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Automated Attendance System by Facial Recognition Using CCTV

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Abstract: Businesses, organizations, and educational institutions all require reliable and accurate attendance monitoring solutions in today's hectic world. This paper presents an automated attendance system employing facial recognition technology based on CCTV video. The system uses strategically placed CCTV cameras to capture real-time video footage of individuals entering or leaving the premises. Facial detection algorithms locate and identify human faces, and facial recognition algorithms extract unique facial features to create facial templates. These templates are compared to a pre-registered database for facial matching, and attendance is recorded upon successful identification. Advanced features like liveness detection enhance accuracy and security.Attendance data is securely stored in a centralized database and can be integrated with other systems. This study describes an automatic attendance system that uses CCTV video-based facial recognition technology.

Keywords: facial recognition, automatic attendance system, CCTV, centralized database.

I. INTRODUCTION

The eyes and ears of the security sector have always been cameras. Every year, hundreds more cameras are added to surveillance networks as a result of growing demand and falling costs, the surveillance sector is growing at an exponential rate, which has resulted in an explosion of footage . With the use of facial recognition technology, computers are now able to recognize individuals based only on their facial traits. A facial recognition system takes pictures of faces with a camera and compares them to databases of faces belonging to people it is familiar with. The computer can identify who was there when the picture was taken if it discovers a match [2]. The automated attendance system offers improved accuracy, efficiency, cost savings, enhanced security, convenience, real-time monitoring, scalability, adaptability, and reduced environmental impact when compared to traditional attendance methods. We employ the FaceNet model [4] for face identification and embedding, which has shown exceptional performance in previous studies [3]. collecting the photos, enhancing their quality with pre-processing, figuring out what characteristics are crucial for identifying pupils, and then applying machine learning methods like MultiTask Cascaded Convolutional Neural Networks (MTCNNs) to precisely categorize [1]. An input image will be processed using the Open CV face recognition technique, and a face will be identified [4]. Flask serves as the backend framework, providing a robust foundation for handling HTTP requests and responses. Leveraging its simplicity and flexibility, Flask seamlessly integrates with the PyTorch-based facial recognition module and PostgreSQL database. The integration of Closed-Circuit Television (CCTV) cameras in the automated attendance system using facial recognition technology is fundamental to its operational success. These cameras serve as the primary source for capturing live video feeds, essential for detecting and localizing faces within the monitored area. Through the sophisticated MTCNN (Multi-task Cascaded Convolutional Neural Network) algorithm [5], CCTV cameras enable precise face detection, providing the system with clear and high-quality images for facial recognition. Furthermore, the role of CCTV extends beyond attendance tracking to encompass real-time monitoring and security enhancement. Administrators and educators benefit from live feeds displayed on the system's interface, allowing them to track attendance instantaneously

II. LITERATURE REVIEW

Advances in computer vision algorithms and facial recognition technologies have transformed many fields, including attendance management systems, in recent years. Conventional techniques for recording attendance, including manually filling out sign-in sheets or using swipe cards, can be laborious and error-prone. The development of automatic attendance systems that make use of facial recognition technology to precisely and effectively track attendance has therefore gained popularity.

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The goal of this literature review is to present a thorough summary of the research and advancements that have been made in the area of automated attendance systems that use CCTV and facial recognition. We look for the most recent methods, difficulties, and opportunities in this field by examining pertinent research, scholarly articles, and technical reports. Convolutional layers are used in the architecture of MTCNN to extract features from the input image at various scales and resolutions, enabling reliable face detection across a range of face sizes. The network also makes use of cascade to gradually cut down on false positives and increase the accuracy of face detection [1].

Authors in [3] tested the accuracy of two face recognition models, Facenet and VGG-16, with regard to a single face is compared using a real-time dataset. With scores of 99.63% for LFW and 99.38% for the real-time dataset, Facenet outperforms VGG-16 in terms of accuracy for both datasets. VGG-16's real-time dataset received a score of 51.30%. This indicates that while VGG-16 may not do as well in real-world scenarios, Facenet is a more accurate model for facial recognition tasks that need real-time processing. The real-time dataset only has one image of each student since VGG-16 requires a large dataset with several photographs for each class. In this project FaceNet, is utilizing the VGG-16 architecture, for facial feature extraction and recognition. Using Flask Framework, information about the student and trained the model is stored, and picture of the student is captured which gets tested, and attendance was taken based on that picture[4].

III. METHODOLOGY

A. Proposed System:

The proposed automated attendance system is designed to streamline the traditional attendance tracking process through the integration of facial recognition technology and CCTV monitoring. This innovative system harnesses the power of advanced algorithms such as FaceNet and MTCNN to achieve accurate[6] and efficient face detection and recognition. FaceNet, built on the VGG-16 architecture, extracts high-dimensional feature vectors, or embeddings, representing unique facial characteristics. Complementing this, the Multi-task Cascaded Convolutional Neural Network (MTCNN) algorithm [5] precisely localizes faces within live video feeds from CCTV cameras, ensuring real-time monitoring. OpenCV serves as the backbone for data collection, facilitating the retrieval of video streams from CCTV cameras and processing uploaded images for registration. Through OpenCV's image preprocessing capabilities, including resizing and normalization, the system ensures uniformity and quality in the facial images used for recognition. This proposed system offers a sophisticated yet user-friendly solution for attendance management, promising enhanced accuracy and efficiency while reducing the burden of manual tracking processes.

