Face Recognition Attendance System

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1 Abstract

The Face Recognition Attendance System (FRAS) offers an efficient solution to attendance management through AI-powered facial recognition. This project focuses on developing an automated system that accurately tracks attendance, eliminating the need for time-consuming manual processes like paper sheets or websites.
The methodology involves the instructor capturing an image of the students in class. The program then applies computer vision and machine learning techniques to detect faces and mark the identified students as present.
By replacing manual methods with this automated approach, FRAS improves efficiency and security, addressing the growing demand for reliable attendance systems across different sectors.
Furthermore, this research contributes to advancements in computer vision and identification systems, tackling challenges such as lighting variations, facial expressions, and facial distances.
In summary, FRAS represents a significant step forward in attendance tracking, providing practical advantages while contributing to AI-driven solutions for everyday challenges.

2 Introduction

In universities, taking attendance using Paper sheets or the website is time-consuming due to the number of students in one class. Usually, this takes the time of the lecture or the break time. So, to avoid this problem, we will develop The Face Recognition Attendance System (FRAS). This project will aim to manage the attendance of the students, by recognizing their faces without the need to use time-consuming manual processes. However, there are some challenges with this system such as facial expressions, students' expressions such as smiling, laughing, or talking will make the system fail to recognize the person. Secondly, facial distance, the system may not recognize students far in the corner or sitting behind another student. In addition, one of the major problems in this project is data. How are we going to collect data? And how much data should we need? This will be a big challenge for us that we will solve.

3 Problem Definition

The current attendance system in every educational facility is that the teacher calls the students everyone by their names and from what we see as students and from what we hear from our teachers this way needs to be improved because we want to use the whole lecture time to learn and get new information but taking the attendance takes a large amount of time and some time it's not that efficient, For example, if the class is 50 minutes and has 48 students the teacher will have to call for the 48 names this process will take the time that's dedicated to the lecture and maybe the students will not hear their names clearly or the teacher will not hear the response from the students this will lead to a mistake in the process of taking the attendants. That's why we wanted to use this problem and find a solution for it in our project and develop a FACE RECOGNITION ATTENDANCE SYSTEM.

4 Aims and Objective

4.1 Aims

- Improve the efficiency of taking the attendance of the students automate.
- To reduce the amount of time that the doctor takes for attendance.
- Provide the professor with time information of student attendance.
- Enhance the accuracy of attendance and reduce the errors.
- Discourage absenteeism by implementing the Face Recognition System for early detection.

4.2 Objectives

- Achieving high accuracy rate of to identify a student.
- Accommodating future increases in student enrollment.
- Provide training materials and documentation for administrators.
- Implement ethical AI practices in Face Recognition System development and usage, ensuring alignment with ethical standards.
- Integrate the Face Recognition Attendance System with existing databases.
- Develop a reliable system.
- Develop a friendly user interface for administrators and students.

5 Literature Review

In the past, attendance was a slow and boring task. Teachers would call out names, waiting for students to reply, while offices relied on timecards or sign-in sheets. These methods, though common, often had mistaken and wasted valuable time. As technology improved, people began to ask if attendance tracking could be faster, more accurate, and completely automatic. The idea of using facial recognition started to take shape—a system that could recognize people by their faces and mark them present without any extra work. What once seemed impossible quickly became a challenge for researchers who wanted to make it real [01][02][06].

At first, the systems were simple. Early methods used tools like Haar Cascade Classifiers, which looked at grayscale images to find faces. To recognize who the faces belonged to, they used Local Binary Patterns Histograms (LBPH). LBPH turned the textures of a face into numbers, which could be compared to find matches. These early systems worked well in controlled environments with good lighting and easy conditions. But when the settings became more complicated, with different lighting, angles, and backgrounds, these systems struggled to keep up [02][03][07].

A big step forward came with deep learning. Deep Convolutional Neural Networks (DCNNs) changed the way facial recognition worked. Models like FaceNet and DeepFace introduced new ways to identify faces by creating unique mathematical patterns, called embeddings. These embeddings acted like a fingerprint for each face, helping the system compare and match faces with great accuracy. FaceNet used a method called the triplet loss function, which grouped images of the same person close together while keeping images of different people far apart. Meanwhile, DeepFace, created by Facebook, used large amounts of data and advanced tools to achieve accuracy close to human levels. These improvements made it easier for systems to handle changes in lighting, facial expressions, and angles, making them much more useful in real life [05][08][11].

