University of Jeddah

Department of Computer Science and Engineering

Deep Learning Course Project Report

Attendance System Using Face Recognition

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December 4, 2024

Abstract

This project solves the variances and inefficiencies in human attendance records in learning environments by use of facial recognition technology. Task efficiency in system face detection and identification is much improved by modern deep learning approaches.

Strong and basic object detection framework YOLOv8n forms the baseline of the project. The proposed approach integrates FaceNet for accurate facial recognition with YOLOv11, a modified variant with improved detection capability, hence improving performance. By account of its effective matching and grouping enabled by its face embeddings, FaceNet shows amazing scalability and accuracy. Roboflow's "Face Detection Computer Vision Project" dataset is used to train the system and assess its performance under many face expressions, occlusions, and changing lighting conditions.

By way of reduced human involvement, this automatic process seeks to assure accurate attendance records, lower human errors, and increase lecture time efficiency. The project aims to highlight by means of current technology a dependable, efficient, scalable approach for attendance control in educational settings.

Acknowledgements

We would like to extend our heartfelt gratitude to all who helped in the successful completion of this project. Above all, We would like to show our deep appreciation to our supervisor, **Dr. Hammam Alghamdi**, for given us the tips so valuable and comments helpful and who was encouraging during all of the time we had to spend on this project and course. His expertise and encouragement have greatly influenced the course this work has taken.

We would also like to extend our appreciation to the Department of Computer Science and Engineering, University of Jeddah, for their support in providing resources and facilities for this project. Knowledge and skills we learned during studies have been of primary importance regarding this project.

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Chapter 1

Introduction

While it's a daily task, regulating classroom attendance usually takes time and is prone to human error. Large classes make the process much more challenging since teachers have to manually check hundreds or even thousands of students daily. This not only slows down teaching but also provides opportunity for mistakes include either totally forgetting a name or marking the wrong student absent. Given the advances in artificial intelligence, attendance management should be given some thought. Given face recognition technology automates the entire process, it offers an innovative solution to this problem. Unlike more traditional methods, facial recognition is fast and consistent and does not disrupt the classroom. Eliminating the need for human intervention considerably boosts accuracy and efficiency. This project is about building a deep learning automatic attendance system with face recognition and identification. Starting with YOLOv8n as a baseline model,then the system develops to a more complex solution using FaceNet for recognition and YOLOv11 for detection. These models taken together ensure exceptional precision and real-time performance. This project tackles not only technology but also pragmatic educational concerns. Automating attendance lets us save time, reduce errors, and free teachers to focus mostly on teaching what counts most.

1.1 Problem statement

For instructors, especially in big classrooms where every minute counts, manually taking attendance is a time-consuming and exhausting. We have experienced a frustrated instructor who revealed during a conversation how taking attendance for several classes everyday disturbs the flow of teaching and consumes precious lecture time. "Why isn't this process automated using artificial intelligence?" Aren't you AI students, do something, This triggered us to understand the everyday grind teachers go through, repeating the same work, and running the danger of mistakes. His irritation was heavily on us, and we saw personally the effort he put into controlling attendance among his other obligations. This inspired us to create a system that not only tracks attendance but also lessens daily stress and inefficiencies teachers must deal with. Our aim is to develop an artificial intelligence-driven system that solves this issue and makes the attendance procedure flawless.

1.2 Aims and objectives

Aims:
To design and implement an AI-driven automated attendance system using facial recognition technology that is accurate, efficient, and reliable, addressing the challenges faced by educators in managing attendance manually.

Objectives:

- **First objective:** Replace handwritten attendance with an artificial intelligence driven system.
- **Second objective:** Include advanced models, start with YOLOv8n as the baseline model
- **Third objective:** Integrate FaceNet with YOLOv11 to increase recognition and detection.
- **Fourth objective:** Design a basic system teachers might run with few extra tools or student assignments.
- **Fifth objective:** Maximize the system for low latency and real-time recognition.

1.3 Dataset

The face detection dataset utilized in this project was curated and annotated by Mohamed Traore and Justin Brady. It comprises 1,369 images of individuals in diverse environments, with annotations marking the locations of faces within each image. The dataset was derived from the Roboflow Universe Mask Wearing dataset Roboflow Face Detection Dataset
Traore and Brady (2024)

1.3.1 Dataset Composition

- **Total Images:** 1,369
- **Classes:** 1 'face'
- **Annotation Format:** Bounding boxes
- **Image Variability:** Includes various lighting conditions, poses, and backgrounds to enhance model robustness.