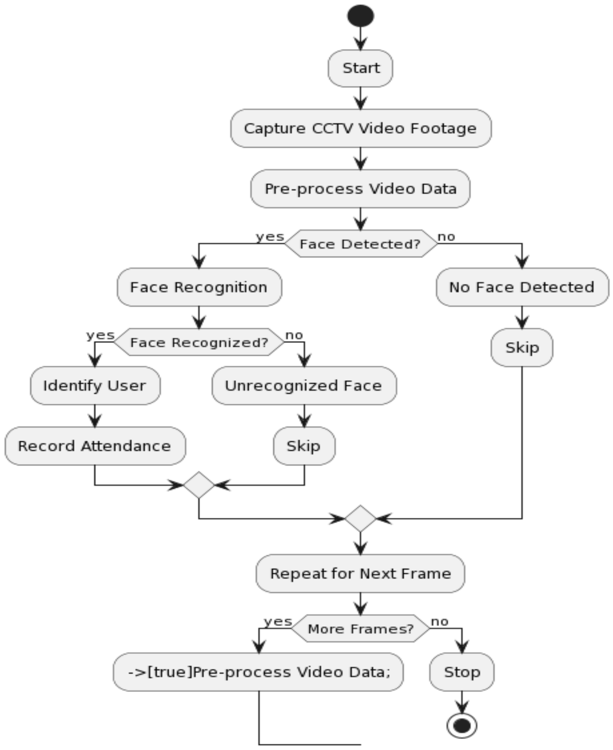

FIG.1. FLOW DIAGRAM OF PROPOSED SYSTEM

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B. Algorithms:

MTCNN:

In the automated attendance system project utilizing facial recognition and CCTV, the MTCNN (Multi-task Cascaded Convolutional Neural Network) algorithm plays a crucial role in the initial stage of the face recognition process: face detection. Here's how the MTCNN algorithm contributes to the project:

Face Detection:

MTCNN is responsible for detecting and localizing faces in the CCTV footage captured by the cameras. It scans the video frames using sliding windows of different scales to identify candidate regions containing faces. The algorithm predicts the probability of each candidate region containing a face and provides bounding box coordinates around the detected faces. By accurately detecting faces in the video stream, MTCNN enables subsequent stages of the face recognition pipeline to focus on processing only the regions containing faces, thus improving efficiency.

Overall, the role of the MTCNN algorithm in this project is to accurately detect faces in the CCTV footage, which serves as the foundation for subsequent stages of the face recognition process, such as feature extraction and matching. By leveraging MTCNN for face detection, the automated attendance system can efficiently track individuals' presence without manual intervention, enhancing the system's accuracy and reliability.

The MTCNN algorithm is integrated with the OpenCV library and Python programming language to perform face detection and facial landmark localization tasks. OpenCV is used to read video streams from CCTV cameras and preprocess frames for input to the MTCNN algorithm. Python serves as the primary programming language for implementing the integration, handling communication between OpenCV and the MTCNN algorithm, and processing the detected faces and landmarks.

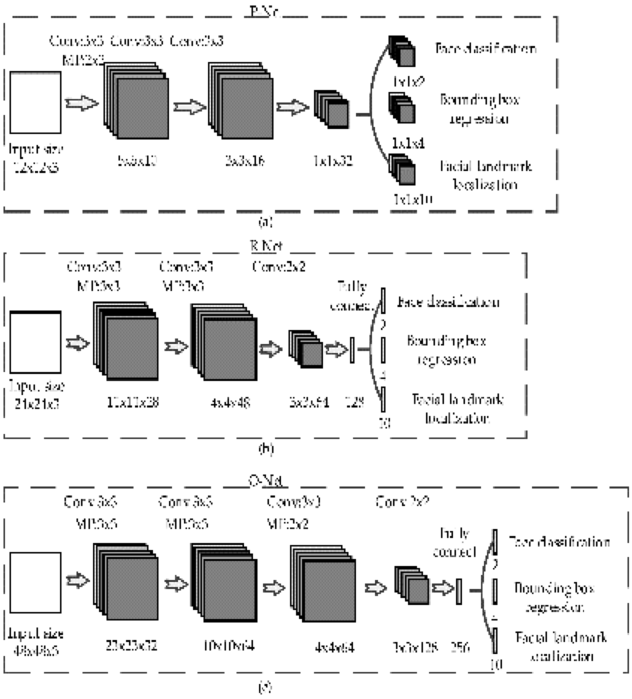

FIG.2. ARCHITECTURE OF MTCNN

YOLOv8 (You Only Look Once version 8):

YOLOv8 is responsible for detecting and localizing objects of interest in the CCTV footage captured by the cameras, including individuals. It processes video frames from the CCTV feed and identifies regions within the frames that contain objects of interest. YOLOv8 is optimized for real-time performance, allowing it to process video frames rapidly and efficiently [5].

This enables the automated attendance system to continuously monitor the CCTV feed in real-time and detect individuals as they enter and exit the scene without significant delay. By accurately detecting individuals in the CCTV footage,

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YOLOv8 ensures that attendance records are reliable and comprehensive, even in complex environments. By localizing individuals in the video frames, YOLOv8 provides regions of interest where facial recognition can be applied, improving the efficiency and accuracy of the overall attendance tracking system.

The YOLOv8 algorithm is integrated with the OpenCV library and Python programming language to perform real-time object detection tasks, including detecting individuals in CCTV footage. OpenCV is used to read video streams from CCTV cameras and preprocess frames for input to the YOLOv8 algorithm. Python is utilized to implement the integration, manage communication between OpenCV and the YOLOv8 algorithm, and process the detected objects.

C. Generating embeddings:

Generating embeddings in the automated attendance system begins with FaceNet (VGG-16) [4], extracting high-dimensional feature vectors from detected faces. These embeddings, capturing facial details, are normalized for consistency and stored in the database with associated metadata. During recognition, a new face's embedding is compared to stored embeddings using metrics like Euclidean distance. If similarity surpasses a set threshold, the system recognizes the individual, balancing accuracy and false positives. This meticulous process ensures reliable identification for attendance tracking. Through continuous learning, the system adapts and improves recognition over time, maintaining accuracy. Embeddings play a crucial role, forming the foundation for precise facial recognition in the system.

