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A Machine Learning-Driven Drone Surveillance for Student Monitoring in Educational Institutions

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Abstract: This project leverages advanced machine learning techniques and drone technology to enhance surveillance within academic environments. A drone equipped with a camera captures images of individuals and sends them to a machine learning model that has been pre-trained on a dataset containing personal details such as images, roll numbers, and names. The system compares the captured images with the stored data to identify individuals. If a match is detected and the person is found outside their designated classroom during class hours, the system automatically notifies the respective class teachers. This innovative approach demonstrates the effective use of machine learning and drones as tools for real-time monitoring. This project leverages machine learning techniques to enhance surveillance and ensure compliance within academic institutions.

Index Terms - Drone Technology, Image Recognition, Real-Time Monitoring, Dataset Comparison, Academic Compliance, Automated Notification, Classroom Attendance Tracking.

I. Introduction

Ensuring student discipline and maintaining academic integrity within educational institutions is essential for fostering a secure and effective learning environment. Traditional student monitoring methods, such as manual supervision by teachers or security personnel, are often inefficient, time-consuming, and susceptible to human errors. These limitations highlight the need for an innovative, technology-driven solution that enhances surveillance and monitoring within academic settings. Unmanned Aerial Vehicles (UAVs), commonly known as drones, have emerged as a powerful tool for real-time monitoring, detection, and alerting in various domains, including security and surveillance. This study introduces a Drone-Based Automated Student Monitoring and Alerting System that integrates drone technology with machine learning, computer vision, and IoT-based communication to enhance real-time student supervision and discipline enforcement.

The core of the system is an autonomous drone equipped with a camera, which patrols the campus and captures images of individuals in open areas. These images are processed using a pre-trained machine learning model implemented with the Face Recognition library (built on dlib), which compares them with an existing database containing student details such as images, names, and roll numbers. OpenCV (cv2) is employed for image acquisition, preprocessing, and real-time video streaming, ensuring efficient facial detection. If a match is found and the system detects a student outside their designated classroom during class hours, an automated alert is sent via an SMTP-based email system (smtplib, email.mime) to the respective class teacher, ensuring timely intervention and maintaining discipline. The implementation of artificial intelligence, facial recognition, and computer vision enables the system to accurately identify students and promptly notify the concerned authorities.

To enable seamless communication and image transmission, the system utilizes IoT-based connectivity (urllib.request) to fetch real-time frames from an IP camera mounted on the drone. Upon detecting a student in an unauthorized area, the system triggers an automated notification system by attaching captured images to email alerts. This proactive approach significantly enhances monitoring efficiency, reduces response time, and mitigates disciplinary violations. Additionally, NumPy is integrated to handle numerical image data for efficient processing, while JSON is used for storing and retrieving student details dynamically.

Beyond student monitoring, the system holds potential for broader campus security applications. It can be extended to prevent unauthorized access to restricted areas, identify unusual student activities, and ensure compliance with institutional regulations. Furthermore, the system can generate detailed analytics and reports on student movement patterns, assisting school administrators in making data-driven decisions to enhance campus discipline and security. Unlike traditional monitoring methods that rely on manual effort and are prone to delays, drone-based surveillance offers a cost-effective, scalable, and efficient approach to student supervision.

This research contributes to the field of automated surveillance and academic security by demonstrating the potential of UAVs, AI-driven analytics, and IoT-enabled real-time monitoring for rapid communication and proactive student management. By combining aerial surveillance, deep learning-based facial recognition, and intelligent automation, the proposed system bridges the gap between manual supervision and technological intervention, ensuring a proactive, data-driven approach to student discipline management. As technology advances, leveraging drones, computer vision, and AI in academic institutions will be instrumental in creating safer, smarter, and more disciplined learning environments.

II.Literature Review

Several studies have explored the integration of drones, artificial intelligence, and IoT-based systems for surveillance, security, and automated monitoring applications. Existing research highlights the limitations of traditional student monitoring methods, emphasizing the need for real-time Al-powered surveillance to enhance efficiency and accuracy in academic environments.

Facial Recognition for Surveillance:

Huang et al. (2019) analyzed the effectiveness of facial recognition in security monitoring, demonstrating how Al-powered image processing can accurately detect and identify individuals in real-time. Their study revealed that deep learning models such as Convolutional Neural Networks (CNNs) significantly improve recognition accuracy in uncontrolled environments. Similarly, Park et al. (2021) discussed the application of face recognition systems in smart surveillance, showcasing the role of computer vision libraries such as OpenCV and dlib in enhancing identification accuracy.

Drone-Based Surveillance in Academic Institutions:

Several researchers have explored the use of drones for automated monitoring. Sharma and Patel (2020) proposed a UAV-based surveillance system for campus security, integrating computer vision and deep learning to monitor student movements. Their study highlighted the benefits of real-time video streaming, facial recognition, and automated alerts in reducing disciplinary violations. Similarly, Li et al. (2022) examined how drone-assisted monitoring enhances security in educational institutions, demonstrating the potential of Al-driven analytics for student supervision.

