

IMAGE PROCESSING AND COMPUTER VISION



FACE SECURITY SYSTEM:

ENHANCING SAFETY WITH FACE RECOGNITION, EMOTION DETECTION AND GENDER CLASSIFICATION

This project leverages computer vision and deep learning techniques to perform face recognition, emotion analysis, and gender prediction. It integrates multiple AI models to identify individuals, detect their emotions, and classify their gender using images or live webcam footage

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1. Project Objective

This project aims to create an advanced computer vision system that performs face recognition, emotion detection, and gender classification in real-time or from a static image. The system uses pre-trained deep learning models for gender classification, the FER library for emotion detection, and a custom approach for face recognition. In addition, it logs the recognition results into an Excel file, providing valuable insights into the faces detected and their associated attributes, such as emotion and gender. Recognizes faces using pre-trained encodings.

2. Tools and Libraries Used

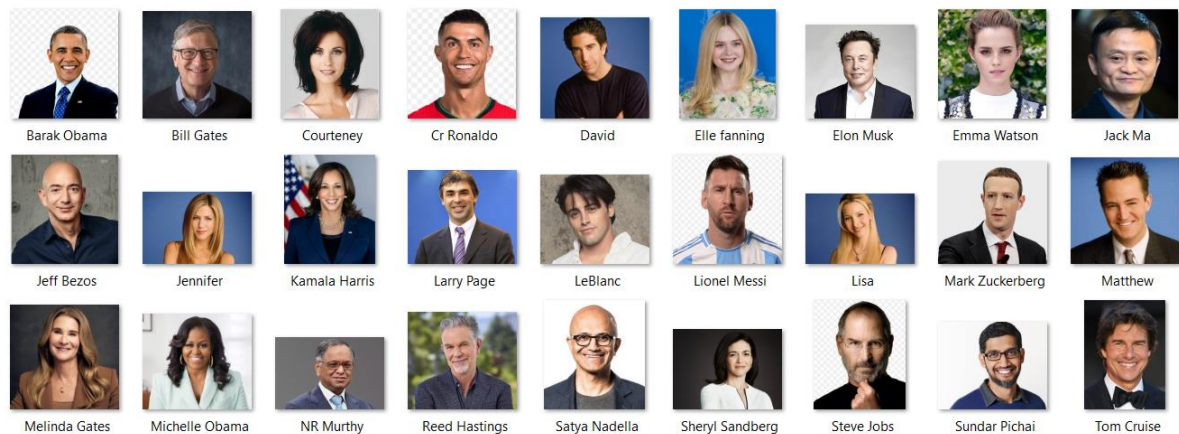
This project uses a combination of Python libraries and pre-trained models to accomplish the required tasks. Below is a list of the primary libraries used:

1. **face_recognition:** This Python library is built on top of dlib and provides simple face detection and recognition functions. It is one of the most accurate libraries for face recognition and is widely used for similar tasks.
 - Primary Functions Used: face_locations, face_encodings, compare_faces, face_distance.
2. **cv2 (OpenCV):** OpenCV is an open-source library used for computer vision tasks, and it provides functionality for reading, processing, and displaying images. This is used for image manipulation, face detection, and visual annotation of faces and results.
 - Primary Functions Use: imread, dnn.readNetFromCaffe, blobFromImage, forward, rectangle, putText, imshow.
3. **FER (Facial Expression Recognition):** The FER library is designed to detect emotions in facial expressions. This library is easy to use and comes pre-configured with pre-trained models for emotion recognition.
 - Primary Functions Used: detect_emotions.
4. **pandas:** Pandas is used to handle data manipulation and logging. In this project, it is used to store the results of each face recognition attempt in an Excel file.
 - Primary Functions Used: read_excel, DataFrame, concat, to_excel.
5. **datetime:** Used to capture the current date and time when logging the results of each face detection.
 - Primary Functions Used: strftime.
6. **os:** This is used to handle file paths, list files in directories, and manage file operations.
 - Primary Functions Used: listdir, path.exists.

