AUTOMATED ATTENDANCE SYSTEM USING FACE RECOGNITION AND MACHINE LEARNING

Mini Project 2A Report

Submitted in partial fulfillment of the requirement of University of Mumbai

for the Degree of

Bachelor of Engineering

By

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SH-2023

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Academic Year 2023-24

CERTIFICATE

This is to certify that the mini project 2A entitled **"Automated attendance system using face recognition & machine learning"** is a bonafide work of

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submitted to the University of Mumbai in partial fulfillment of the requirement for the award of the Bachelor of Engineering (Artificial Intelligence & Data Science).

Prof. Vishal Gotarane	Dr. Sandeep B. Raskar	Dr. L. K. Ragha
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Project Report Approval

This Mini Project 2A Report – entitled **"Automated attendance system using face recognition & machine learning"** by followingstudents is approved for the degree of ***B.E. in "Artificial Intelligence & Data Science"***.

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Declaration

We declare that this written submission represents our ideas in our own words and where others' ideas or words have been included, we have adequately cited and referenced the original sources. We also declare that we have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in our submission. We understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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Acknowledgement

We would like to express our sincere gratitude towards our guide **Prof. Vishal Gotarane**, Mini Project Coordinator **Prof. Vishal Gotarane** for their help, guidance and encouragement, they provided during the project development. This work would have not been possible without their valuable time, patience and motivation. We thank them for making our stint thoroughly pleasant and enriching. It was great learning and an honor being their student.

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Abstract

The main purpose of this project is to develop an automated attendance system using cutting-edge face recognition and machine learning algorithms such as MTCNN, FaceNet, and SVM. This system aims to enhance and modernize the existing attendance tracking procedures in educational institutions, significantly improving efficiency and accuracy.

The current conventional system is plagued with ambiguities, leading to inaccuracies and inefficiencies in attendance management. Moreover, the inability to enforce attendance regulations has posed numerous challenges for authorities.

Our technological approach leverages the uniqueness of the human face as a natural identifier. The use of face recognition technology, supported by machine learning algorithms, ensures a lowprobability of deviation or duplication.

During attendance sessions, our system will actively extract student data from the Firebase database, utilizing MTCNN and FaceNet to detect and verify faces. These faces are then compared against the database to establish individual identities with a high degree of precision. When successful identification occurs, attendance records are automatically recorded and savedin an Excel sheet. It's worth noting that the student data extraction process is seamlessly integrated with the Firebase database, ensuring that the attendance system is consistently up to date with the most current information, enhancing overall system accuracy and reliability.

Keywords: Face Recognition, Machine Learning, MTCNN, FaceNet, SVM, Firebase Database.

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Chapter 1

Introduction

1.1 Motivation:

Attendance holds paramount significance for both educators and students within an educational institution. This system eradicates traditional methods of student identification, such as verbally calling out names or inspecting student identification cards. These conventional methods can not only disrupt the teaching process but also induce stress, especially during examination periods.

1.1.1 Need of the problem:

The need for addressing the problem of the old attendance system and implementing a new automated system with face recognition and machine learning arises from the inefficiency, inaccuracy, security vulnerabilities, and time-consuming nature of manual attendance recording. Modernizing the attendance process is essential to improve accuracy, security, user experience, and compliance with legal requirements while leveraging advanced technology for enhanced efficiency.

1.2 Scope of the project:

The primary goal of this project is to address the issues associated with the existing attendance system while introducing an innovative and efficient solution that can enhance the institution's convenience. The project will involve the development of an application capable of recognizing and recording the identity of individuals, utilizing machine learning algorithms for enhanced accuracy and reliability.

Additionally, attendance data will be stored in a database, and an Excel sheet containing student attendance will be automatically generated and sent to the respective faculty members.

The project's scope includes the following aspects:

- The attendance monitoring system will target both students and staff within an educational institution.
- The database for attendance management can accommodate information for up to 2000 individuals.
- The facial recognition process will be designed to recognize one person at a time.
- An Excel sheet will be generated, displaying student attendance, and will be sent to the respective faculty.

1.1 Aim: To solve the issues encountered in the old attendance system while enhancing a brand-new automated attendance system based on face recognition & machine learning algorithms.

Chapter 2

Problem Statement

2.1 Problem statement

The current attendance system faces two critical challenges: data accuracy boris compromised due to the potential for third-party attendance marking, and it is highly time-consuming, allowing only about 60 students to sign in an hour. The project's objective is to develop an upgraded automated attendance system that utilizes face recognition and machine learning. This new system will rectify the limitations of the manual system, improving data accuracy and efficiency. It will also incorporate a student details database for streamlined record-keeping, ensuring the maintenance of precise attendance data. Ultimately, the project aims to modernize attendance tracking in educational institutions, offering a more dependable and user-friendly solution for both students and faculty.

2.2 Features

- The system should be able to identify and recognize the face of the user.
- This involves capturing an image of the user's face and comparing it to the stored images in the system datasets
- The system should be able to track attendance, allowing for accurate tracking of student attendance. The system should have an easy-to-use interface that is intuitive and user-friendly, allowing for quick and hassle-free attendance tracking

2.3 Objectives

- To ensure the speed of the attendance recording process is faster than the previous system which can go as fast as approximately 3 second for each student.
- Able to recognize the face of an individual accurately based on the face database.
- Develop a database for the attendance management system.
- Provide a user-friendly interface for admins to access the attendance database and for non-admins (parents) to check their child’s attendance by mailing the attendance.
- Allow new students or staff to store their faces in the database by using a GUI.

Chapter 3

Literature Survey

Sr. No.	Title	Problem Addressed	Methodology	Advantages	Limitations
1	Prof. Shweta S Bagali, Dr K Amuthabala, Prof. Iranna Amargol. "Smart Attendance System using Machine Learning" International Journal of Engineering Research & Technology, Volume 10, Issue 12, ISSN: 2278-0181, 2022	Inefficiency and errors associated with traditional manual attendance systems.	Face Detection and Extraction Face Recognition and Matching Data Storage and Management Attendance Recording User Interface	Accuracy Efficiency Real-time Tracking Reduced Administrative Burden	Privacy Concerns Lighting and Environmental Factors Variability in Appearance False Positives and Negatives

Sr. No.	Title	Problem Addressed	Methodology	Advantages	Limitations
2	Sachin Wakurdekar, Utkarsh Nagpure, Eshika Kothari. "Python GUI intergrated attendance system using face recognition" International Journal of Scientific Development and Research, Volume 7 Issue 7, ISSN: 2455-2631, July 2022	Creating a system that is secure, efficient, time-saving, and user-friendly	Utilizing facial recognition technology Image processing techniques Feature extraction methods GUI Integration	User-Friendly Database Management	Hardware Requirements Accuracy Concerns Environmental Factors