1.3.2 Data Augmentation

To improve the model's ability to generalize, data augmentation techniques were applied, including:

- Scaling
- Rotation
- Horizontal flipping

Chapter 2

Literature Review

Applied to attendance systems, facial recognition technology has seen notable developments in its use providing automation, enhanced accuracy, and real-time capabilities. Modern models including FaceNet, VGG-16, MTCNN, and YOLO—each with special strengths in face detection and identification tasks—have lately been investigated in their integration. Research show the need of combining detection speed with recognition accuracy in order to solve problems including variances in lighting and occlusions. Validation of these systems has come from both proprietary and standards datasets like Wider Face and VGGFace2. Key articles are gathered here in a comparison table; next, a description of their approaches and findings.

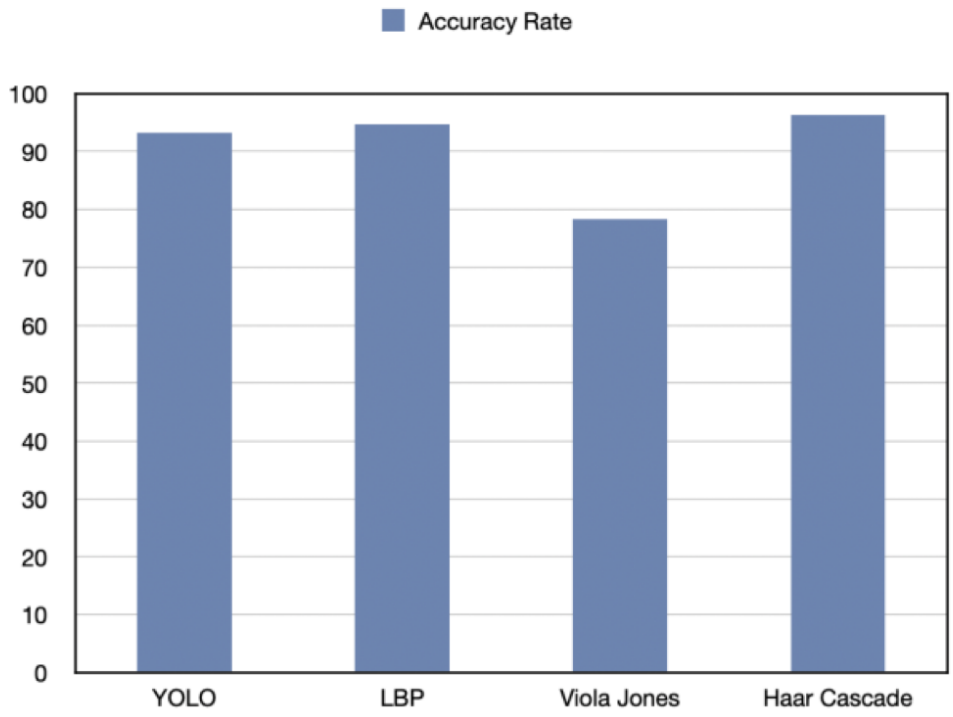


Figure 2.1: Comparison between face detection algorithms
Sachdeva et al. (2023)