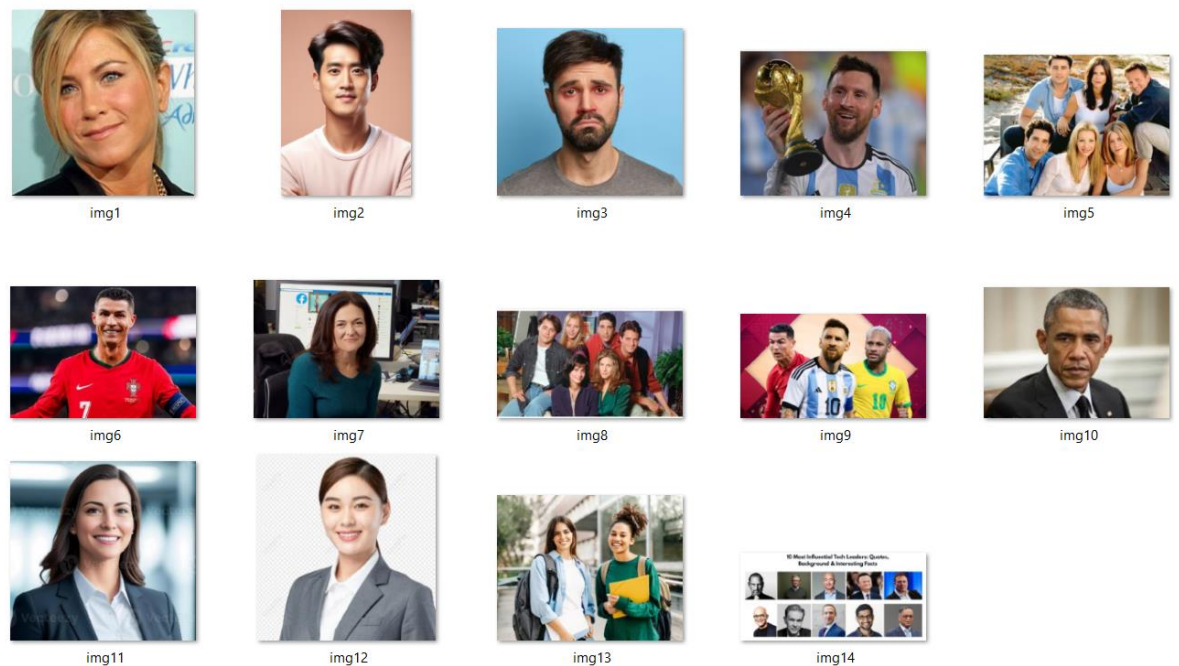
3. Dataset Images

The Training and Testing folders are crucial components for preparing and evaluating a face recognition system. The training folder should contain a diverse set of labeled images, while the testing folder should include images from various scenarios to validate the model's robustness.

3.1 Training folder



3.2 Testing Folder



4. Project Workflow

4.1 Loading and Encoding Training Images

The project begins by loading images from a directory `./train/`, which contains the training images of individuals whose faces we want to recognize. These images are used to train the face recognition system by extracting face encodings. Each encoding represents a unique biometric feature of the person's face that is used to identify them in future images.

Key Steps:

1. Image Loading: Each image in the `./train/` directory is loaded using the `face_recognition.load_image_file` function.
2. Face Encoding: The face encoding for each image is extracted using the `face_recognition.face_encodings` function. This method detects the face in the image and converts it into a feature vector that uniquely represents the person's facial features.
3. Storing Encodings: The extracted face encodings and corresponding names are stored in the lists `known_name_encodings` and `known_names`. The name is derived from the filename of each image (removing the file extension).

4.2 Loading Gender Classification Model

The gender classification model is a pre-trained Caffe model loaded using the `cv2.dnn.readNetFromCaffe` function. This model predicts the gender (Male or Female) of the detected face.

Key Steps:

1. Model Loading: The `deploy_gender.prototxt` configuration file and the `gender_net.caffemodel` pre-trained weights file are loaded into OpenCV's DNN module.
2. Prediction: The input face image is preprocessed into a blob and passed through the network to predict gender.

4.3 Emotion Detection

The FER library detects emotions such as happiness, sadness, neutral, etc. Each detected emotion has a score, and the dominant emotion is chosen for display.

4.4 Analyzing Test Image

The test image is analyzed to detect faces, recognize individuals, predict emotions, and classify gender.

Key Steps:

1. Face Detection: The image is passed through the `face_recognition.face_locations` function, which returns the coordinates of detected faces.
2. Face Encoding: The `face_recognition.face_encodings` function generates encodings for each detected face.
3. Face Recognition: The program compares the detected face encodings with the known encodings to identify the individual using the `face_recognition.compare_faces` and `face_recognition.face_distance` functions.
4. Emotion Detection: The `FER.detect_emotions` function is used to detect the emotions of the face by analyzing facial landmarks.
5. Gender Prediction: The image of the face is fed into the gender classifier to predict the individual's gender.