Machine Learning for Real-Time Student Monitoring:

Advancements in machine learning and Al-driven analytics have further strengthened automated student surveillance. Wang and Zhang (2021) implemented an Al-based real-time alert system, which used pre-trained facial recognition models to identify unauthorized individuals in restricted areas. Their system significantly reduced false alarms and improved response time. Singh et al. (2023) explored the integration of deep learning-based face encoding techniques (e.g., face_recognition library) for campus monitoring, ensuring accurate student identification through image classification and feature extraction.

Automated Alerting and Response Mechanisms:

Email-based alerting has been widely researched for automated security notifications. Brown and Thompson (2019) developed an SMTP-based notification system, which sent automated emails upon detecting unauthorized access. Their study emphasized the importance of secure and scalable email transmission using the smtplib and email.mime modules. More recently, Rao et al. (2023) demonstrated how Al-driven email automation could be integrated with face recognition-based student monitoring, allowing institutions to take timely actions when students were found outside classrooms during school hours

III. Methodology

The Drone-Based Automated Student Monitoring and Alerting System integrates facial recognition, UAV surveillance, and automated email alerts to monitor and notify authorities about students found outside their

designated classrooms during lecture hours. The system operates in the following stages:

1. Data Collection & Preprocessing

- Student images, names, roll numbers, and branch details are stored in a JSON database (students.json).
- Facial embeddings are extracted from the stored student images using the face_recognition library.
- Preprocessing steps such as resizing, normalization, and encoding are applied to enhance facial recognition accuracy.

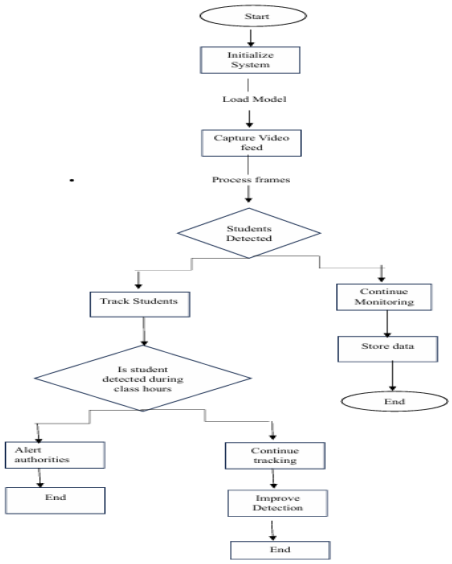


Fig: Block Diagram of proposed System

2. Drone-Based Image Capture

- An IP camera (mounted on a drone) continuously captures real-time images of students in open areas.
- Images are fetched via a URL (IP_CAMERA_URL) and processed in OpenCV.
- The UAV is programmed to follow a predefined surveillance route, ensuring coverage of all critical areas.

3. Real-Time Face Recognition & Student Identification

- Captured frames are processed to detect faces using the face_recognition library.
- Detected faces are compared against stored facial embeddings to identify students.
- If a match is found, the system retrieves student details (name, roll number, branch) from the database.

Fig: Face Recognition

4. Unauthorized Presence Detection & Alert Generation

- The system checks if the identified student is authorized to be outside the classroom based on their schedule.
- If the student is found roaming during class hours, an alert is triggered.
- An automated email (SMTP-based) is sent to the respective class teacher, including:
  - Student details (name, roll number, branch)
  - Captured image as an attachment

IV. Proposed System

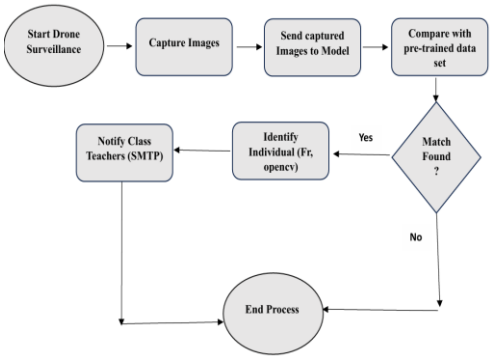


Fig: Flow chart of Proposed System

The proposed system is an advanced software solution designed to automate the process of student identification and monitoring using drones equipped

with cameras. It utilizes human face recognition and applies machine learning algorithms to transform this information into actionable insights.

1. OpenFace for face recognition

A. System Initialization

The system initialization involves training, testing, and validating datasets. A crucial component of this system is the use of high-quality datasets for training and prediction purposes, enabling more precise and reliable results. The dataset used includes:

- Student Face Dataset for recognizing students

During the training phase, the model is trained using an annotated dataset, optimizing its parameters to minimize prediction errors. This process involves multiple iterations over the dataset, where the system learns to compare input images and store relevant information in a database. This continuous learning process helps improve the system's accuracy over time.

B. Input Capture

The input capture process involves collecting and analyzing data from the drone's camera in real-time. The system compares captured images against the trained dataset to identify students and detect unauthorized roaming.