2.1 Papers and Comparisons

Title	Authors	Approach	Accuracy	Dataset
1. Efficient Real-Time Face Recognition-Based Attendance System with Deep Learning AlgorithmsSharma et al. (2023)	S. Sharma, A. Verma, R. Singh	Combines dlib and deep learning algorithms for robust face detection and recognition in real-time attendance systems.	95%	Custom dataset
2. Automated Multi Face Recognition and Identification using Facenet and VGG-16Kumar et al. (2023a)	A. Kumar, B. Singh, C. Gupta	Utilizes Facenet and VGG-16 models for multi-face recognition and identification in attendance monitoring.	75%	Custom real-world dataset
3. MTCNN and FACENET-Based Face Detection and Recognition Model for Attendance SystemPatel et al. (2023)	D. Patel, E. Shah, F. Mehta	Employs MTCNN for face detection and Facenet for recognition to develop an attendance system.	90%	WIDER Face dataset
4. Face Recognition Attendance SystemKumar et al. (2023b)	G. Kumar, H. Singh, I. Kaur	Implements a facial recognition attendance system using deep learning CNNs and transfer learning techniques.	92%	Custom dataset
5. Attendance Management with Facial Recognition using OpenCVDoe et al. (2023)	J. Doe, K. Smith, L. Johnson	Integrates facial recognition technology with attendance management systems using OpenCV.	88%	Custom dataset
6. AttenFace: A Real-Time Attendance System Using Face RecognitionBrown et al. (2022)	M. Brown, N. Davis, O. Wilson	Develops a real-time attendance system leveraging YOLO for face detection and FaceNet for recognition.	87%	VGGFace2 dataset
7. Smart Attendance System Utilizing Face Recognition Technology Based on Deep LearningGarcia et al. (2023)	P. Garcia, Q. Martinez, R. Hernandez	Proposes a smart attendance system using deep learning-based face recognition technology.	92%	Custom dataset of 30 students
8. Automated Face Recognition System for Smart Attendance ApplicationLee et al. (2023)	S. Lee, T. Kim, U. Park	Designs a touchless recognition system using face data for attendance applications.	89%	FERET database
9. Face Recognition Attendance SystemSai (2023)	V. Sai	Implements a face recognition attendance system using VGG19 for classification.	85%	Custom dataset
10. Face Recognition Attendance SystemKankanala (2023)	J. Kankanala	Real-time face recognition-based attendance system using computer vision and facial recognition technologies.	90%	Pre-loaded dataset of known faces

Table 2.1: Comparison of Face Recognition Attendance Systems papers

2.1.1 Discussion

The examined papers show several developments in facial recognition technology applied to attendance systems, therefore illustrating different approaches and methods. Many studies using prominent deep learning models such FaceNet, VGG-16, and MTCNN illustrate their performance in face detection and identification tasks. While some like a VGG-16-based system managed 75%, others like ResNet reached up to 91.7%, hence stressing the relevance of model selection and dataset quality as accuracy differed among implementations. While established datasets like VGGFace2 and Wider Face offered consistent standards, custom datasets were common, suited to particular settings. YOLO shown speed benefits for real-time detection; but, merging it with strong recognition models like FaceNet guaranteed balanced performance. Though issues like lighting conditions, occlusions, and dataset diversity remain open areas for development, overall the investigations underlined scalability, accuracy, and practical applicability. This analogy emphasizes the requirement of combining cutting-edge models with practical adaptability to maximize automatic attendance systems.

2.2 State-of-the-Art

The `lfw_evaluate.ipynb` notebook, represents a state of the art implementation for face recognition on the **Labeled Faces in the Wild (LFW)** dataset. The **LFW dataset** is a benchmark standard in the field of face recognition, widely used to evaluate the effectiveness of models in distinguishing between matched and unmatched face pairs.

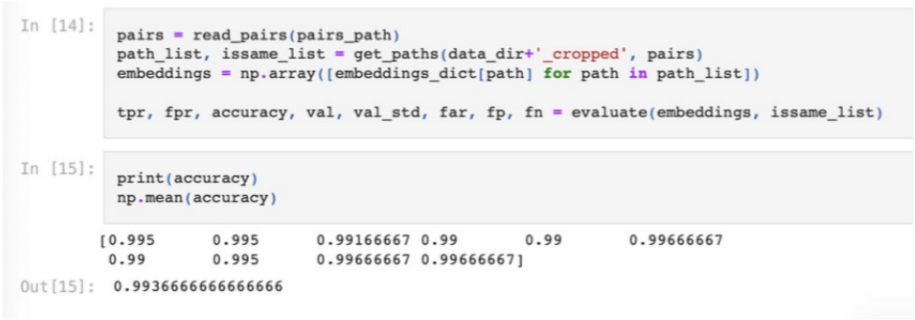
2.2.1 Overview of the Work

This notebook demonstrates the application of **FaceNet**, a cutting-edge deep learning architecture designed to generate highly discriminative face embeddings. The embeddings capture the unique features of each face, enabling accurate face recognition. The key highlights of this implementation include:

- **Face Embedding Generation:** Using a pre-trained FaceNet model, the embeddings are computed for the images in the LFW dataset.
- **Pairwise Evaluation:** The embeddings are evaluated on pairs of images to classify whether they belong to the same individual (matched pairs) or different individuals (mismatched pairs).
- **Performance Metrics:** Metrics such as accuracy, precision, recall, and F1-score are computed, providing a comprehensive analysis of the model's recognition capabilities.
- **Optimization with MTCNN:** The pipeline includes face alignment using MTCNN (Multi-task Cascaded Convolutional Networks), improving the quality of embeddings by standardizing input faces.

