Intelligent Consumer Technologies

Incremental Face Recognition System

Anass nassiri
908475

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Project Overview

The objective of the project is to make an Incremental Face Recognition System.

The scenario I work on is :

- the system will authorized student to enter the exam classroom or not ,
- if not and for example the professor want to add them, he can by capturing their picture and entering the name of student

Dataset Description

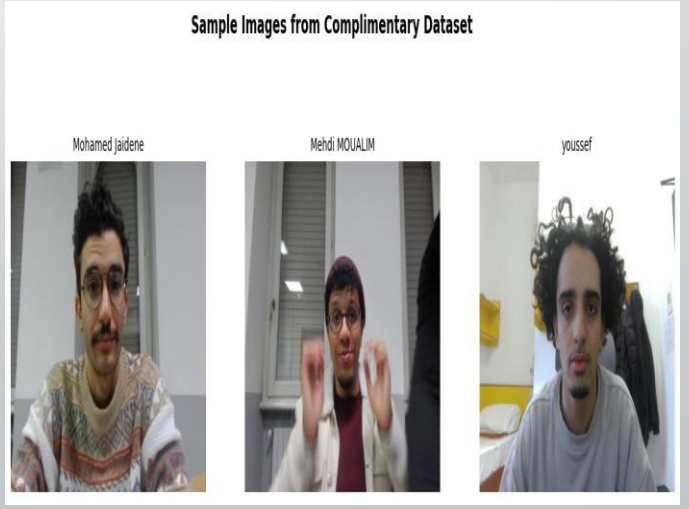
LFW Dataset (Labeled Faces in the Wild)

- 13,000+ images, 5,749 individuals
- Unconstrained real-world conditions (varied lighting, angles)
- Used widely for face recognition & verification