Sr. No.	Title	Problem Addressed	Methodology	Advantages	Limitations
3	Md Abu Talha Reyaz, K Sunil Kumar, Arun Kumar, Aathimuthu. "Facial Recognition Attendance System Using Deep Learning" International Journal for Research in Applied Science & Engineering Technology, Volume 10, Issue VI, ISSN: 2321-9653, June 2022	Inaccurate Attendance Tracking Time and Effort in Attendance Taking Aims to provide accurate, efficient, secure, and convenient attendance tracking	Image Data Collection Data Implementation Model Training Image predictions	Enhanced Security Time and Resource Efficiency	Data Requirements Computational Resources

Sr. No.	Title	Problem Addressed	Methodology	Advantages	Limitations
4	Mohd Azlan Abu1, Nurul Hazirah Indra1, Abdul Halim. "A study on Image Classification based on Deep Learning and TensorFlow" International Journal of Engineering Research and Technology. Volume 12, ISSN 0974-3154, Number 4 (2019), pp. 563-569	Improving image classification accuracy through the utilization of deep learning techniques and the TensorFlow framework	Data collection Implementing a DNN using TensorFlow and MobileNet Configuring the parameters for optimal performance	By utilizing DNN with the TensorFlow framework, the researchers are likely to achieve high accuracy rates.	Dependency on Pre-trained Models Limited Domain

Sr. No.	Title	Problem Addressed	Methodology	Advantages	Limitations
5	Ankit Yadav, Ibtesaam Rais, Manoj Kumar. "Image Classification using Deep Learning and Tensorflow" International Journal for Research in Applied Science & Engineering Technology, Volume 10, Issue V, ISSN: 2321-9653, May 2022	Improving image classification accuracy and efficiency.	Deep Learning and TensorFlow Neural Network Architecture Transfer Learning Model Training and Evaluation	Feature Extraction Hierarchical Representations Efficiency with TensorFlow	Data Requirements Model Complexity Dataset Bias

Sr. No.	Title	Problem Addressed	Methodology	Advantages	Limitations
6	Dr. V Suresh, Srinivasa Chakravarthi Dumpa, Chiranjeevi Deepak Vankayala. "Facial Recognition Attendance System Using Python and OpenCv" Quest Journals, Journal of Software Engineering and Simulation, Volume 5, Issue 2, ISSN: 2321-3795, (2019) pp: 18-29	Inaccurate Data Collection Time-Consuming Process Limited Accessibility Resource Intensive	Image Acquisition and Pre-processing Database Creation CSV File Creation Recognition Process	Ease of Use Versatile Face Recognition Efficient Feature Extraction	Accuracy Concerns

Sr. No.	Title	Problem Addressed	Methodology	Advantages	Limitations
7	Bharath Tej Chinimilli, Anjali T, Akhil Kotturi. "Face Recognition based Attendance System using Haar Cascade and Local Binary Pattern Histogram Algorithm" 4th International Conference on Trends in Electronics and Informatics (ICOEI)(48184) 2020	Variability in Student Appearance Unknown Person Detection	Haar Cascade for face detection Local Binary Pattern Histogram (LBPH) algorithm for face recognition	Recognize student's faces in real-time video streams, even when there are variations in appearance	Limited to Detection False Positives/Negatives

Sr. No.	Title	Problem Addressed	Methodology	Advantages	Limitations
8	Dr.Vinayak Bharadi, Mr.Rutik Sansare, Mr.Tushar Padelkar. "Real Time Face Recognition System Using Convolutional Neural Network" International journal of creative research thoughts, Volume 10, Issue 4, ISSN: 2320-2882, 4 April 2022	Need for a reliable and accurate method of identifying individuals through their faces.	Convolutional Neural Networks (CNNs) with the VGG16 architecture and Transfer Learning.	High Accuracy Real-Time Processing Robust to Variability	Variability in Lighting and Pose Small Training Data Performance in Crowded Scenes

Sr. No.	Title	Problem Addressed	Methodology	Advantages	Limitations
9	Abhijith S, Jeeshma Jeevan. "Automatic attendance marking system using facenet" Journal of Emerging Technologies and Innovative Research (JETIR) June 2021, Volume 8, Issue 6	Inefficiency of Manual Attendance Potential for Errors: Fraudulent Attendance	Uses a compounded deep learning model, including (MTCNN), for feature extraction and landmark detection. Features of individuals are saved in a No-SQL MongoDB database	Elimination of Manual Work Accuracy Real-Time Attendance Fraud Prevention Database Maintenance	Privacy Concerns Hardware Requirements False: Positives/Negatives

Sr. No.	Title	Problem Addressed	Methodology	Advantages	Limitations
10	Rishabh Karmakar. "Facial attendance system using MTCNN and feature mapping" International Journal of Engineering Applied Sciences and Technology, 2020 Vol. 5, Issue 4, ISSN No. 2455-2143, Pages 546-550	Traditional attendance marking system is manual, time-consuming, and prone to errors. Overcoming the limitations of existing attendance systems, such as portability, accessibility, authenticity, accuracy, efficiency, and cost.	Utilization of Multi-Task Cascaded Convolutional Neural Network (MTCNN) for face detection. Training of the FaceNet model with extracted features. Support Vector Classifier (SVC) used for classification based on trained models	Automation of attendance marking Increased accuracy in attendance records Reduced chances of proxies and errors in marking attendance High security through face recognition	Initial setup and data collection time-consuming Dependence on reliable facial recognition system Potential issues with recognizing faces in varying lighting conditions