As technology improved, researchers began to solve new problems. In places with bad lighting or where faces were partly hidden, facial recognition alone didn't always work. To fix this, systems were developed to combine facial recognition with other methods, like voice or fingerprint scanning. These multimodal systems made recognition more secure and accurate, even in tough situations [09][12][15].

Another important improvement was the need for real-time recognition. Systems had to process faces instantly to work in busy places like classrooms or offices. Lightweight models like MTCNN (Multitask Cascaded Convolutional Networks) became popular because they could detect and align faces quickly and accurately. YOLO (You Only Look Once) was another tool that sped up face recognition by analyzing entire images at once. These innovations made real-time attendance systems possible, allowing them to track large groups efficiently [04][13][18].

One challenge that remained was the lack of data to train these systems. Researchers used image augmentation techniques to create more data by slightly changing existing images, such as rotating, scaling, or adding noise. This helped the systems learn better and work well in different situations [10][14][19].

As these systems became more advanced, keeping the data secure became a big concern. Attendance records and facial information were stored in safe databases like MySQL or SQLite. Web-based tools built with frameworks like Flask or CodeIgniter made sure only authorized users could access or change the data. These steps improved the reliability of the systems and addressed worries about privacy and safety [06][20][21].

Schools and universities were among the first to use these systems. Automating attendance tracking reduced the workload for teachers and made the process faster and more accurate. Sliding cameras were used to capture faces in large classrooms, and edge computing helped process data locally, reducing delays. These changes brought the idea of smart classrooms closer to reality [07][16][22].

Today, facial recognition attendance systems are changing the way attendance is taken. They save time, reduce mistakes, and provide an easy solution to an old problem. But there are still challenges, like privacy concerns, occasional errors, and the cost of setting up these systems. Researchers are working hard to solve these problems, making the systems faster, smarter, and more secure. From simple grayscale detection to advanced real-time recognition, the journey of facial recognition attendance systems shows how innovation can solve everyday problems. As technology continues to improve, these systems promise a future where attendance tracking is not just efficient but effortless [03][08][25].

6 Methodology

This section presents the approach used to develop and implement a face recognition-based attendance system for educational purposes. The system uses FaceNet for face feature (embedding) extraction, combined with a Support Vector Machine (SVM) classifier for matching embeddings with classes.[26] [27]

6.1 System Overview

The face recognition-based attendance system automatically identifies students from facial images and records their attendance. The system performs face detection, embedding extraction, and identity classification using a SVM model that we've trained. The approach is implemented in Python, using libraries such as OpenCV, Keras, and scikit-learn.

6.2 Data Collection and Preprocessing

The dataset used for this project includes face images of students (various angles), where each student's face image is labeled with their name and student ID in a file separated from the student images file. The images were preprocessed to ensure they were suitable for face detection and embedding extraction: Data Augmentation: To improve the model's ability to recognize, data augmentation was applied to the images during preprocessing. The following augmentation techniques were used:

- Rotation: Random rotations within a specified range to simulate real-world variations in orientation.
- Width and Height Shifts: Random horizontal and vertical translations to handle slight translations of faces.
- Zoom: Random zooming in or out to simulate different distances between the camera and the face.
- Flipping: Random horizontal flips for face orientations.
- Brightness Adjustment: Random changes to the image's brightness to simulate different lighting conditions.

Figure 1: MTCNN Cropped face

The augmentation was applied on the fly during training to avoid overfitting. The augmented dataset helped to improve the model's performance by making it more robust to changes in pose, face expressions, and positioning.

- Face Embeddings: After data augmentation, the FaceNet model was used to generate 128 dimensional embeddings for each detected face. These embeddings are unique numerical representations of the faces (eyes, nose, mouth, etc.), which are then used by the SVM model for classification.