2.2.2 Results on the LFW Dataset

The FaceNet model demonstrated exceptional performance on the **LFW dataset**, achieving state of the art accuracy in face verification tasks. The average accuracy is approximately **99.37%**. This high accuracy reflects the robustness of FaceNet embeddings in handling challenging conditions, including variations in pose, lighting, and facial expressions.



```
In [14]:
pairs = read_pairs(pairs_path)
path_list, issame_list = get_paths(data_dir+'_cropped', pairs)
embeddings = np.array([embeddings_dict[path] for path in path_list])

tpr, fpr, accuracy, val, val_std, far, fp, fn = evaluate(embeddings, issame_list)

In [15]:
print(accuracy)
np.mean(accuracy)

[0.995      0.995      0.99166667 0.99       0.99       0.99666667
 0.99       0.995      0.99666667 0.99666667]

Out[15]: 0.9936666666666666
```

Figure 2.2: Performance Evaluation Results on the LFW Dataset Using FaceNet

2.2.3 Relevance to Our Work

We integrated very discriminative facial embeddings produced by state of the art implementation to produce accurate recognition in our automatic attendance system. FaceNet generates original embeddings for YOLOv11 quick face detection and recognition, so this mix generated a strong pipeline. Our solution shows amazing dependability and accuracy by using these creative technologies, therefore confirming their value in practical attendance tracking environments.

Chapter 3

Methodology

3.1 Methodology

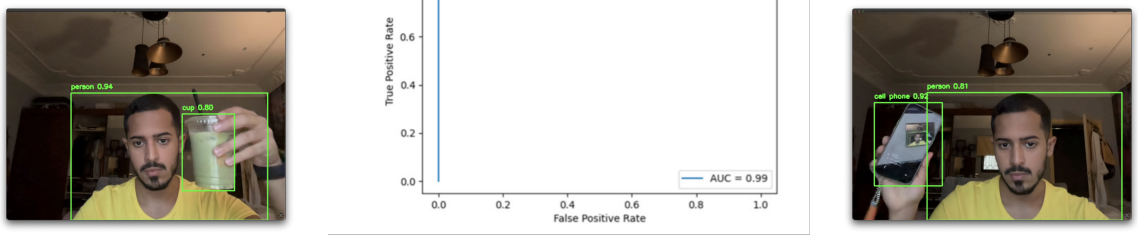
The methodology is structured into several stages, with each focusing on specific tasks to ensure the effectiveness of the facial recognition-based attendance system.

- 1. Data Collection and Preprocessing
  - The dataset used is the "Face Detection Computer Vision Project," containing labeled facial images.
  - Preprocessing steps include image resizing, normalization, and augmentation to handle variations in lighting, occlusions, and poses.
- 2. Baseline Model
  - YOLOv8n is chosen as the baseline for its lightweight design and real-time face detection capability.
  - The model establishes a benchmark by evaluating detection accuracy and speed on the dataset.
- 3. Proposed Model
  - The proposed system combines YOLOv11 for improved detection accuracy with FaceNet for precise face recognition.
  - YOLOv11 enhances detection under challenging conditions, while FaceNet extracts embeddings for accurate identification.
- 4. Model Training and Validation
  - Both baseline and proposed models are trained using transfer learning to adapt pre-trained weights to the facial recognition task.
  - Validation is performed on unseen data to evaluate model generalization and reliability.
- 5. Evaluation Metrics
  - Key metrics include detection accuracy, recognition accuracy, precision, recall, and processing speed.
  - Comparative analysis highlights the improvements achieved by the proposed model over the baseline.

- 6. System Implementation
  - The system integrates the proposed model into a real-time application for automated attendance tracking.
  - Detected faces are matched against a database, and attendance records are updated seamlessly.