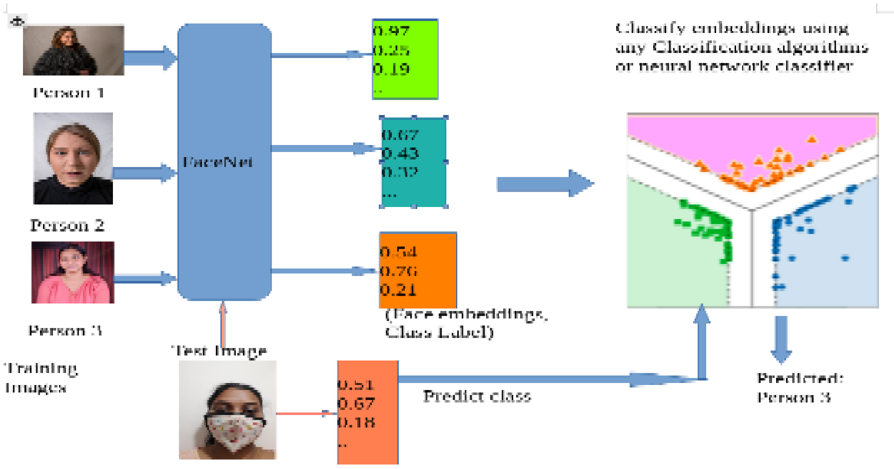

Fig.3. FACE RECOGNITION THROUGH FACENET

D. Efficient usage of CCTV:

CCTV cameras are strategically placed to cover key areas, ensuring comprehensive monitoring. OpenCV processes live video feeds from these cameras, enabling real-time analysis. YOLOv8 detects objects, including individuals, while MTCNN focuses on precise face detection within the video frames. This integration optimizes CCTV usage for efficient object and face detection. The system's interface provides administrators with live feeds and attendance updates, enhancing overall monitoring efficiency. Through this approach, the system achieves accurate attendance tracking while maximizing the utility of CCTV resources.

E. Frontend:

The frontend of the automated attendance system, developed with HTML, CSS, JavaScript, and React, features a user-friendly dashboard displaying attendance statistics and notifications. Users can manage their attendance history, register their faces, and receive real-time updates. Administrators have access to user management, attendance reports, and system settings. The interface is responsive, ensuring optimal display across devices, with secure authentication using JWT tokens. Notifications alert users of important events, and error handling provides clear feedback for user interactions. Overall, the frontend offers an intuitive and visually appealing platform for efficient attendance tracking and management.

F. Database:

The database for the facial recognition system is designed with tables to store individual information such as names, IDs, and timestamps. Using a chosen DBMS like PostgreSQL, tables are created with fields for face embeddings and associated metadata. Each registered person has a unique entry with their facial embeddings linked to their identity. This database acts as a repository for face data, enabling efficient retrieval during recognition.

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Proper indexing and organization optimize search and retrieval operations. Through this structured approach, the system ensures fast and accurate identification of individuals for attendance tracking.

G. Data collection and preprocessing:

In the automated attendance system utilizing facial recognition technology, data collection and preprocessing are efficiently managed through OpenCV, PyTorch, and Python. OpenCV serves as the primary tool for interfacing with CCTV cameras, capturing live video feeds, and processing uploaded images. Python scripts leverage OpenCV's **cv2.VideoCapture()** to initialize and stream video from cameras, ensuring a seamless data collection process. The system also supports image uploads for registration, with OpenCV used to read and preprocess these images. For face detection, the Multi-task Cascaded Convolutional Neural Network (MTCNN) algorithm [5], implemented with PyTorch, plays a pivotal role. OpenCV facilitates the conversion of video frames to PyTorch tensors, enabling accurate face localization through MTCNN. Additionally, OpenCV's image preprocessing functions, such as resizing and normalization, ensure consistency and quality in the facial images processed by the system. Through the combined power of OpenCV [1], PyTorch, and Python, the system efficiently collects and preprocesses data, laying a solid foundation for accurate facial recognition and automated attendance tracking.

H. Flask web application:

Flask, a micro web framework for Python, is integrated with Python to develop APIs for communication between the front-end interface and the back-end server. Python scripts utilizing Flask handle incoming HTTP requests, process data, and generate appropriate responses based on the requested endpoints. Flask's integration with Python enables seamless communication between different components of the automated attendance system, facilitating interaction between the user interface, facial recognition algorithms, and database management.

I. Fine-tuning the facial recognition model:

Fine-tuning our facial recognition model involves customizing a pre-trained model like FaceNet or VGG-16 using transfer learning [4]. This process adapts the model to recognize specific facial features relevant to attendance tracking, optimizing hyperparameters such as learning rate and batch size. Through feature extraction and loss function optimization, we enhance the model's ability to distinguish between individuals accurately. Regularization techniques are applied to prevent overfitting, and the model's performance is evaluated using metrics like accuracy and precision. Overall, fine-tuning ensures the model is finely tuned to the system's requirements for efficient and accurate facial recognition.