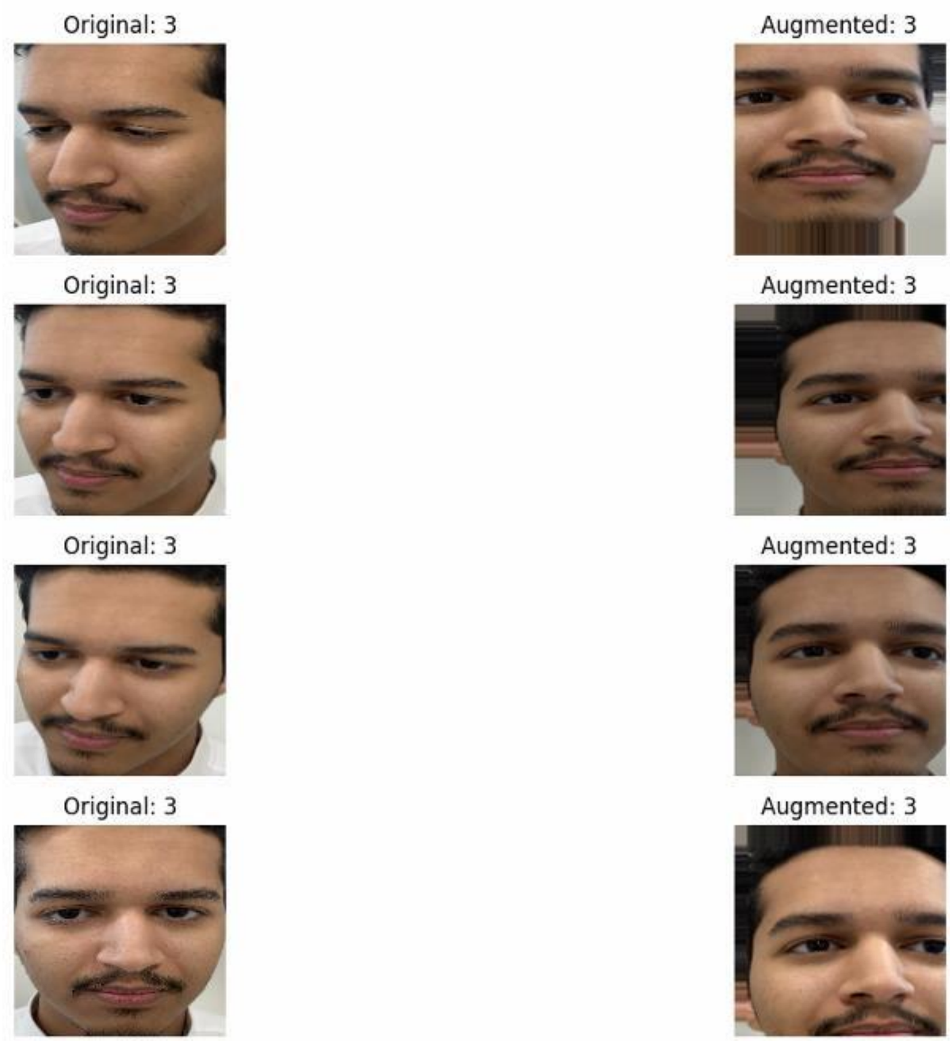

Figure 2: Data Augmentation

6.3 Model Design

The system uses a two-step approach for face recognition:

- FaceNet Embeddings Extraction: The FaceNet model is a deep convolutional network that maps images of faces into a 128-dimensional vector space. These vectors, called embeddings, encode the unique features of each face.

- Why FaceNet: FaceNet produces high-quality embeddings of faces. A key aspect of FaceNet's success lies in the use of triplet loss during its training phase. Instead of using traditional loss functions like softmax, which only classifies the face, FaceNet uses triplet loss to optimize the embeddings themselves.
  - Triplet Loss Explained: The triplet loss function is designed to minimize the distance between embeddings of same-person faces (Anchor & Positive) and maximize the distance between embeddings of different-person faces (Anchor & Negative). A triplet consists of three images:
    - Anchor: A face image of a person.
    - Positive: A different image of the same person.
    - Negative: An image of a different person.
- SVM Classification: The Support Vector Machine (SVM) is used to classify the embeddings into distinct identity labels. The SVM was trained using the embeddings of known students, where each label corresponds to a student's identity.

6.4 System Implementation

1. Detection: Face detection is performed using MTCNN (Multi-task Cascaded Convolutional Networks). MTCNN is employed to identify faces in input images, and the bounding boxes around detected faces are used to crop out individual faces. [03]

2. Face Cropping: The faces detected by MTCNN are cropped and resized to the required dimensions (160x160 pixels) for embedding extraction.

3. Features (Embeddings) Extraction: FaceNet is used to extract 128-dimensional embeddings for each cropped face. These embeddings are the primary input for the SVM model.

4. Identity Recognition: After the embeddings are generated, they are fed into the SVM model, which predicts the identity of the person based on the trained embeddings.

7 Result and Finding

The Face Recognition Attendance System (FRAS), with the help of FaceNet, shows excellent improvement in accuracy and efficiency for attendance management. FaceNet's advanced approach allows FRAS to achieve high overall accuracy rates of 99%. Also, we tested the Recall, F1-score and precision for each class and for the model and received excellent results in all of them.