Chapter 4

Design and Implementation

4.1 Architecture Diagram of the System:

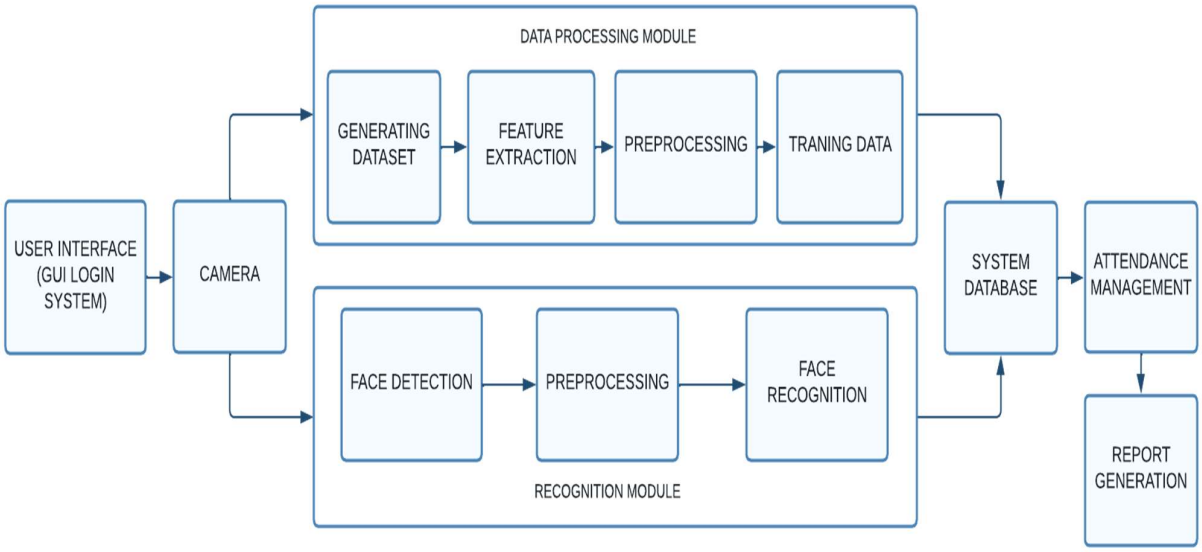


Fig 4.1: Architecture Diagram of Attendance System Using Face Recognition

4.2 Tool Used:

- **Pycharm(IDE)**
- **Tensorflow / keras**
- **MTCNN**
- **FaceNet**
- **SVM**
- **Firebase**

4.3 Software Components:

- **opencv -contrib-python / opencv-python**
- **tensorflow==2.14.orc1**
- **numpy**
- **pandas**

- **matplotlib**
- **scikit-learn**
- **tkinter**
- **keras**
- **firebase**
- **mtcnn**

4.4 Working of the System:

1. Data Collection: Gather a dataset of student facial images, along with their corresponding details, which will serve as the training data for the system.

2. Preprocessing: Preprocess the facial images to standardize size, lighting, and orientation, improving the quality and consistency of the dataset.

3. Face Detection (MTCNN): Employ the Multi-task Cascaded Convolutional Networks (MTCNN) to detect and locate faces within images, generating bounding boxes around each face.

4. Face Recognition (FaceNet): Utilize FaceNet, a deep learning model, to extract unique facial embeddings from the detected faces, converting each face into a numerical vector.

5. Database Integration: Store the facial embeddings along with student details in a student database, facilitating efficient record-keeping.

6. Training (SVM): Train a Support Vector Machine (SVM) classifier on the extracted facial embeddings and their associated student labels, creating a model that can recognize individual students.

7. Real-time Attendance Tracking: During an attendance session, capture students' facial images and apply the MTCNN for detection and FaceNet for recognition. Retrieve the recognized student's name from the SVM classifier.

8. Attendance Logging: Record the attendance, including student names and timestamps, and store it in an attendance database.

9. Accuracy Enhancement: Employ additional machine learning techniques to refine the system's accuracy, such as adjusting confidence thresholds and using multiple images per student for recognition.

13. User Interface: Develop a user-friendly interface for teachers and administrators to access and manage attendance data.

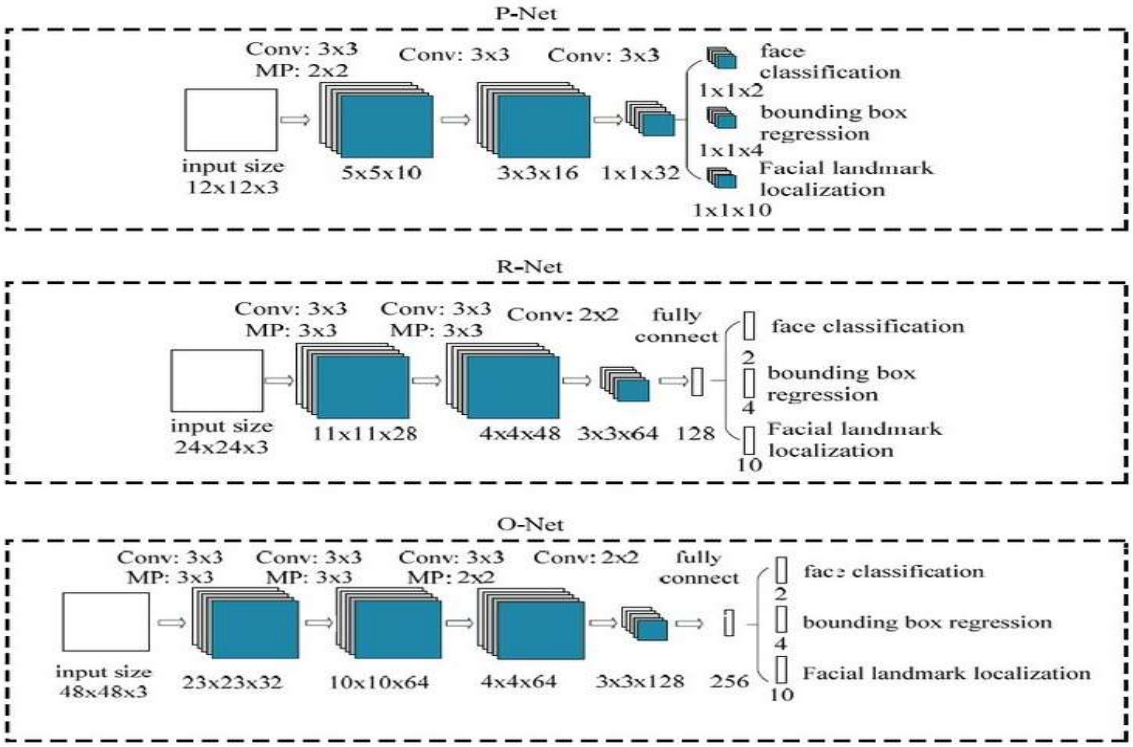
4.5 Algorithm:

4.5.1 MTCNN (Multitask Cascaded Neural Network):

MTCNN is a deep learning model designed for the task of face detection. It's particularly effective at detecting faces in images with real-world challenges such as variations in lighting, pose, and scale. MTCNN works in a cascaded manner with three stages, each responsible for different tasks in the face detection process.

Stage 1: Proposal Network (P-Net):
The P-Net proposes potential face regions in an image by sliding a small window and making two predictions: whether a face is present and how to adjust the bounding box around it.
It acts as a fast filter to identify regions of interest.
The output of the P-Net includes a set of candidates bounding boxes with their associated probabilities. These candidate boxes can overlap.
Stage 2: Refinement Network (R-Net):
The R-Net refines the candidate face regions generated by the P-Net. It improves the accuracy of bounding box positions.
It performs both face classification and fine-tuning of bounding box coordinates to filter out false positives.

