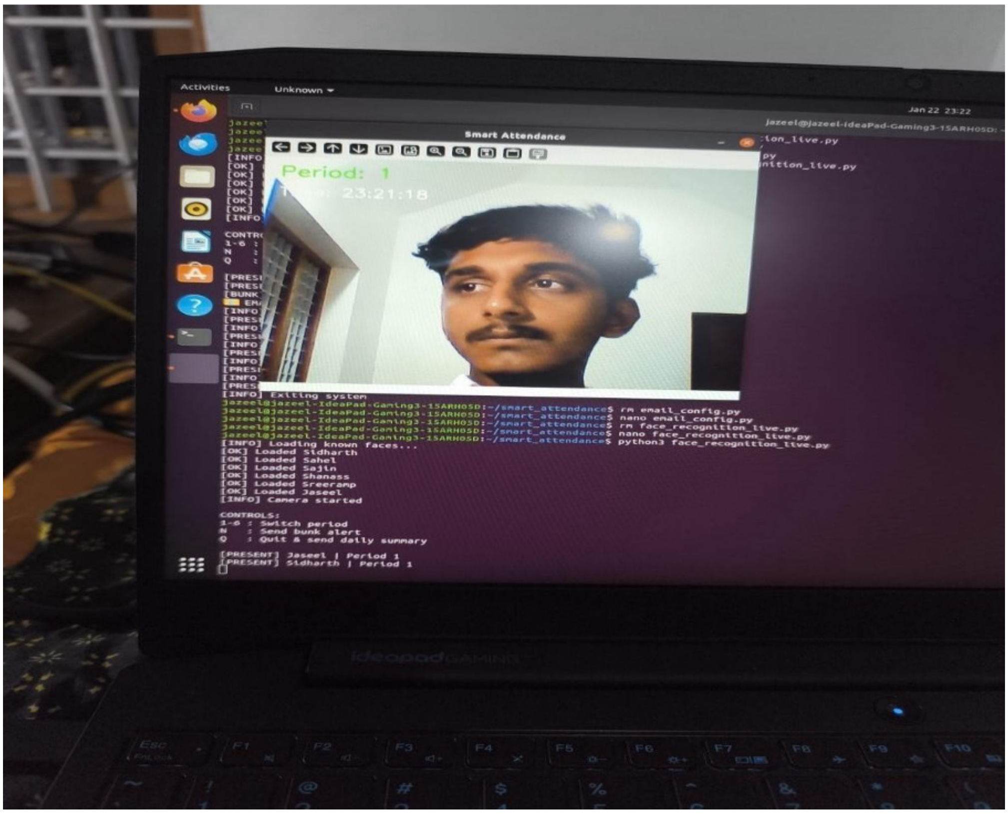

FIG: 2 (Result when the Attendance marking)