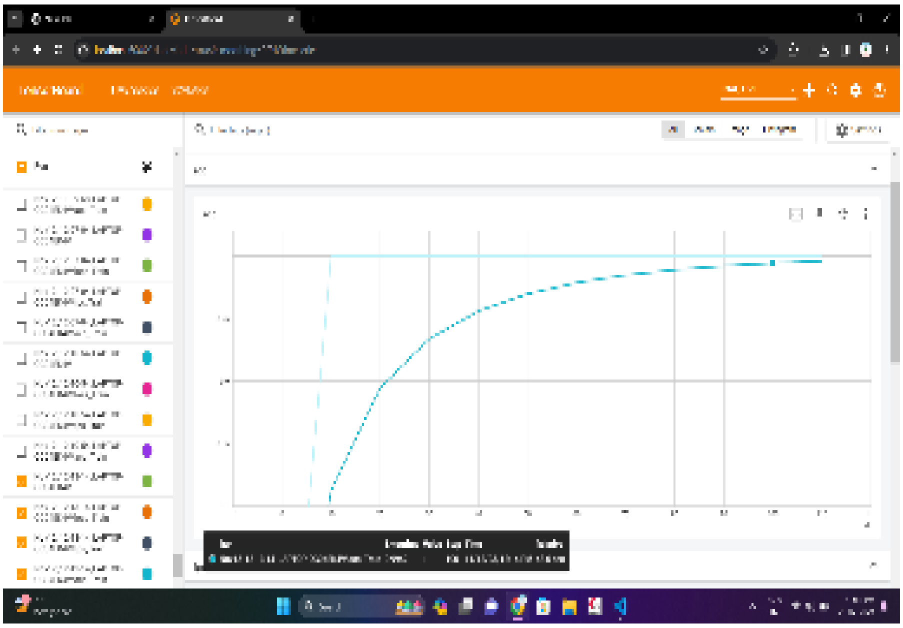

FIG.4.ACCURACY OF MACHINE LEARNING MODEL

The graph visualizes the accuracy (acc) of a machine learning model over time or training steps. It's a crucial metric that reflects how well the model is performing during training.

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The graph shows a curve that starts low and gradually rises. As training progresses, the accuracy improves steadily. The sharp initial increase indicates rapid learning, followed by a more gradual ascent.

The x-axis likely represents the training steps or epochs.The y-axis represents the accuracy percentage (usually ranging from 0% to 100%).

Researchers and practitioners use this graph to monitor the model's performance.

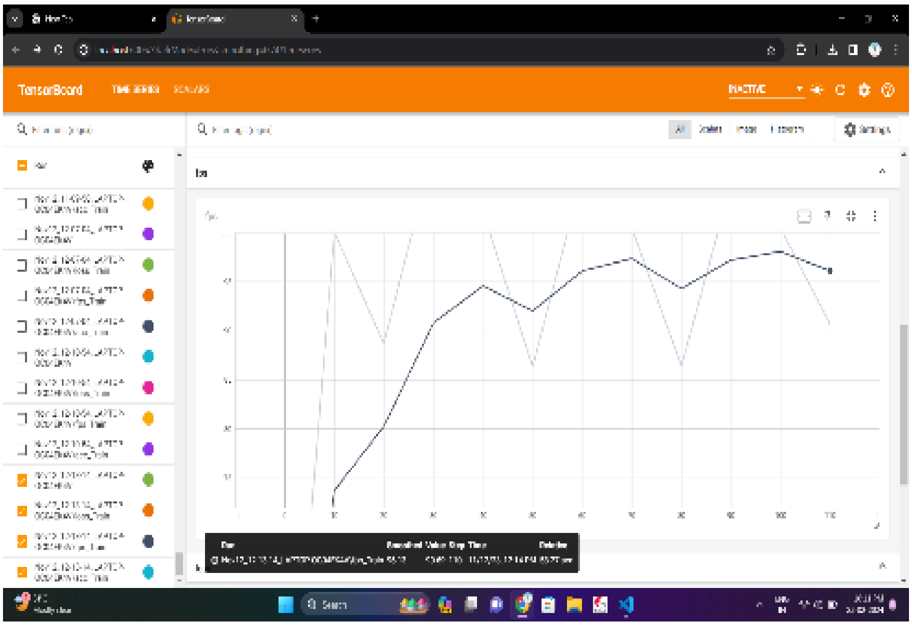

FIG.5. RELATION BETWEEN TWO METRICES

The graph visualizes the relationship between two critical performance metrics during the execution of a machine learning model.

The y-axis represents the **frames per second** (FPS), which indicates how many video frames the system processes in one second. Higher FPS values imply faster processing and smoother execution.

The x-axis represents the **smoothed wall step time**. This metric captures the time taken for each computational step (e.g., forward or backward pass) in the model. As the smoothed wall step time increases), the FPS tends to decrease This inverse relationship suggests that longer computational steps lead to slower overall execution.

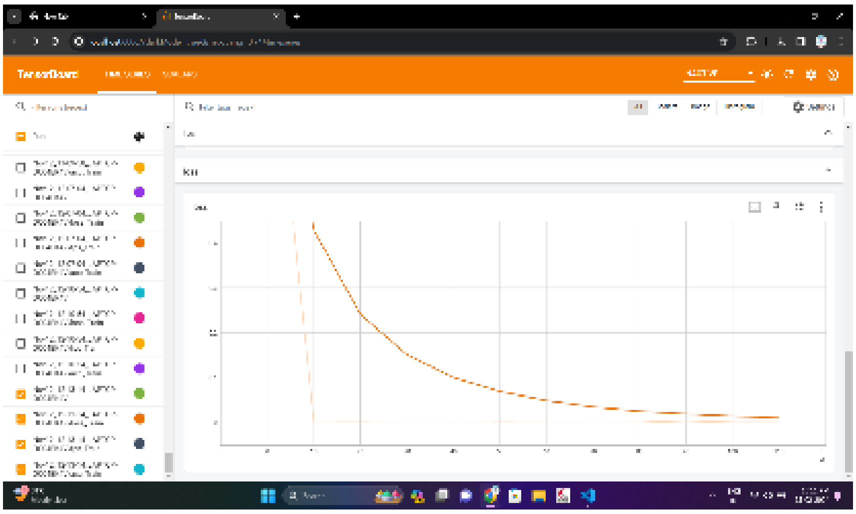

FIG.6.LOSS FUNCTION OF ML MODEL

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The graph visualizes the **loss function** of a machine learning model over training epochs (or iterations).

The y-axis represents the **loss value**. Lower loss values indicate better performance.

The x-axis likely represents **epochs** (training iterations). As the model trains, it adjusts its internal parameters to minimize the loss.

The graph shows a sharp decrease in loss as training progresses. The model learns from the data, updating its weights to improve predictions. After the initial descent, the loss reduction becomes more gradual. The model fine-tunes its parameters to minimize errors. Researchers and practitioners monitor this graph to ensure the model is learning effectively.