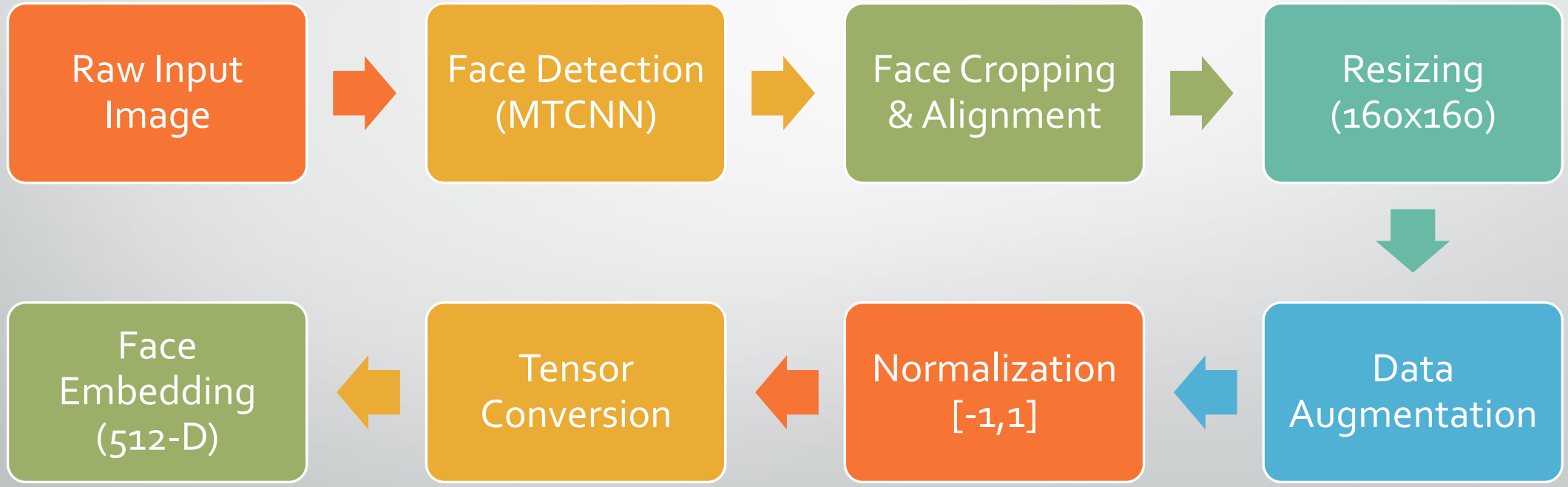
Complementary Student Dataset

I collected images of some friend and colleges of mine

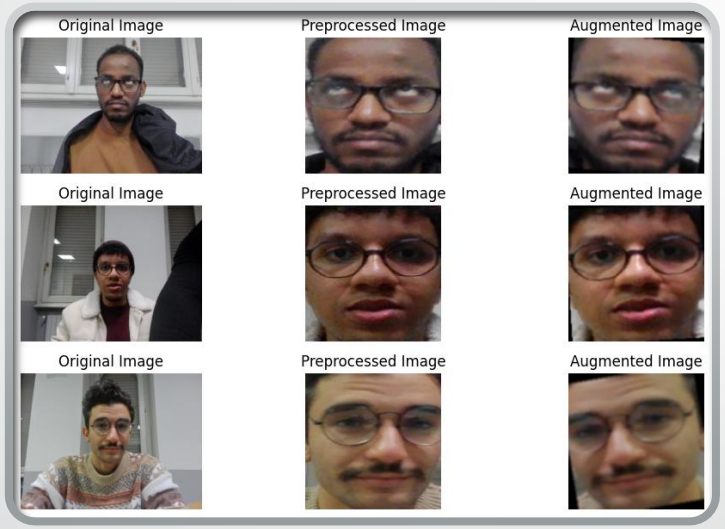
- Collected images in a clear setting
- Captured using the same webcam setup
- Supports **incremental learning** by adding new users dynamically