Stage 3: Output Network (O-Net):
The O-Net is the final stage, providing accurate facial landmarks and precise bounding boxes.
It performs face classification, further refines bounding box positions, and predicts five facial landmarks, such as eyes, nose, and mouth corners.
The output is highly accurate face localization with landmark information.



4.5.2 FaceNet:

FaceNet is a deep neural network model designed for face recognition. It learns to map facial features into a high-dimensional space (embedding space) where the Euclidean distance between embeddings corresponds to the similarity between faces. The key to FaceNet's success is its use of the triplet loss function, which helps in training the network to create well-separated clusters for different individuals while keeping similar faces close together in the embedding space.

4.5.2.1 FaceNet Architecture:

FaceNet uses a Siamese network architecture, where two identical subnetworks share weights. These subnetworks take in two face images as input.
Each input image goes through a series of convolutional and fully connected layers, ultimately producing an embedding vector of a fixed length (e.g., 128 dimensions) for each face.

4.5.2.2 Triplet Loss Function:

The triplet loss function encourages the model to minimize the distance between the embeddings of two images from the same person (positive pair) and maximize the distance between the embeddings of images from different people (negative pair).
It does this by comparing three embeddings: an anchor (A), a positive (P), and a negative (N) embedding.

The triplet loss can be defined as follows:

$$L(A, P, N) = \max(0, ||f(A) - f(P)||^2 - ||f(A) - f(N)||^2 + \alpha)$$

Here, L represents the triplet loss, f(X) is the embedding produced by the FaceNet network for image X, ||...|| denotes the Euclidean (L2) distance between embeddings, and α is a margin parameter that specifies how much separation is required between the positive and negative pairs.
The loss term max(0, ...) ensures that the loss is only computed when the negative pair is closer to the anchor than the positive pair by at least α.

4.5.2.3 Triplet Selection:

The selection of triplets in FaceNet involves choosing an anchor, a positive sample (from the same person as the anchor), and a negative sample (from a different person). The choice of triplets is crucial to the effectiveness of the training. Here's how it's done:
Selecting Triplets:
Anchor (A): Randomly select an anchor image from the dataset. This image will serve as the reference point for the triplet.
Positive (P): Randomly choose a positive image from the same person's images as the anchor. The positive image should be visually similar to the anchor.
Negative (N): Randomly select a negative image from a different person's images. The negative image should be visually dissimilar to the anchor.

Balancing Triplets:
It's essential to balance the selection of triplets to ensure that you have a mix of easy, semi-hard, and hard triplets for effective training. The choice of triplets depends on the margin parameter α in the triplet loss function. The loss function can be expressed as:

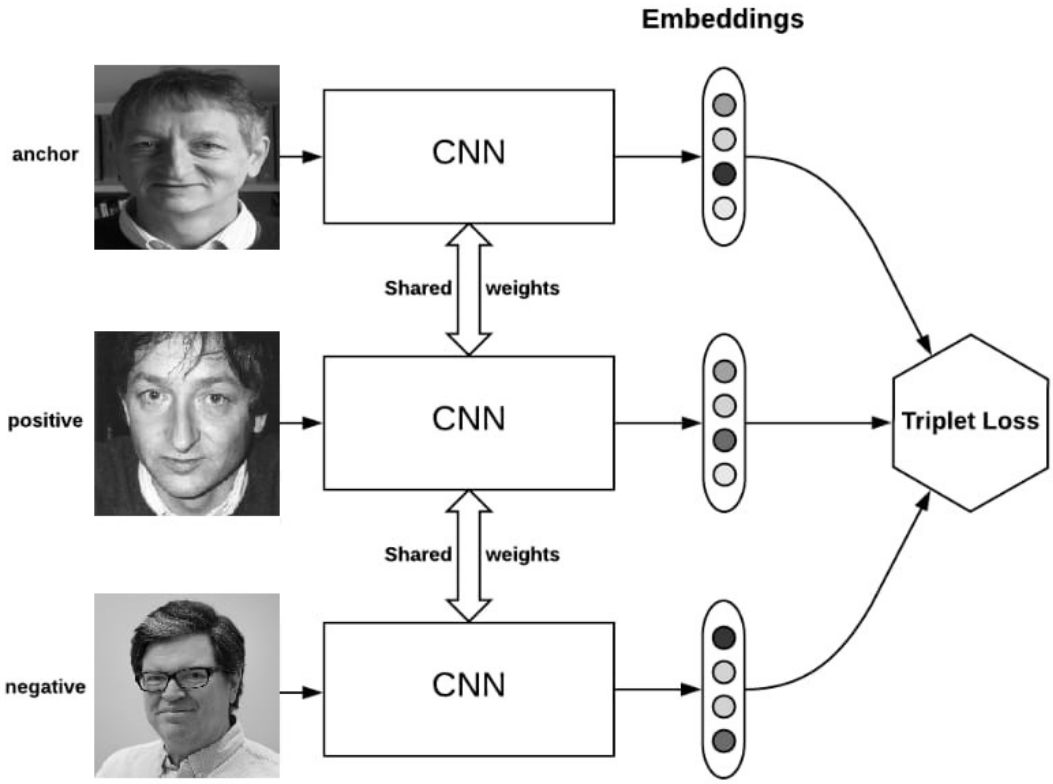
$$\mathbf{L(A, P, N) = max(0, ||f(A) - f(P)||^2 - ||f(A) - f(N)||^2 + \alpha)}$$

If ||f(A) - f(P)||^2 is small, the loss encourages ||f(A) - f(N)||^2 to be small as well, pushing the network to improve separation for easy triplets.

If α < ||f(A) - f(P)||^2 - ||f(A) - f(N)||^2, it's considered an easy triplet.

If α > ||f(A) - f(P)||^2 - ||f(A) - f(N)||^2, it's a hard triplet because it's difficult to satisfy the margin requirement.

Balancing the selection to include a mix of these triplet types is crucial for effective training in FaceNet. The choice of α determines what constitutes an easy or hard triplet, and you can experiment with different values to fine-tune the training process.



4.6 SVM (Support Vector Machine):

Support Vector Machine (SVM) for Face Recognition:

It is a supervised machine learning algorithm used classify these face embeddings into different categories, each corresponding to a specific student in the system.. It works by finding an optimal hyperplane that best separates data points into different classes.

4.6.1 SVM Training And Testing :

1. Training:-

The training data, which includes the face embeddings from FaceNet and their corresponding class labels (the known identities of the individuals), is used to train an SVM classifier.
The SVM's objective is to find the optimal decision boundary that separates these feature embeddings into their respective classes. It looks for a hyperplane that maximizes the margin between different classes while minimizing classification errors.
Support vectors, which are the feature embeddings closest to the decision boundary, play a key role in determining the position and orientation of the boundary.