IV. RESULT

The attendance management system using facial recognition is very easy to use. The login process ensures that only authorized users can access the automated attendance system, maintaining security and integrity of attendance data. By incorporating authentication methods such as username/password, two-factor authentication, and optional facial recognition, the system provides a robust and user-friendly login experience for administrators and other users. The admin should login using the User ID and Password as shown in the below Fig 2.

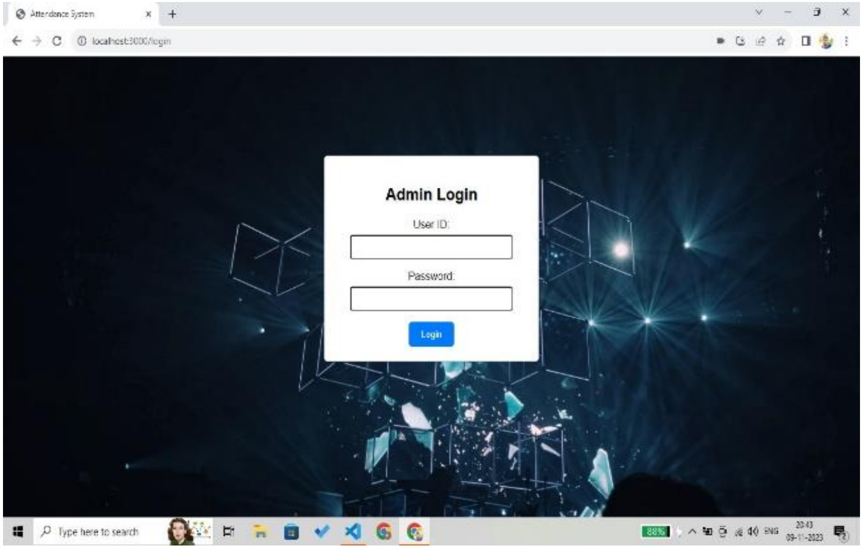

FIG.7. LOGIN PAGE

After successful login we will be directed to the Dashboard where the student's ID, name, class and their attendance will be shown as shown in the Fig 3.

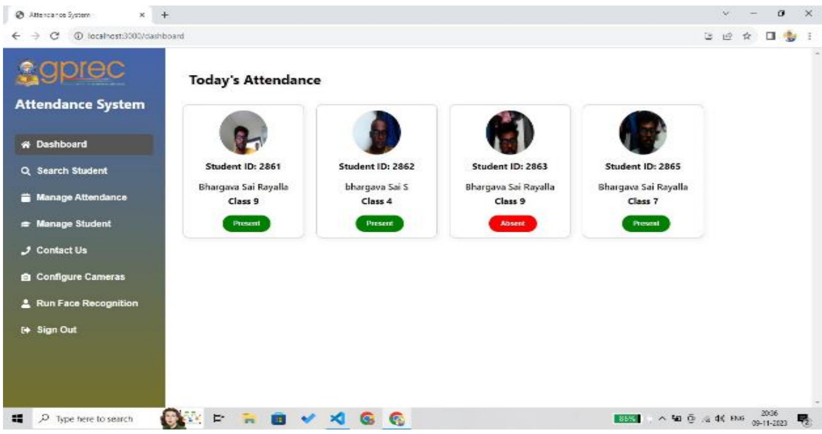

FIG.8. DASHBOARD

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Below the dashboard there is search student option where we can search the student and get the details of the student such as Student ID, name, image, class, Date of birth, Guardian Name, Guardian contact, Address as shown in the Fig 4 below.

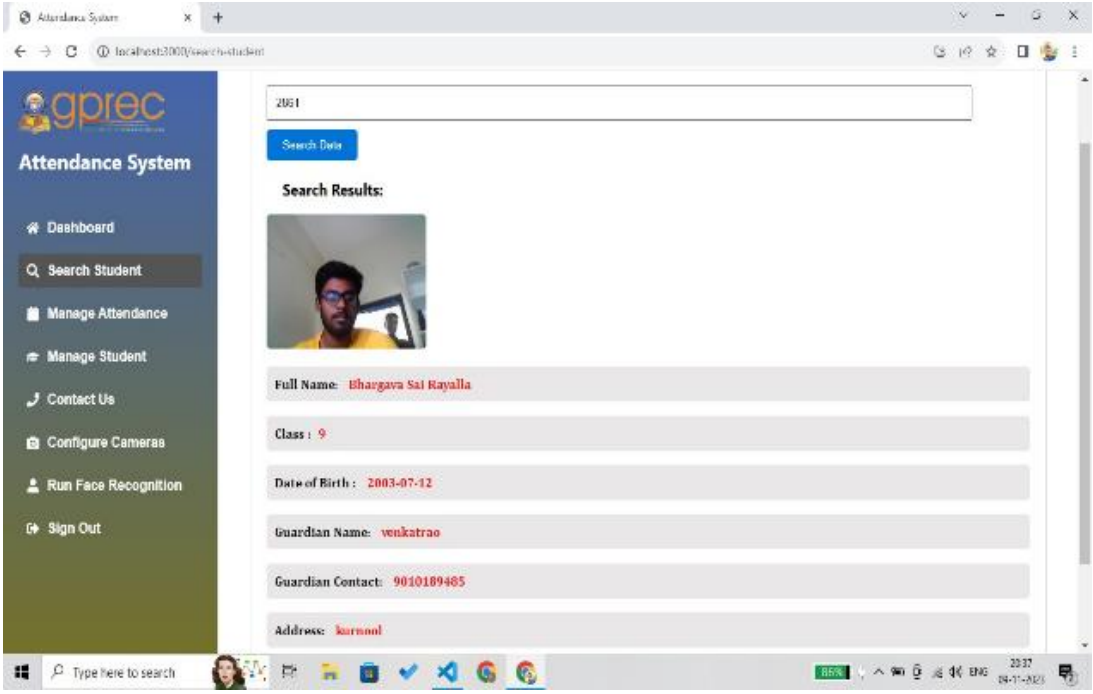

FIG.9. SEARCH STUDENT

Then we have manage attendance option where we can manage the class attendance and student attendance