Data Preprocessing Pipeline



Images before and after preprocessing

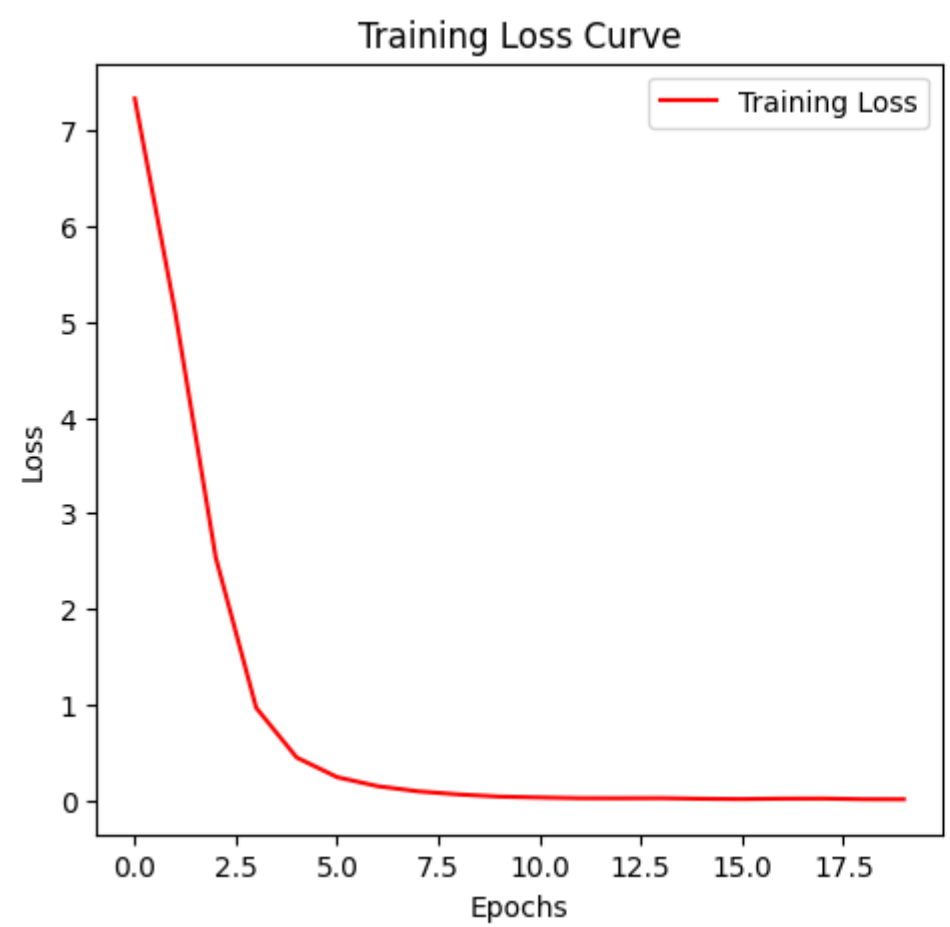


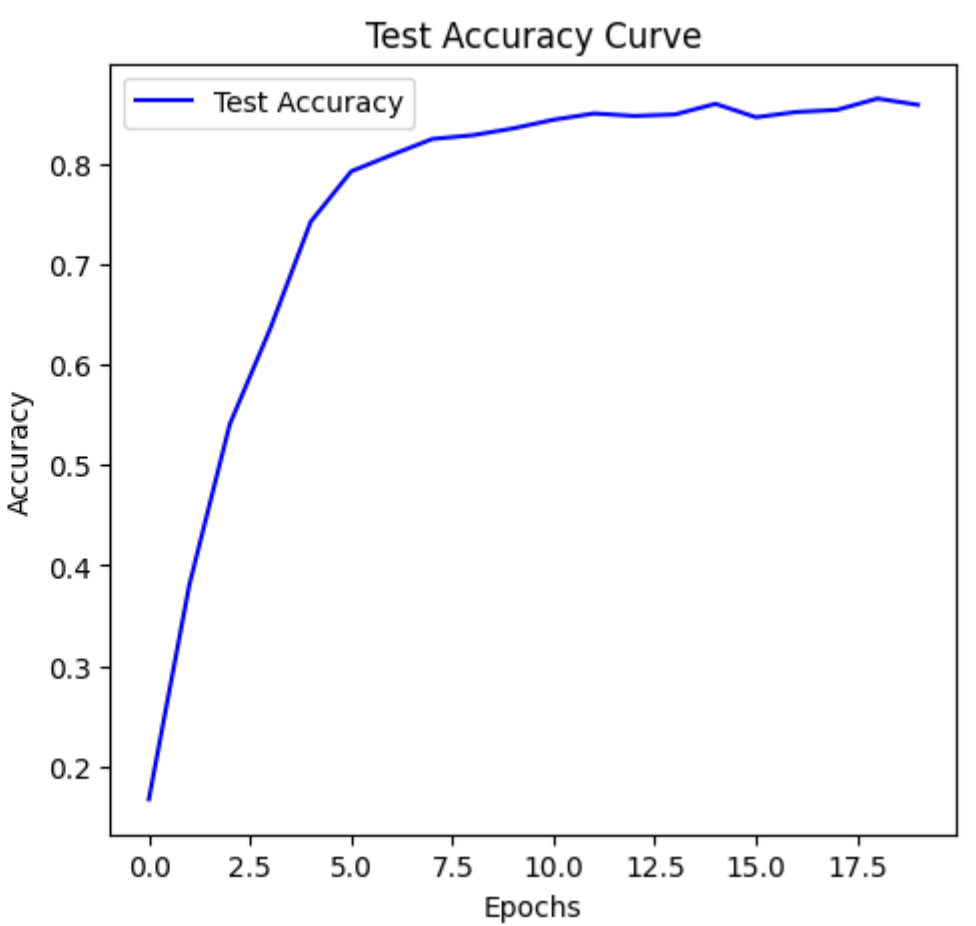
Model Architecture

Models Comparison

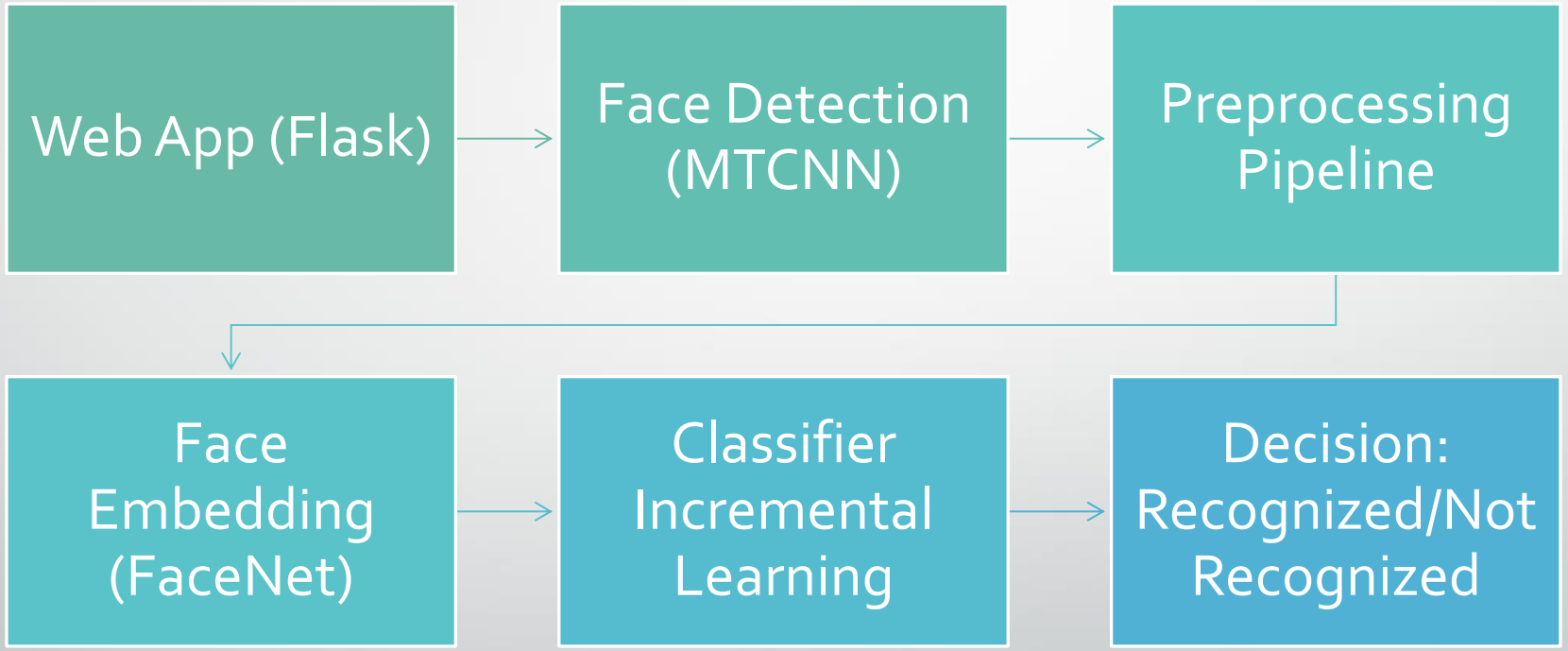
Feature	Incremental Learning (Used in Project)	Traditional Retraining & Fine-Tuning
Training Efficiency	Efficient, updates without full retraining	Requires full model retraining
New Data Handling	Adds new students dynamically	Needs dataset augmentation for new data
Model Update Speed	Fast, updates embeddings only	Slow, requires backpropagation on full dataset
Computational Cost	Low, no need for entire model retraining	High, needs GPU resources
Memory Usage	Low, stores only embeddings	High, entire model is stored
Risk of Forgetting Old Data	No forgetting, keeps previous data	Risk of catastrophic forgetting
Scalability	Highly scalable for large datasets	Limited, becomes slow as data grows
Real-Time Capability	Yes, works in real-time	Not real-time, requires retraining phase

The **Incremental Learning approach** I used in this project falls under "Feature-Based Incremental Learning" (also called Embedding-Based Incremental Learning).
This method does not retrain the full model but instead stores new embeddings for newly added students and updates the classifier dynamically.