FRAS will perform well under different challenges like diverse facial expressions, and partial occlusions. In the testing part, we found that FaceNet's results are better than previous models, by showing less false positives and negatives in face-matching. Also, the system's scalability was validated by successfully handling a large dataset of student's faces without damaging the performance. This high accuracy and performance make FRAS a reliable solution for real-world attendance tracking needs by minimizing the errors and saving the time of the class for the learning process.

	precision	recall	f1-score
Faisal	0.83	1.00	0.91
Raheem	1.00	1.00	1.00
Abdulaziz	1.00	1.00	1.00
Saad	1.00	1.00	1.00
Khaled	1.00	1.00	1.00
Jawad	1.00	0.90	0.95

Figure 3: Each Class Results

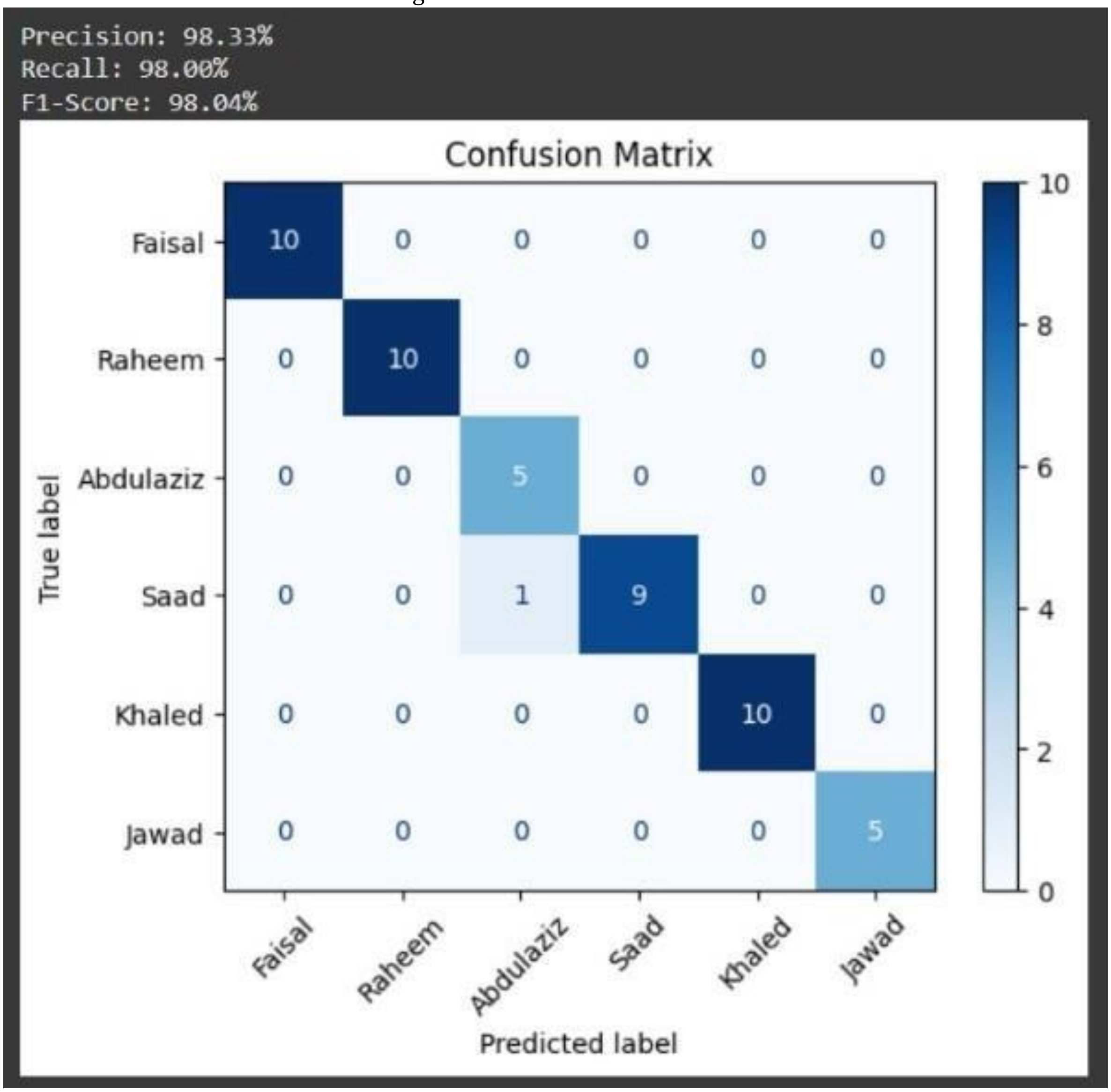

Figure 4: Confusion Matrix

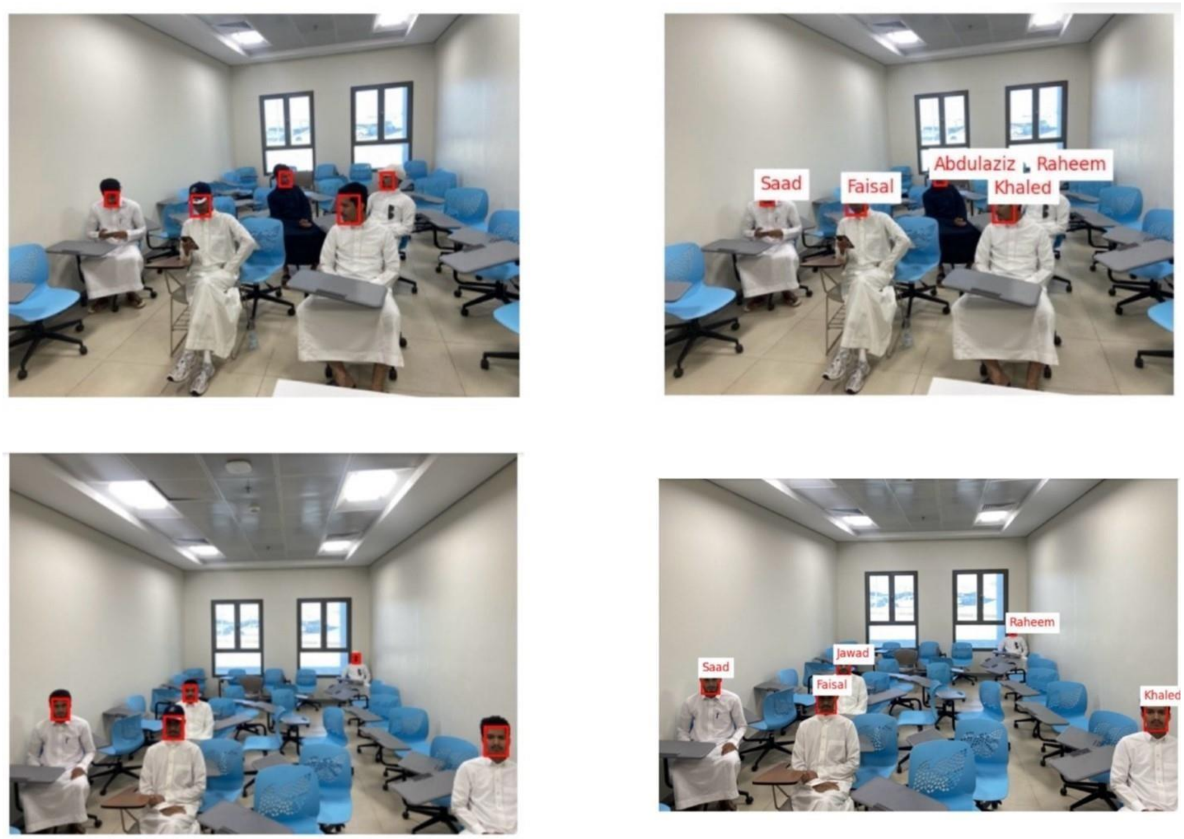

Figure 5: Test Images and Results methods.

8 Conclusion

The Face Recognition Attendance System (FRAS) represents a significant advancement in the way educational institutions manage student attendance. By using facial recognition technology, FRAS provides a more robust, efficient, and secure solution compared to traditional manual attendance

This system not only saves valuable class time but also improves the accuracy and reliability of attendance records, reducing human error and the inefficiencies associated with manual processes. What sets FRAS apart is its ability to provide real-time access to attendance data, enabling seamless communication between students, teachers, and administrators. With features like automatic attendance recording and data reports, FRAS empowers students to actively manage their attendance.

One of the key goals of this project was to design a simple, user-friendly interface that minimizes complexity, allowing users to interact with the system easily and without confusion. FRAS is also built with scalability in mind, ensuring that it can handle future increases in student enrollments, expanding classrooms, and evolving institutional needs. This makes it a long-term solution for educational institutions of all sizes.

In conclusion, the Face Recognition Attendance System (FRAS) is set to update how attendance is managed in universities and other educational settings. By combining new technology with a focus on user accessibility, efficiency, and ethical standards. This project is great example to the power of modern technology for solving real-world problems, offering a practical and smart solution that contributes to a more effective, and engaging educational experience.

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