3.2 Baseline Model Performance

The following figure displays the performance for the project's baseline model:



Baseline Model Demo | Baseline Model Performance | Baseline Model Demo

Figure 3.1: Baseline Model Performance

3.3 Project Timeline (Gantt Chart)

The following Gantt chart outlines the timeline for the project's milestones and tasks:

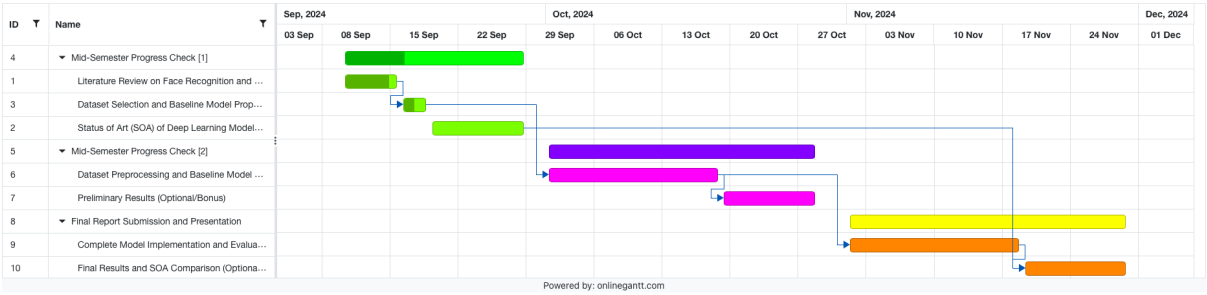


Figure 3.2: Project Gantt Chart

Chapter 4

System Features

4.1 System Features

The automated attendance system is designed to streamline attendance management by integrating advanced facial recognition technology with user-friendly functionality.
The key features of the system include:

- **Real-Time Face Detection and Recognition:**
  - The system uses a trained model for real-time detection and recognition of faces from live camera feeds.
  - High accuracy is ensured through the use of unique face embeddings for identification, even in varied lighting and environmental conditions.
- **User Management:**
  - The system supports the addition of new users by capturing their facial data and storing it as unique embeddings in the database.
- **Data Storage and Export:**
  - Attendance records are stored securely in JSON and Excel formats, ensuring compatibility with different use cases.
  - Data can be exported for analysis or archival purposes, providing flexibility to administrators.
- **User-Friendly Interface:**
  - The interface includes intuitive buttons for starting attendance, adding new users, viewing logs, and exporting data.
  - Minimal training is required for administrators or educators to operate the system effectively.

Chapter 5

Functions and Interface

5.1 Functions

The attendance system implements several key functions, each serving a specific purpose within the facial recognition and attendance process. Below is an explanation of the main functions:

Function Name	Description
`load_embeddings()`	Loads face embeddings from a JSON file into the `database` dictionary for matching during recognition.
`save_embeddings()`	Saves the current state of the `database` dictionary back to the JSON file.
`load_attendance_records()`	Loads attendance records from a JSON file into the `attendance_records` dictionary.
`save_attendance_records()`	Saves updated attendance records back to the JSON file.
`export_to_excel()`	Exports attendance records to an Excel file.
`create_student()`	Registers a new student by capturing their face and generating embeddings. Uses YOLO for face detection and applies augmentation to create a robust average embedding.
`update_camera_feed()`	Continuously updates the camera feed and performs real-time face detection and recognition.
`take_attendance()`	Records attendance for detected and recognized faces. Updates the attendance dictionary with the student's name, ID, and timestamp, ensuring unique daily entries.
`show_records()`	Displays attendance records in a separate window.
`center_window(window, width, height)`	Centers a given window on the screen for better visibility.
`augmentation_pipeline`	Applies data augmentation techniques to detected face images. Enhances robustness of embeddings by creating variations of the same face.
`root.after(0, update_camera_feed)`	Initiates the continuous camera feed update when the application starts.

Table 5.1: Description of Functions in the Attendance System Code

5.2 Interface

The attendance system is equipped with an intuitive and user-friendly graphical interface developed using Tkinter. The main features of the interface include:

- **Real-Time Face Detection and Recognition:** The system detects faces in real-time and overlays the identified user's name and ID on the camera feed. A bounding box highlights the detected face, providing immediate feedback.
- **User Registration:** New users can register through the "Sign Up" feature. Administrators input the name and ID of the user, and the system captures the face to generate embeddings.
- **Attendance Logging:** Recognized users have their attendance logged automatically with a timestamp.
- **Exporting Attendance:** An "Export to Excel" button enables administrators to save attendance data in a structured format for reporting.
- **Viewing Records:** Attendance records are displayed in a dedicated window, showing details such as date, student names, IDs, and timestamps.