Training Loss Curve
Training Loss
Loss
Epochs
0
1
2
3
4
5
6
7
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5


Test Accuracy Curve
Test Accuracy
Accuracy
Epochs
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5

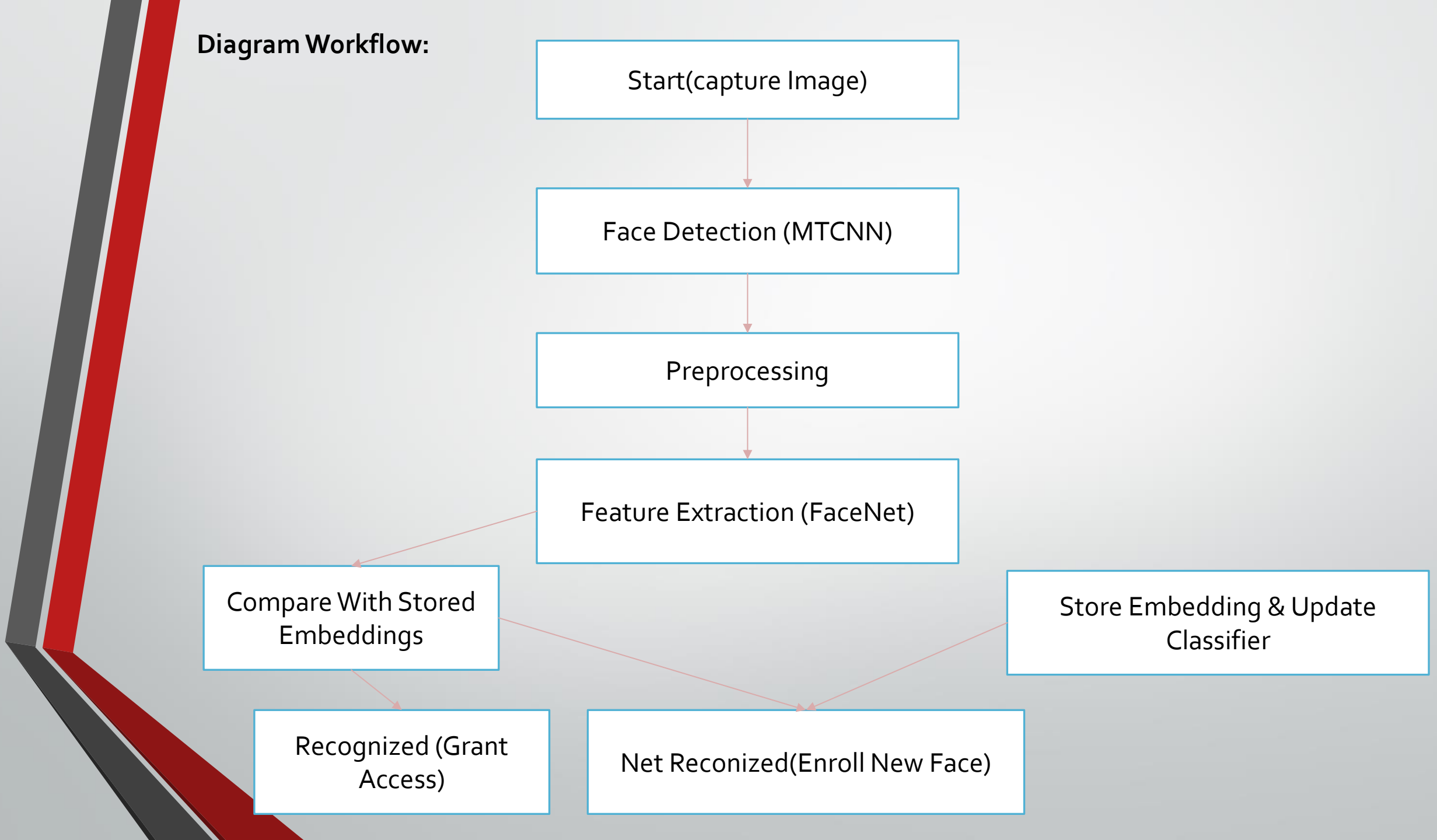
System Architecture - Incremental Face Recognition