2. Testing/Recognition Phase:

In the recognition phase, the goal is to identify the individuals in new, unseen images:
Face Detection and Feature Extraction:
The same face detection and feature extraction steps are performed using MTCNN and FaceNet on the new image containing faces to be recognized.

4.6.2 SVM Classification:

The obtained feature embeddings are then fed into the trained SVM for classification. The SVM calculates the similarity (or distance) between the input feature embedding and the decision boundary that was learned during training.
The SVM assigns the input feature embedding to the class (identity) corresponding to the side of the decision boundary it falls on.

Chapter 5

Results and Analysis

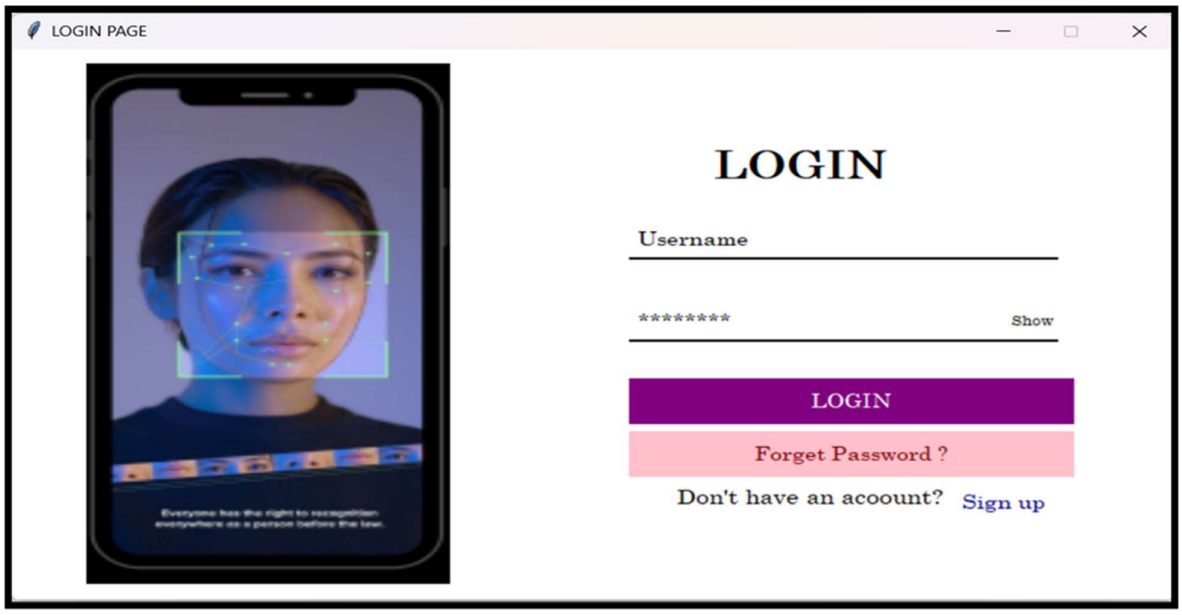