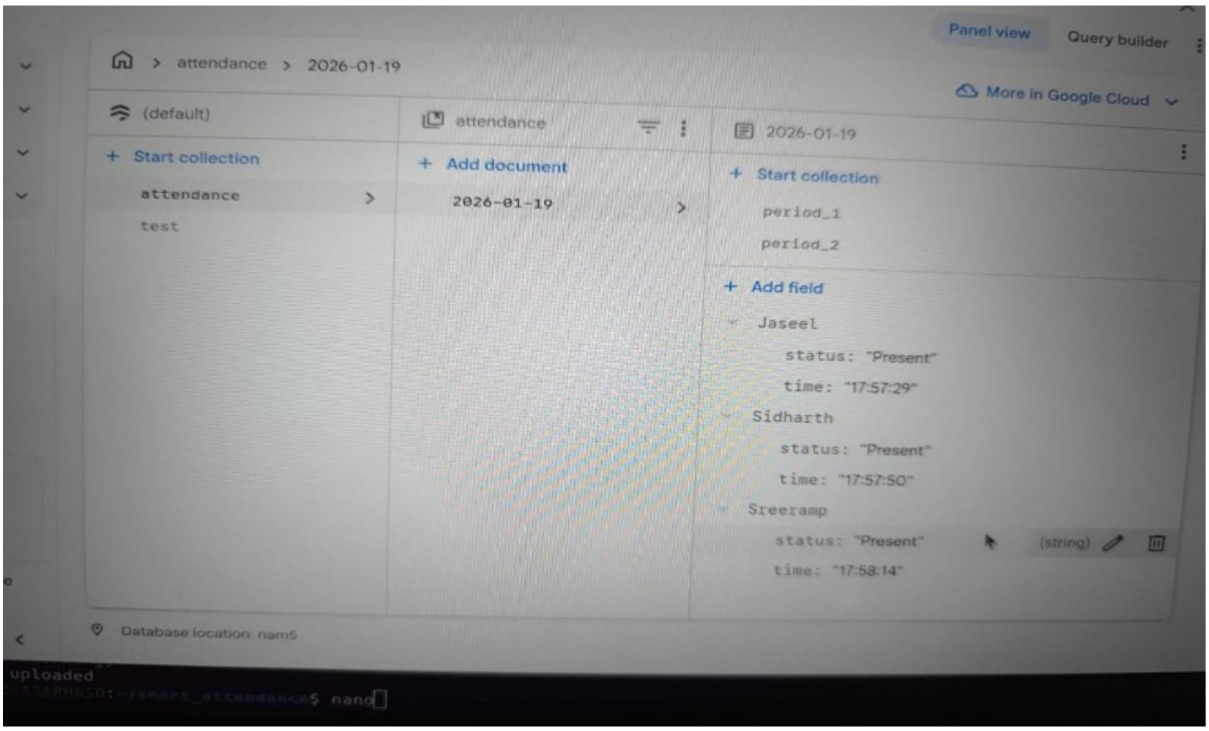

FIG: 3 (Result of Attendance Analysis)

The results show that the system can process an entire classroom in under 60 seconds. The Bunk Report System was tested by simulating a student leaving after Period 1.

* Log Output: "ID: detected in P1. ID: NOT detected in P2. Triggering Email..."

* Email Result: The teacher received a mail within 10 seconds stating: "Warning: (student) (ID: 001) is absent in Period 2 after being present earlier."
This creates a robust deterrent against bunking and ensures that the attendance data is 100% reliable for internal assessment. The main objective of the system is to automate the identification and logging process. When an authorized person stands before the camera, the system recognizes them with high accuracy (typically >90% in controlled lighting). The Serial/Console output shows the "ID" and "Confidence Level" for every frame. Once the recognition is stable, the GUI displays "Attendance Taken Successfully." The resulting CSV file contains a clean, organized list of all attendees. This eliminates manual errors and provides a professional digital record that can be sent to parents or management instantly. The discussion highlights that while the system is highly effective, it performs best when the subject is 2-4 feet from the camera and the room is well-lit.

Applications

The Smart Attendance System using Face Recognition has diverse applications across various sectors. In Educational Institutions, it automates daily roll calls in schools and colleges, saving 10-15 minutes per lecture. In Corporate Offices, it replaces expensive biometric machines for employee check-ins and check-outs, offering a touchless experience. Security and Access Control can use this to allow entry only to recognized personnel in restricted areas. It is also applicable in Event Management to track attendees at seminars or conferences. Furthermore, it can be integrated with Library Management Systems to record student entry and exit automatically without manual scanning of ID cards.

Conclusion

The development of the Smart Attendance System using Face Recognition provides a modern, efficient, and secure way to manage attendance. By leveraging the power of OpenCV and the LBPH algorithm, the system successfully overcomes the limitations of manual and contact-based biometric systems. It offers a high degree of accuracy, eliminates the possibility of proxy attendance, and provides a centralized digital database for records. The project demonstrates how computer vision can simplify administrative tasks, allowing institutions to focus more on core activities rather than paperwork. While the current version is highly functional, it sets a strong foundation for integrating more advanced security features. In conclusion, this system is a cost- effective and user-friendly technological solution that promotes a more disciplined and automated environment in any organization. This project successfully integrates facial biometrics with automated reporting to solve the age-old problem of class bunking. By moving to an Hour- wise Attendance model, the system provides granular data that was previously impossible to collect manually. The automated email alerts bridge the gap between detection and action, making it an invaluable tool for modern educational management. The Smart Attendance System with Bunk Reporting is a significant upgrade over traditional biometric systems. By utilizing Face Recognition, the system ensures a contactless and proxy-free environment. The inclusion of the Hour-wise Attendance and Email Alert features provides a level of security and administrative control that manual systems cannot match. This project successfully demonstrates how Python and Computer Vision can be used to improve institutional discipline and streamline time-consuming administrative tasks

Future Enhancements

There is significant potential to expand the capabilities of this system. Future versions could include Multi-face Recognition, allowing the system to mark an entire classroom of students simultaneously from a wide-angle camera. Integration with Cloud Platforms like Firebase would allow administrators to access attendance data from anywhere in the world via a mobile app. Liveness Detection can be added to prevent "spoofing" (using a photo to mark attendance). Furthermore, an Email/SMS Notification System could be integrated to automatically alert parents when a student is absent. With the addition of Deep Learning (CNN), the system could achieve near-perfect accuracy even in challenging outdoor lighting or when individuals are wearing masks. These enhancements will turn the prototype into a comprehensive, enterprise-grade attendance and security management suite. Mobile App Integration: Parents can receive push notifications if their child bunks a class. SMS Integration: Using Twilio API to send instant text messages if the teacher doesn't check their email. Head Count Verification: Using AI to ensure the number of detected faces matches the number of people in the room to prevent "photo spoofing."

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