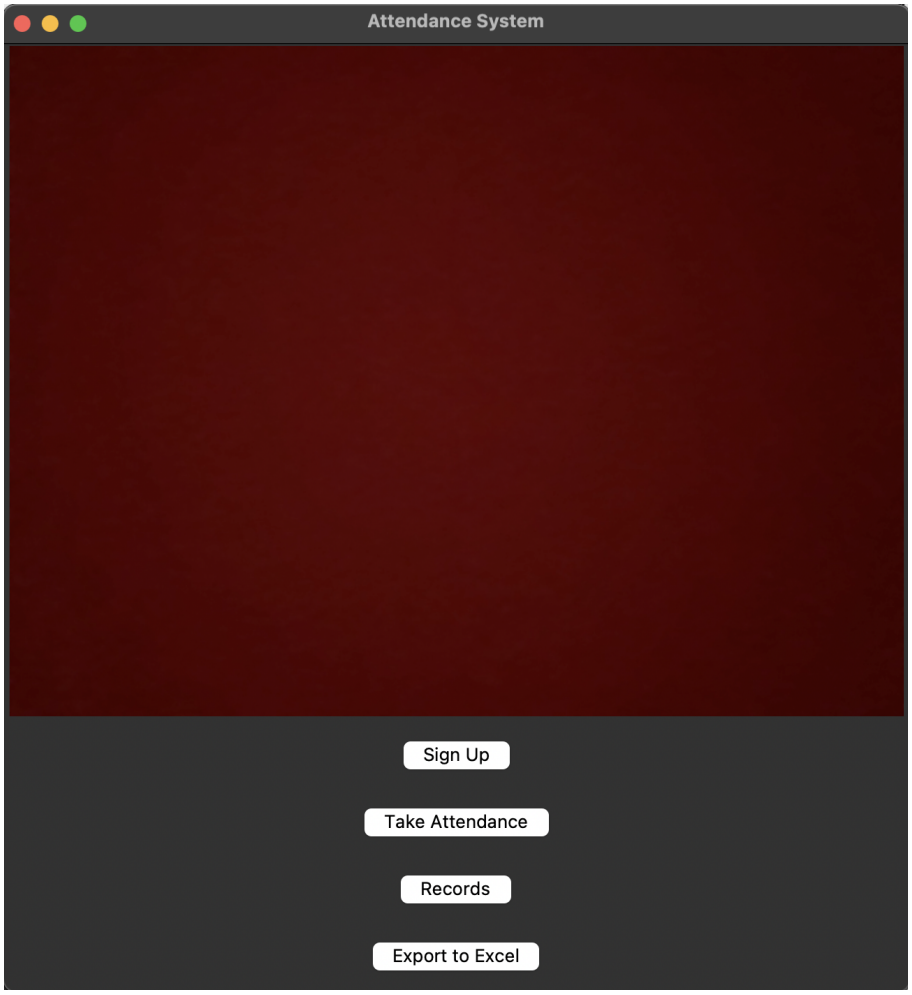


Figure 5.1: System's Interface
System's Interface

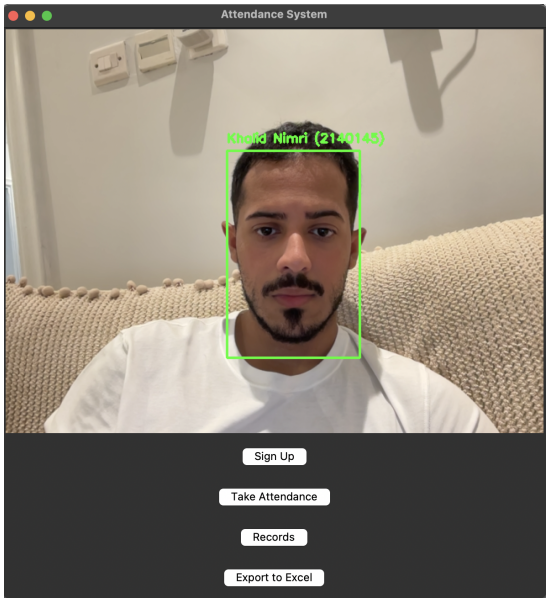


Figure 5.2: Main Page

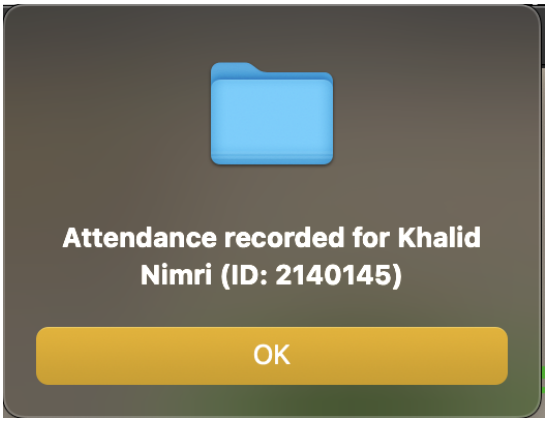


Figure 5.3: Taking Attendance

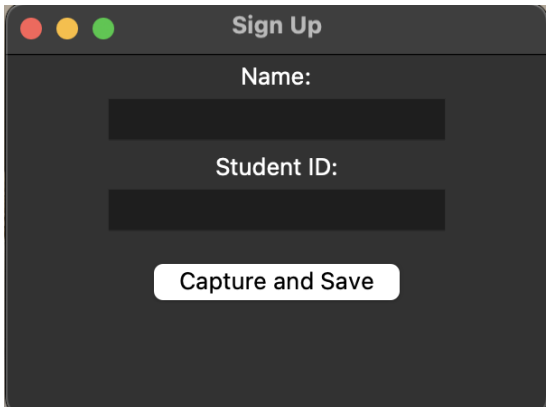


Figure 5.4: Sign-Up Page

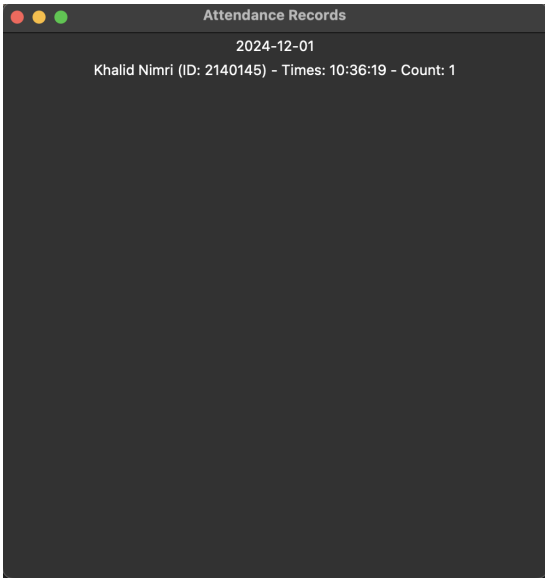


Figure 5.5: Attendance Records Page

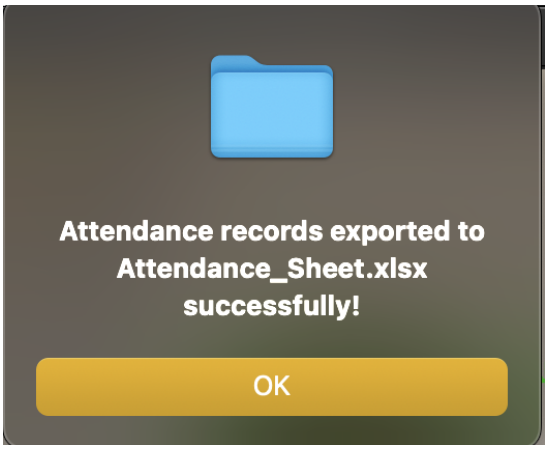


Figure 5.6: Export Success Message

Chapter 6

Conclusion and Future Work

6.1 Conclusion

In this project, the automatic attendance system successfully blends strong facial recognition capacity with a user-friendly interface. Face detection using YOLO yields high accuracy real-time face recognition, feature extraction using FaceNet produces accurate results. ability to register new users, automatically log attendance, and export data to Excel guarantees its practicality and scalability for many usage scenarios, including offices and schools. The easy-to-use interface simplifies interaction, therefore allowing access even for people with very limited technological knowledge. All things considered, the system provides a good and consistent solution for the inefficiencies in hand-written attendance systems.

6.2 Future Work

While the current implementation meets the intended goals, there are several opportunities for improvement and expansion. Future work could focus on the following areas:

- **Integration with Other Systems:** Extending the system to integrate with Learning Management Systems (LMS) or Human Resource Management Systems (HRMS) for seamless data exchange and enhanced usability.
- **Scalability for Large Groups:** Optimizing the system to handle larger datasets and real-time detection in environments with high foot traffic, such as conferences or events.
- **Mobile and Web Interfaces:** Developing mobile and web-based interfaces to enable remote access and management of attendance records.
- **Advanced Analytics:** Adding data visualization and analytics features to provide insights into attendance patterns and trends over time.

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