4.5 Logging the Results

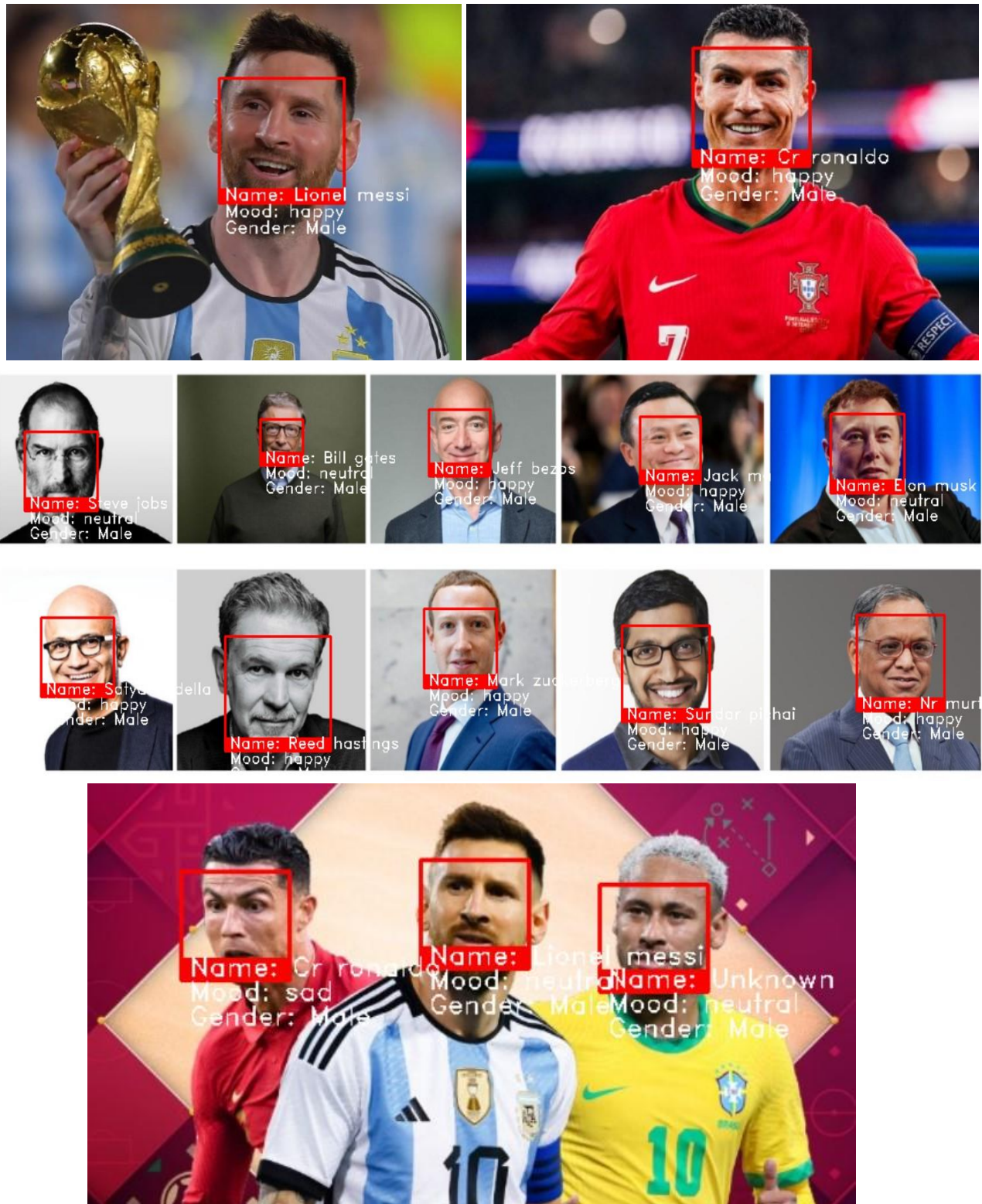
After detecting and analyzing the face, the results (name, emotion, gender, and access status) are logged in an Excel file (`face_log.xlsx`).