How the Incremental learning work

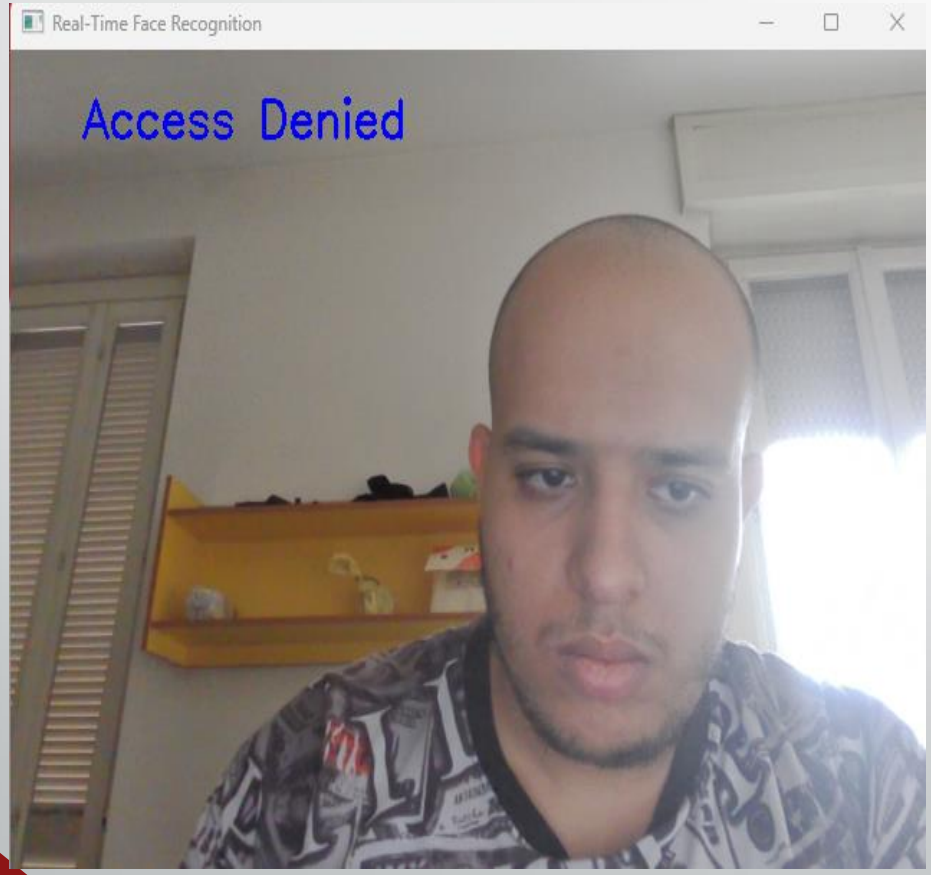
Incremental Learning Process in Face Recognition
Face Detection (MTCNN): Detects and aligns faces from input images.
Feature Extraction (FaceNet): Converts detected faces into **512-dimensional embeddings**.
Database Update: New embeddings are **added to the existing database** without retraining the entire model.
Recognition (Euclidean Distance): Compares embeddings with stored ones to classify faces.
Classifier Expansion: The classification layer updates dynamically to **accommodate new students**.

Diagram Workflow:



Results

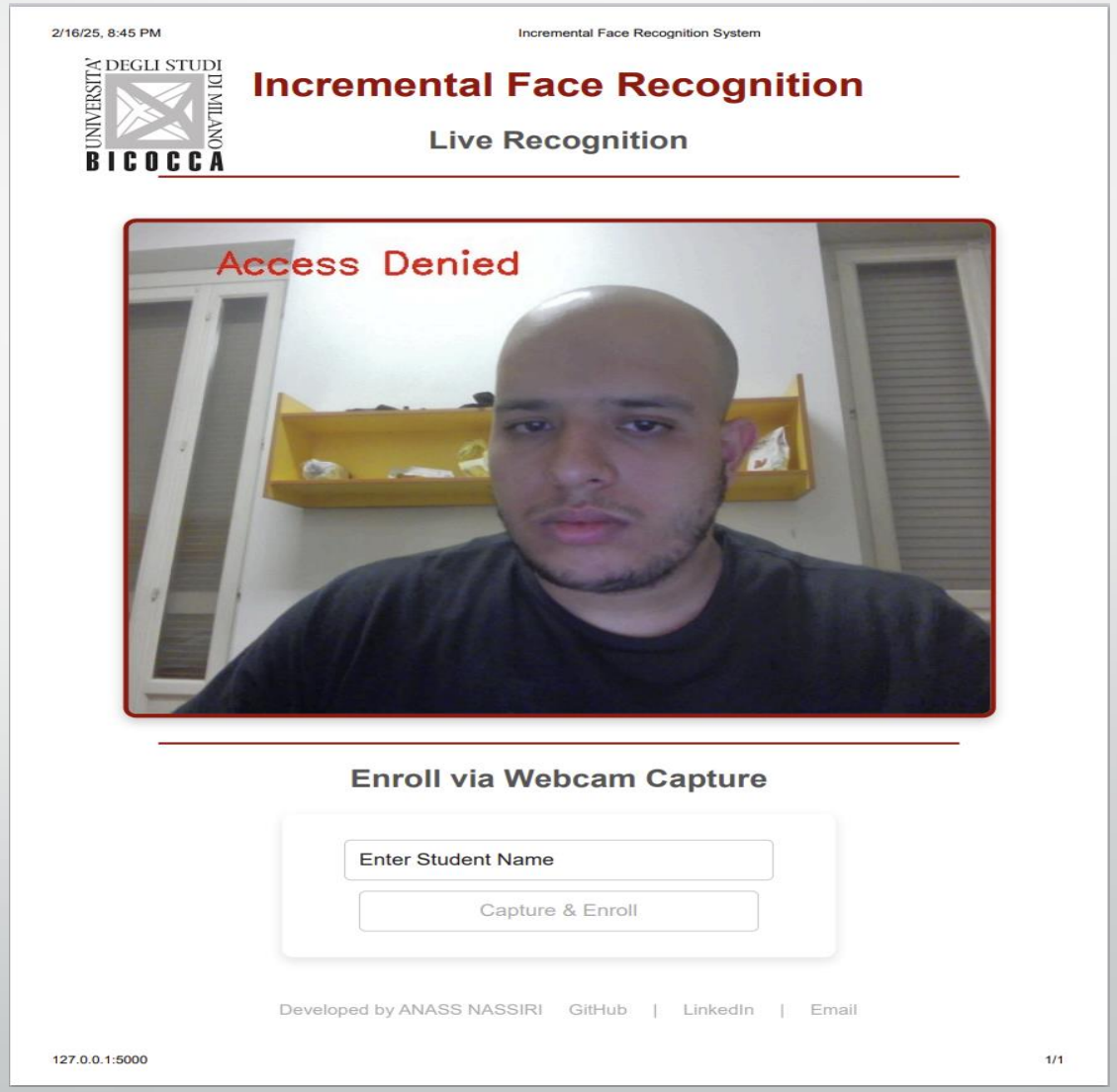
This fegures before and after i add my self using the incrimental learnig system