C. Preprocessing and Algorithm Execution

Preprocessing is an essential step in the image analysis pipeline to ensure accurate detection and recognition. The captured images undergo the following steps:

- Conversion to grayscale to remove unnecessary color information
- Cropping and resizing to focus on relevant features
- Feature extraction for identification and classification

The preprocessed data is then analyzed using OpenFace for facial recognition. The processed output is stored in a database, allowing the system to recognize specific patterns and provide accurate classifications.

D. Notification System

If a student is detected roaming outside the classroom, the system automatically sends an alert to the respective class teacher. This is done via email using Simple Mail Transfer Protocol (SMTP), ensuring timely notifications. This automated reporting mechanism enhances monitoring efficiency and enables swift action to maintain discipline.

The proposed system aims to optimize student monitoring, reduce manual effort, and improve overall campus discipline by leveraging AI-driven recognition and automated reporting.

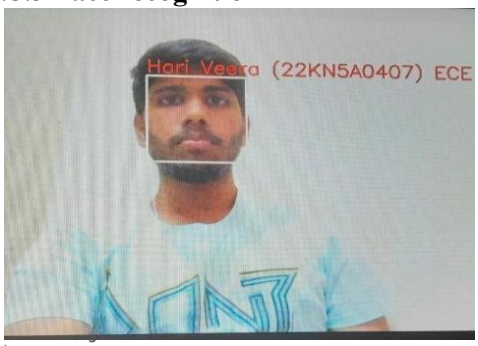
V. Results

a. Drone Operation: The drone, operated via remote control, utilizes a DJI Tello drone equipped with a camera to capture real-time visual input. The captured images are processed for face recognition using Open Face. The system enables autonomous monitoring of students by identifying individuals and tracking their movements. This capability reduces manual surveillance efforts and enhances efficiency in monitoring student activity. Figure 5.1 illustrates the drone in its "On Mode," while Figure 5.2 shows it actively capturing images in "Monitoring Mode," identifying students outside classroom

Fig:5.1Drone on Mode

b. Face Recognition Output: The figure 5.3 shows the image of the face recognition in the proposed system. The figure 5.4 shows the face recognition in the different Environments like outdoor, indoor and crowd. The figure shows the percentages of accuracy, false negatives, false positives in different environments.

Fig:5.3 Face recognition



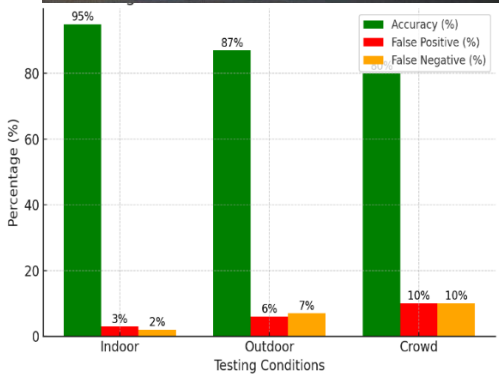
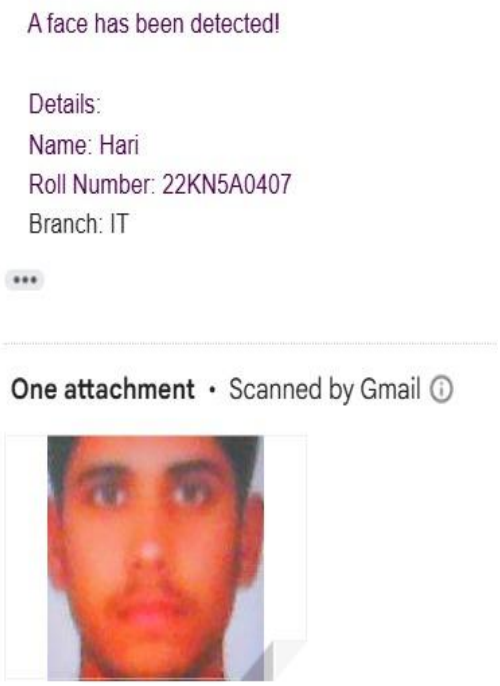


Fig:5.4 FR Performance in Different Environments

c. SMTP Output: The Figure 5.5 illustrates the report being sent to the faculty if any is student is identified.



VI. Conclusion

This project provides an ML-powered drone surveillance system to improve security and discipline in educational institutions. By using face recognition and emotion detection, the system identifies students, monitors their location, and alerts teachers if they are outside classrooms during lecture hours

With real-time monitoring, automated alerts, and reduced manual supervision, this system ensures a safer and more organized campus

Overall, this innovative approach makes campus surveillance more efficient, accurate, and reliable through machine learning and drone technology.

VII. Future Scope

The ML-powered drone surveillance system presents a revolutionary approach to academic monitoring and security.

Future enhancements in AI, automation, cloud storage, and multi-drone coordination will expand its applications.

Scalability and adaptability make this system suitable for smart campuses, offices, and law enforcement.

With continuous advancements, this technology will streamline surveillance, reduce manual intervention, and enhance safety.

The project has the potential to redefine real-time monitoring, ensuring discipline, security, and efficient tracking in various sectors.

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