Fig 5.1: Login Page

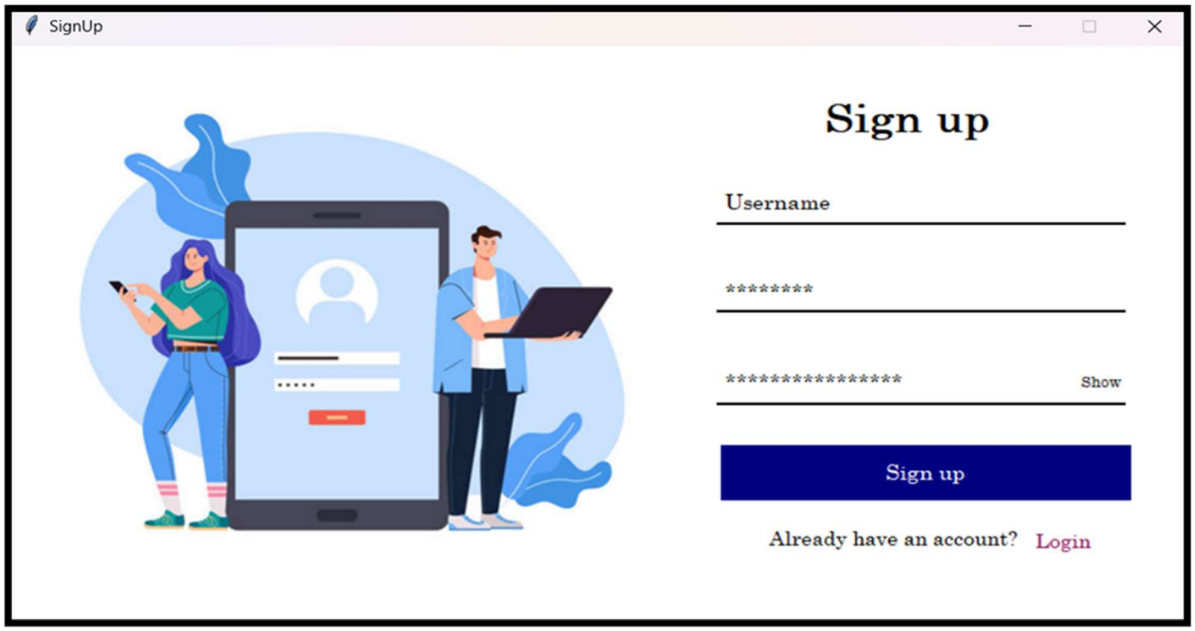


Fig 5.2: Signup Page

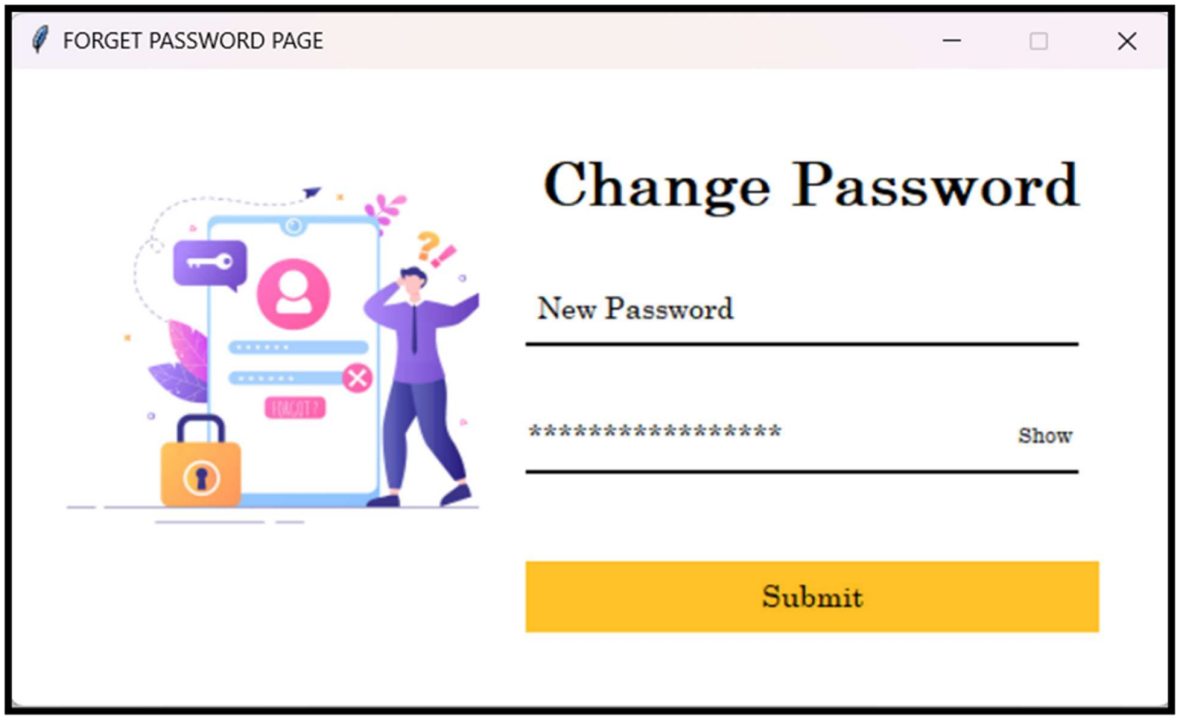


Fig 5.3: Forget Password Page

Fig 5.4: Homepage

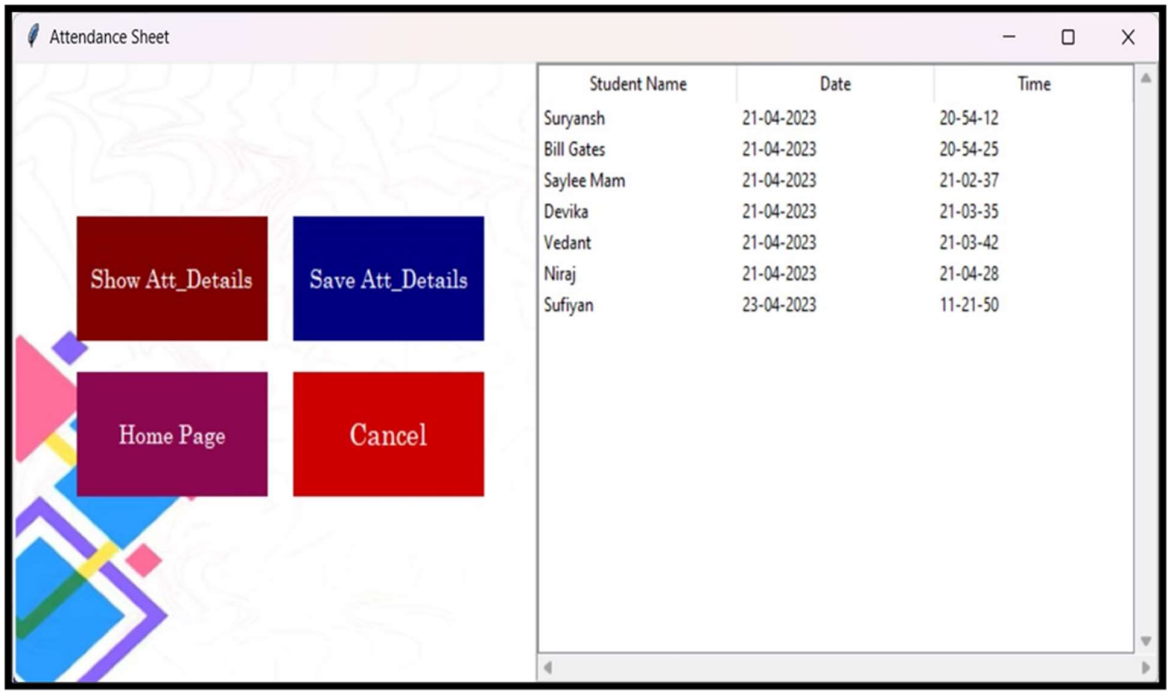


Fig 5.5: Attendance details

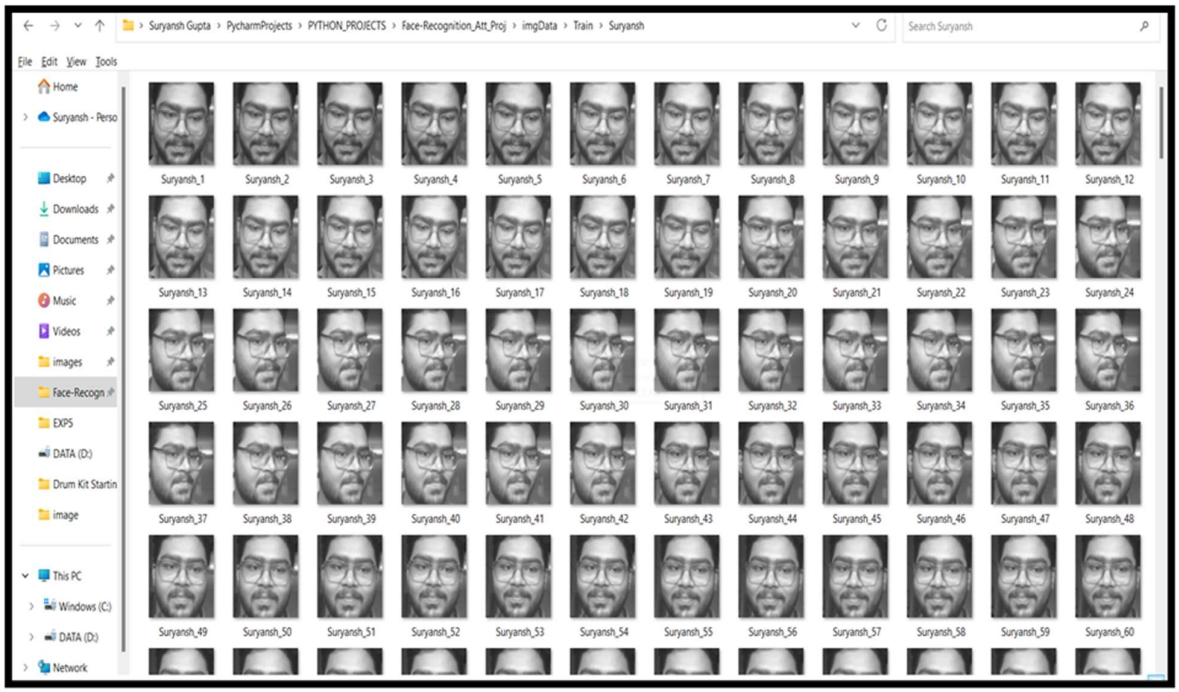


Fig 5.6: Dataset

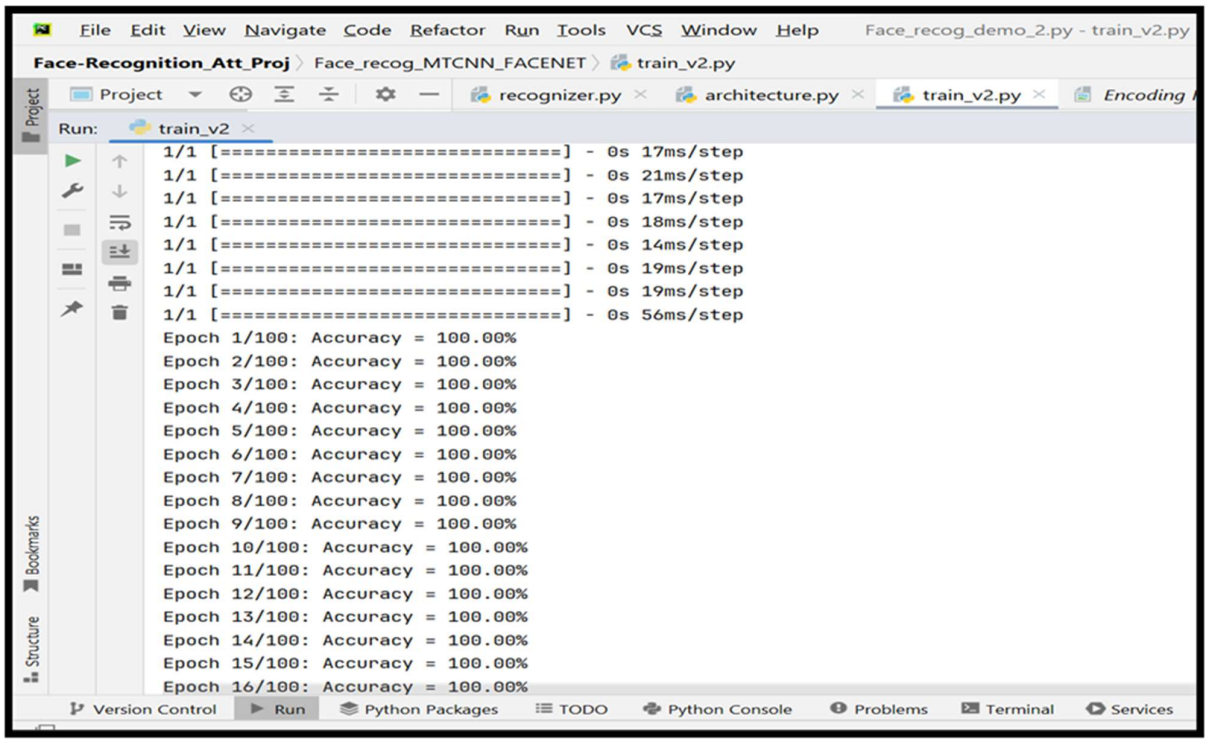


Fig 5.7: Training

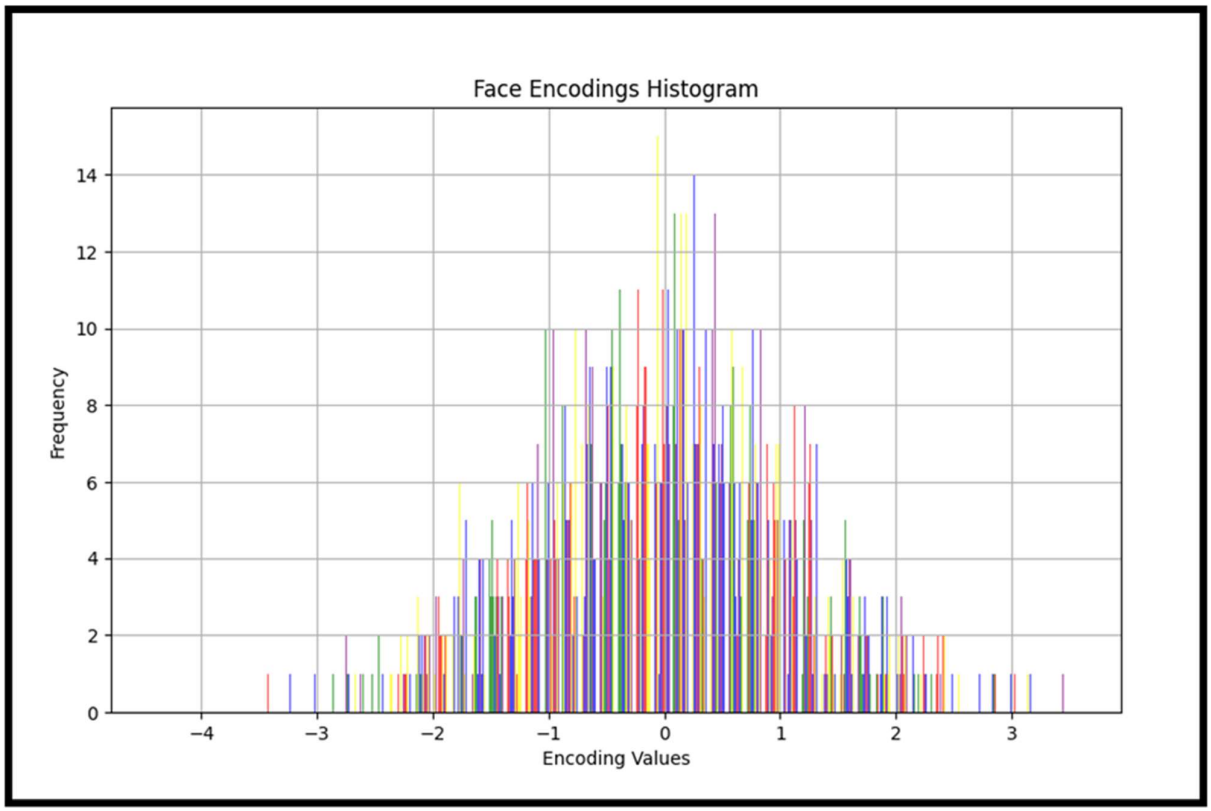


Fig 5.8: Encoding values

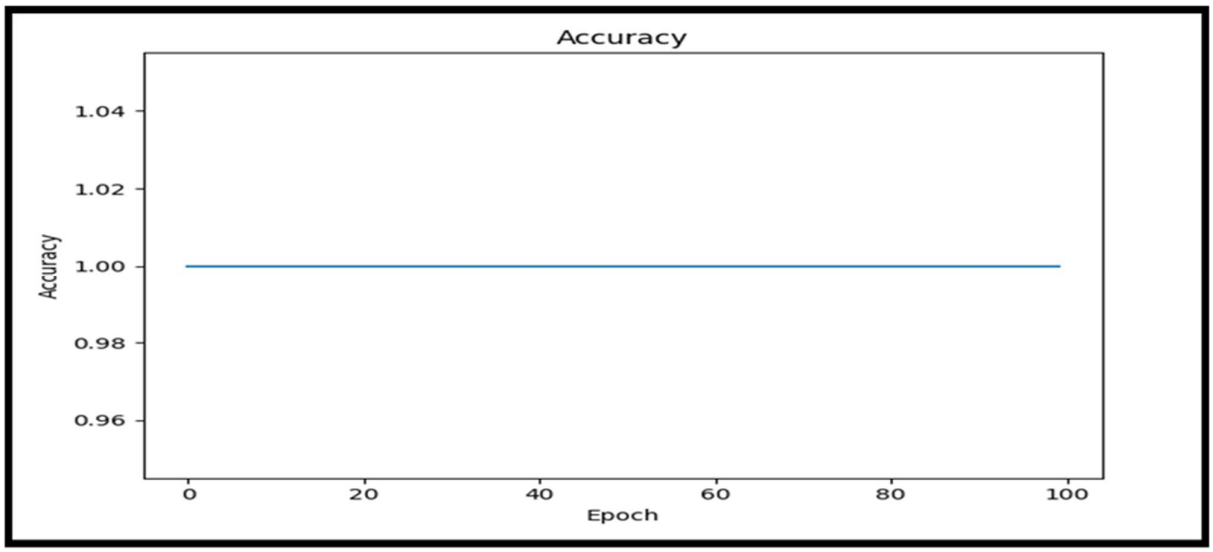


Fig 5.9: Training accuracy

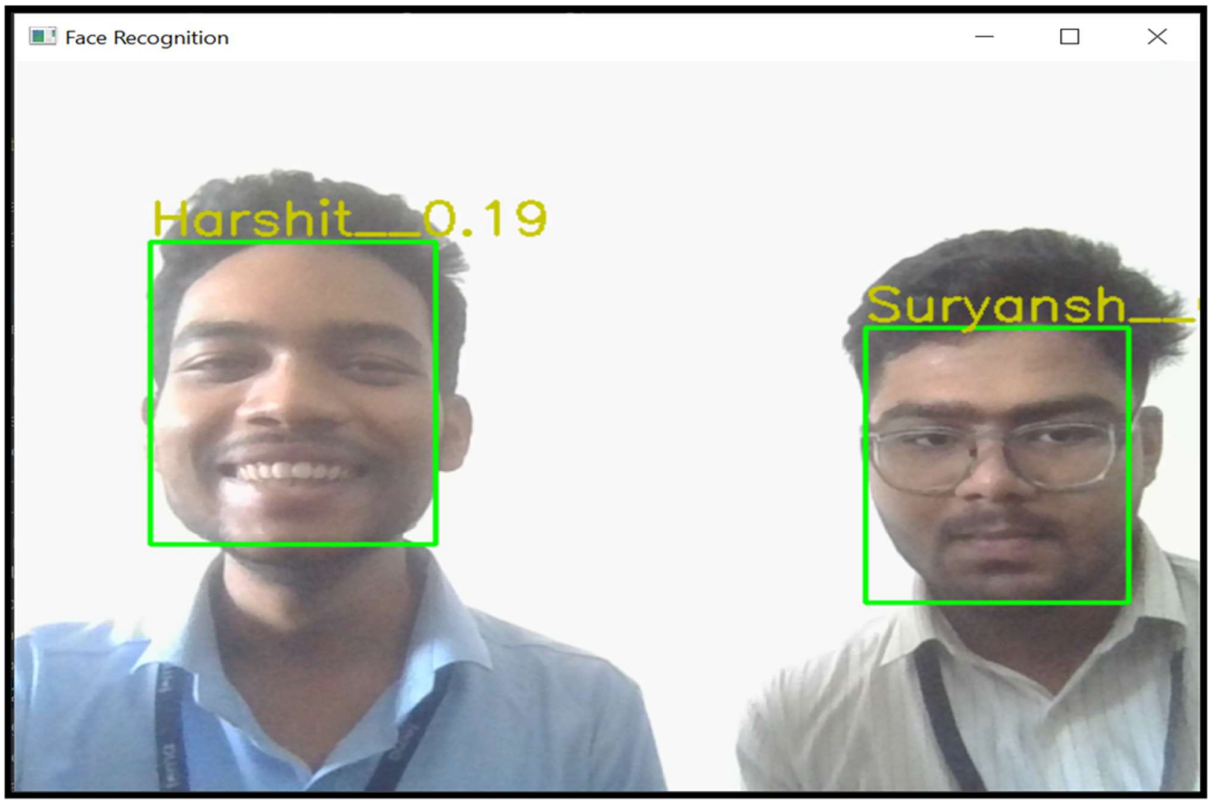


Fig 5.10: Face recognition

Chapter 6

Conclusion and Future Scope

6.1 Conclusion

The automated attendance system using face recognition and machine learning using MTCNN, FaceNet, along with OpenCV and firebase offers an accurate and efficient solution for attendance management, reducing manual work and errors. This system demonstrated the potential for significant improvements in attendance tracking and management, which will save us the time and efforts that were required in the traditional practices. This system harnesses machine learning technologies to streamline the attendance process, enhancing the efficiency and accuracy. This attendance system is not only useful for students, but also for the faculty members of school, colleges, etc. which will help them to keep the track of each student's attendance record.

6.2 Future Scope

• **Enhanced Security Features:** Implementing additional security measures, such as liveness detection, to prevent spoofing and unauthorized access.

• **Mobile Application Development:** Creating dedicated mobile apps for teachers and students to view attendance records, receive notifications, and manage attendance-related tasks.

• **Multi-modal Biometrics:** Exploring multi-modal biometric recognition, combining Facial recognition with other biometric measures like fingerprint or iris scans for enhanced accuracy and security.

References

1. Prof. Shweta S Bagali, Dr K Amuthabala, Prof. Iranna Amargol, “Smart Attendance System using Machine Learning”, International Journal of Engineering Research & Technology, Volume 10, Issue 12, ISSN: 2278-0181, 2022

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