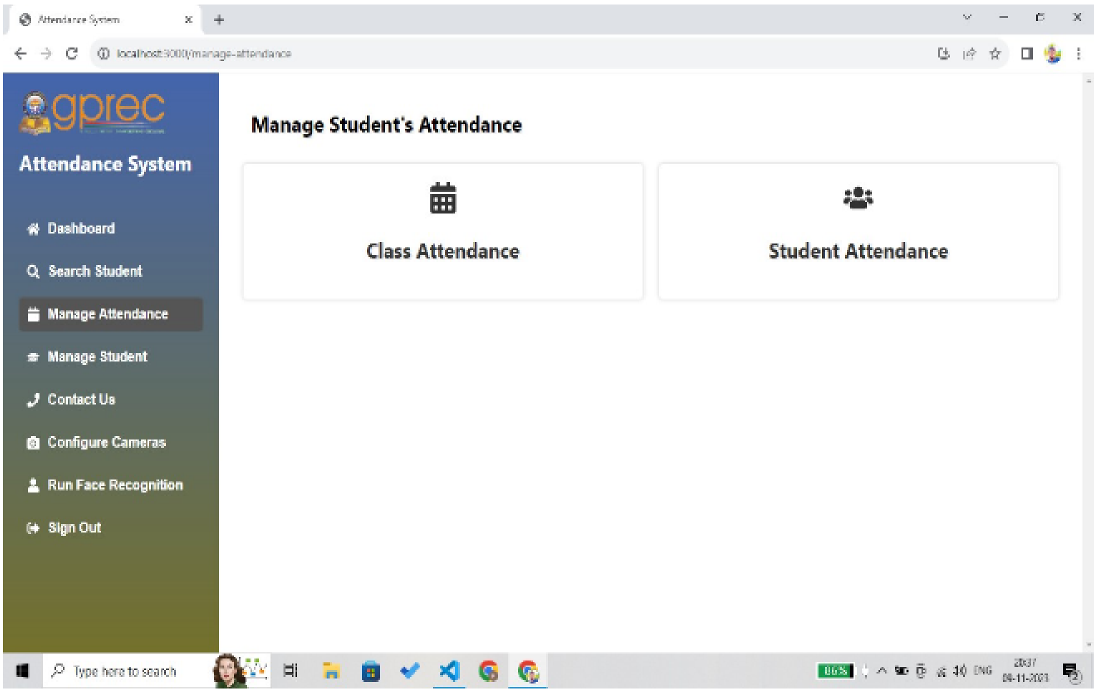

FIG.10. MANAGE ATTENDANCE

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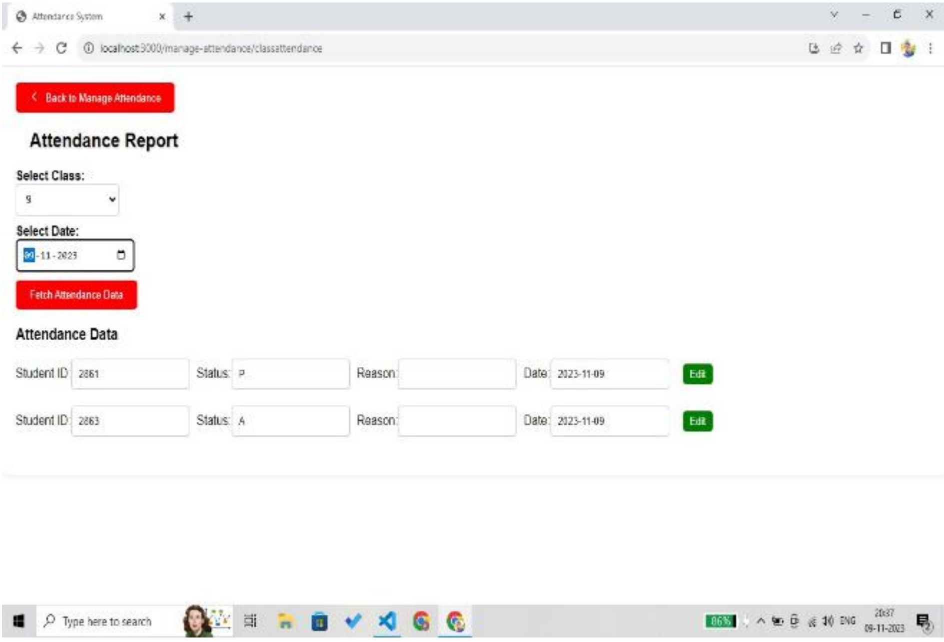

FIG.11. CLASS ATTENDANCE

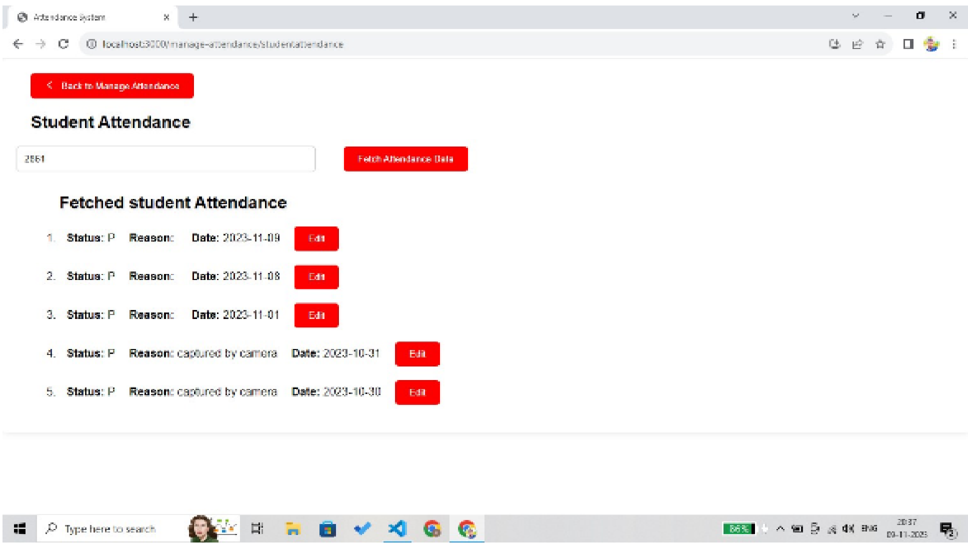

FIG.12. STUDENT ATTENDANCE

We have manage student details where we can add the student, edit the student and delete the student.