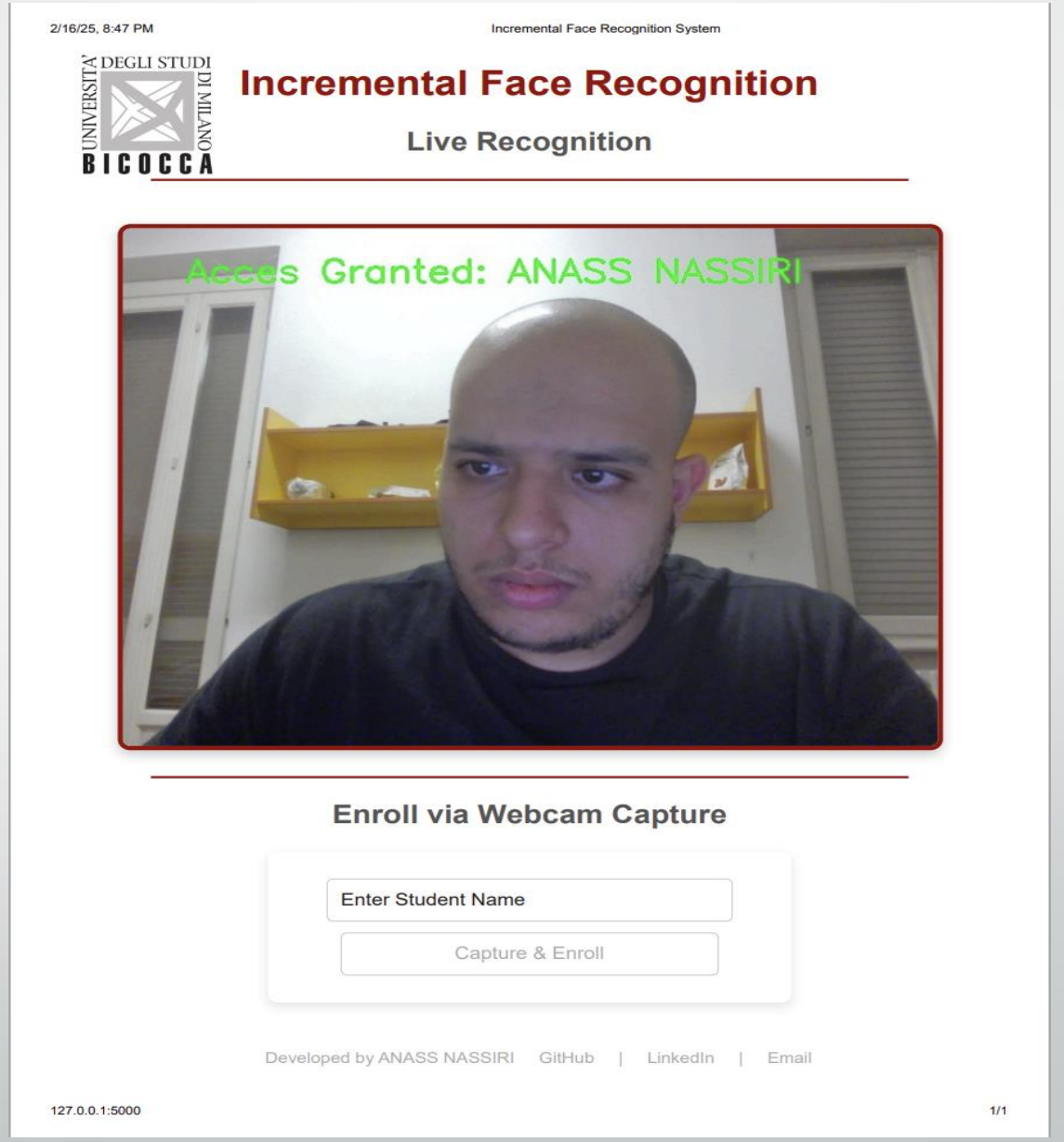
Results

Here the system doesn't recognize me, because i did't train it on my face , I want to test the system by my face .

- I deploy it in web applicationig using FLASK framwork



Here after I added my self by capturing my picture and entring my name, imidiatly the incrimental algorithm work and start reconizing my face



Hardware and environment

The hardware I used for computation for the entire project is :

- i714700hq CPU
- GPU NVDIA RTX 4070, Cuda API
- RAM 32 GB

For capturing the Images:

- Laptop webcam fullHD

The Environment used:

- VS CODE collab notebook style
- Pytorch,

Practical testing

Conclusion

- Incremental face recognition provides an efficient, real-time approach to student authorization
- The system enables dynamic learning without the need for full model retraining.
- Accurate and scalable, ensuring long-term usability in real-world applications.

Future work

- Deploy the system on edge devices or embedded hardware (Jetson Nano, Raspberry Pi).
- Extend functionality to multi-camera networks and cloud-based authentication.
- Optimize storage and retrieval of face embeddings for large-scale deployments.

References

- **LFW Dataset** - Labeled Faces in the Wild for face recognition benchmarking.https://www.kaggle.com/datasets/jessicali9530/lfw-dataset/data
- **Incremental Learning** - Continual learning approaches in classification.
  - https://doi.org/10.1016/j.neunet.2019.01.002
- **FaceNet** - Deep learning-based face recognition and clustering.
  - https://arxiv.org/abs/1503.03832
- **MTCNN** - Multi-task cascaded CNN for face detection & alignment.
  - https://arxiv.org/abs/1604.02878
- **Incremental Classifier Learning** - Updating classifiers without full retraining.
  - https://arxiv.org/abs/2107.04464