Students who need to be added present themselves in front of a designated camera or device. The system prompts the student to provide their details such as name, student ID, course, and any other relevant information. Simultaneously, the system captures multiple images of the student's face from different angles and under various lighting conditions. This is how the student is registered. The manage student details is shown in the below Fig 6.

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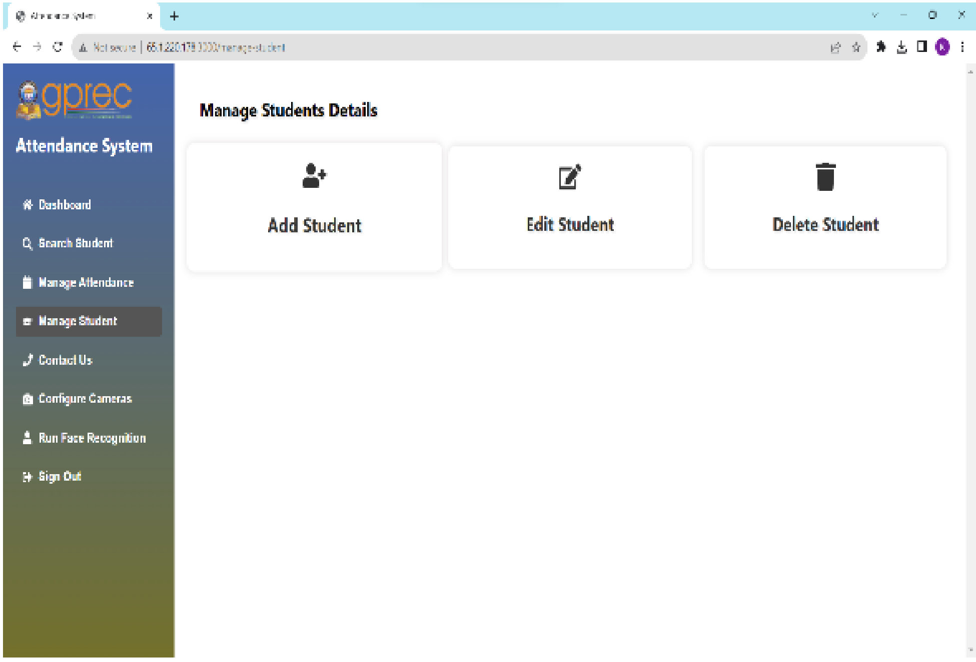

FIG.13. MANAGE STUDENT DETAILS.

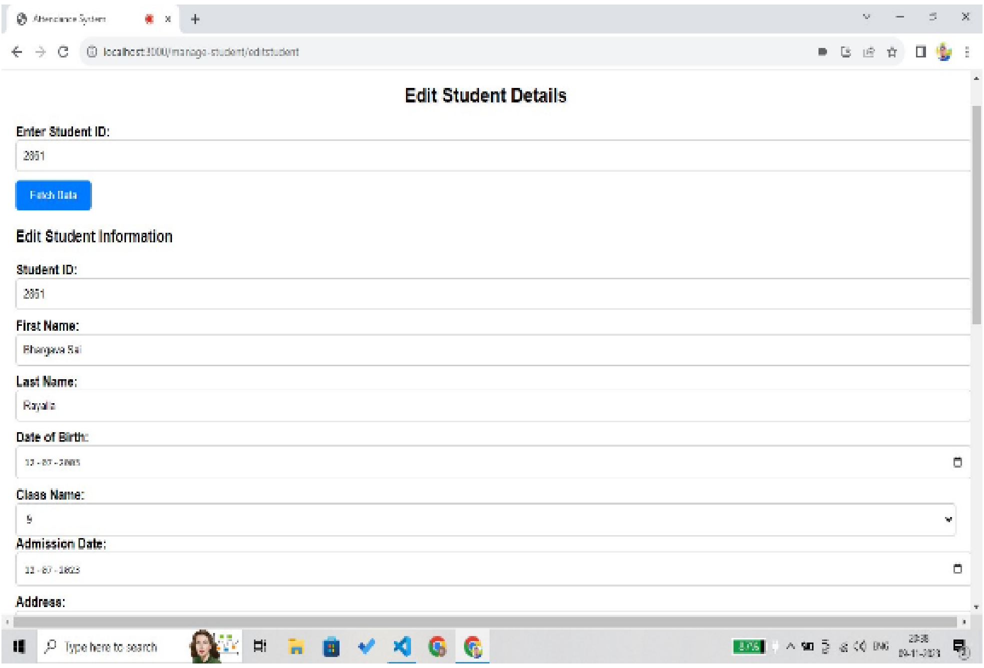

FIG.14. EDIT STUDENT DETAIL

Configuring cameras for facial recognition in the automated attendance system is a critical step to ensure optimal performance and accurate detection. By carefully configuring cameras for facial recognition, the automated attendance system can achieve optimal performance, accuracy, and reliability in identifying individuals from live video feeds. This ensures efficient attendance tracking and enhances the overall functionality of the system.

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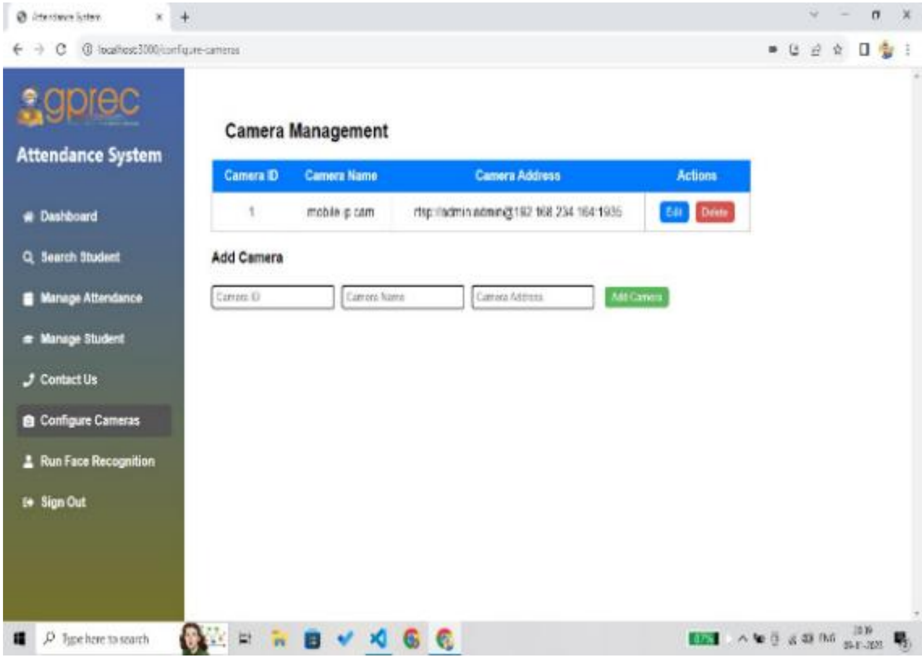

FIG.15. CONFIGURE CAMERA

Fig 8 shows Run facial recognition after this step if the person in front of the camera is recognised then the attendance of the person will be marked as present automatically in the dashboard (Fig.3.).

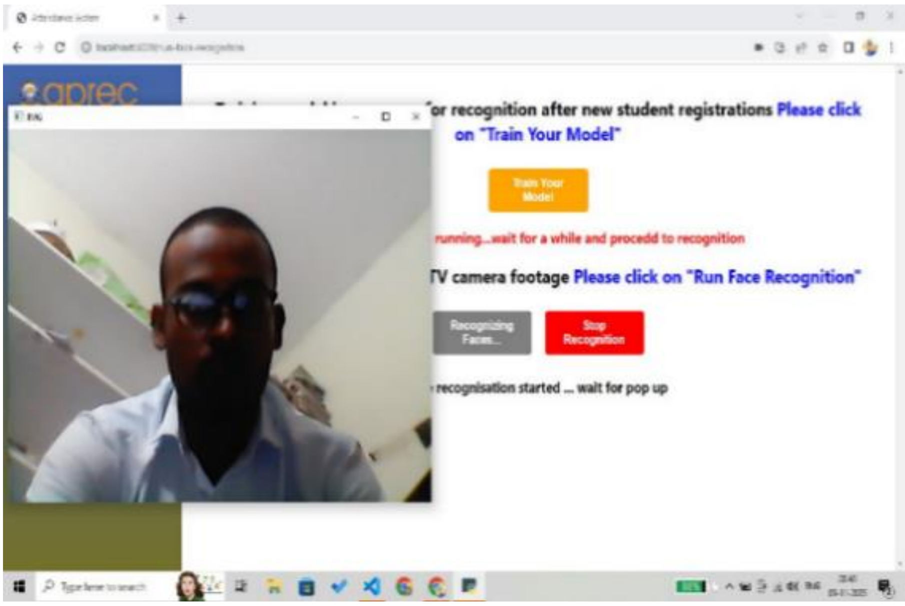

FIG.16 RUN FACIAL RECOGNITION

V. CONCLUSION

In conclusion, the implementation of the Automated Attendance System with Facial Recognition has been a multifaceted and innovative project, combining state-of-the-art technologies and frameworks. Leveraging the power of PyTorch, FaceNet, VGG-16, MTCNN and yolov8, and OpenCV, this system excels in accurate face detection and recognition, providing a robust foundation for attendance tracking. The use of Flask as the backend API, coupled with PostgreSQL as the database, ensures efficient data management and retrieval.

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The integration of HTML, CSS, JavaScript, and React for the frontend creates an intuitive and responsive user interface, enhancing the overall user experience. Moreover, the security and privacy measures, including HTTP and access control, align with ethical considerations and data protection regulations.

The architecture's thoughtful design, featuring components like the notification system and comprehensive data pre-processing steps, reflects a holistic approach to address challenges and enhance system performance. The adoption of PyTorch for deep learning tasks and the incorporation of MTCNN for face detection highlight the commitment to utilizing cutting-edge technologies. YOLO v8, renowned for its real-time processing and accuracy, can play a pivotal role in expanding the system's capabilities beyond facial recognition.

In essence, the Automated Attendance System with Facial Recognition not only streamlines attendance tracking but also serves as a testament to the potential of integrating advanced technologies for real-world applications. The project's success lies not only in its accurate and efficient functionalities but also in its adaptability for future enhancements and widespread deployment.

VI. FUTURE ENHANCEMENTS

- **Attendance Analytics:** Implement machine learning algorithms to analyze attendance patterns, detect anomalies, and establish correlations with external factors, providing valuable insights for educators and administrators.

- **Adaptive Model:** Regularly update the facial recognition model with new facial data, allowing it to adapt to changes in the user base and improve accuracy based on real-time feedback.

- **User Feedback Mechanism:** Implement a user feedback mechanism to gather insights from administrators, teachers, and users, facilitating the refinement of system parameters and enhancing overall performance.

- **Enhanced Security Measures:** Explore advanced security measures such as biometric encryption to further protect facial data and ensure compliance with evolving data protection regulations.

- **Mobile Integration:** Extend the system's accessibility by developing mobile applications, enabling users to conveniently mark attendance and receive notifications on their mobile devices.

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