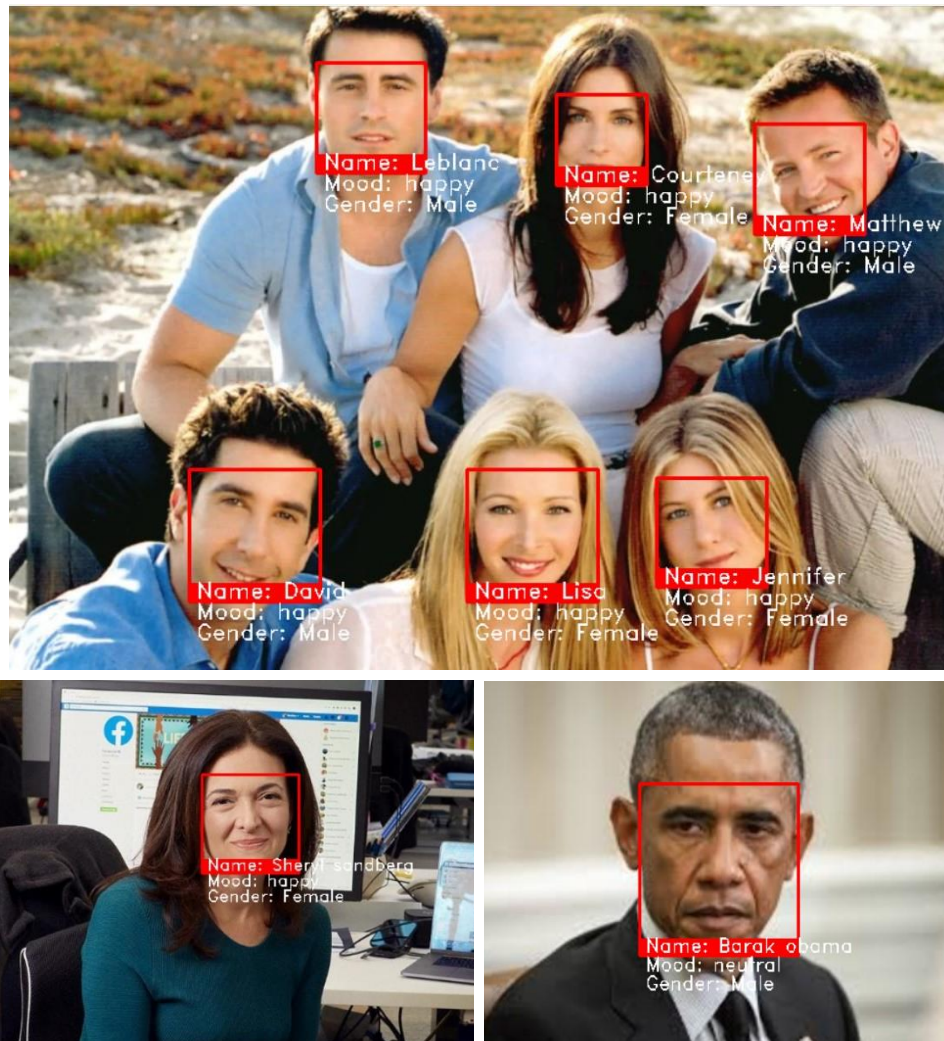
Name	Time	Access	Emotion	Gender
Jennifer	2024-11-25 22:00:31	Authorized	happy	Female
Unknown	2024-11-25 22:02:22	Unauthorized	neutral	Male
Unknown	2024-11-25 22:04:30	Unauthorized	sad	Male
Lionel messi	2024-11-25 22:05:16	Authorized	happy	Male
Leblanc	2024-11-25 22:05:54	Authorized	happy	Male
Lisa	2024-11-25 22:05:54	Authorized	happy	Female
Courteney	2024-11-25 22:05:54	Authorized	happy	Female
David	2024-11-25 22:05:54	Authorized	happy	Male
Jennifer	2024-11-25 22:05:54	Authorized	happy	Female
Matthew	2024-11-25 22:05:54	Authorized	happy	Male
Cr ronaldo	2024-11-25 22:06:30	Authorized	happy	Male
Sheryl sandberg	2024-11-25 22:07:50	Authorized	happy	Female
Lisa	2024-11-25 22:11:16	Authorized	happy	Female
David	2024-11-25 22:11:16	Authorized	happy	Female
Matthew	2024-11-25 22:11:16	Authorized	Not Detected	Male
Jennifer	2024-11-25 22:11:16	Authorized	happy	Female
Leblanc	2024-11-25 22:11:16	Authorized	neutral	Female
Courteney	2024-11-25 22:11:16	Authorized	happy	Male
Unknown	2024-11-25 22:12:05	Unauthorized	neutral	Male
Lionel messi	2024-11-25 22:12:05	Authorized	neutral	Male
Cr ronaldo	2024-11-25 22:12:05	Authorized	sad	Male
Barak obama	2024-11-25 22:12:38	Authorized	neutral	Male
Unknown	2024-11-25 22:13:17	Unauthorized	happy	Female
Unknown	2024-11-25 22:13:48	Unauthorized	happy	Female
Unknown	2024-11-25 22:14:29	Unauthorized	happy	Female
Unknown	2024-11-25 22:14:29	Unauthorized	happy	Female
Jeff bezos	2024-11-25 22:15:11	Authorized	happy	Male
Mark zuckerberg	2024-11-25 22:15:11	Authorized	happy	Male
Elon musk	2024-11-25 22:15:11	Authorized	neutral	Male
Nr murthy	2024-11-25 22:15:11	Authorized	happy	Male
Bill gates	2024-11-25 22:15:11	Authorized	neutral	Male
Sundar pichai	2024-11-25 22:15:11	Authorized	happy	Male
Reed hastings	2024-11-25 22:15:11	Authorized	happy	Male
Steve jobs	2024-11-25 22:15:11	Authorized	neutral	Male
Satya nadella	2024-11-25 22:15:12	Authorized	happy	Male
Jack ma	2024-11-25 22:15:12	Authorized	happy	Male

4.6 Visualization/Results

Finally, the processed image is displayed using cv2.imshow with rectangles drawn around the detected faces, along with annotations showing the name, emotion, and gender.

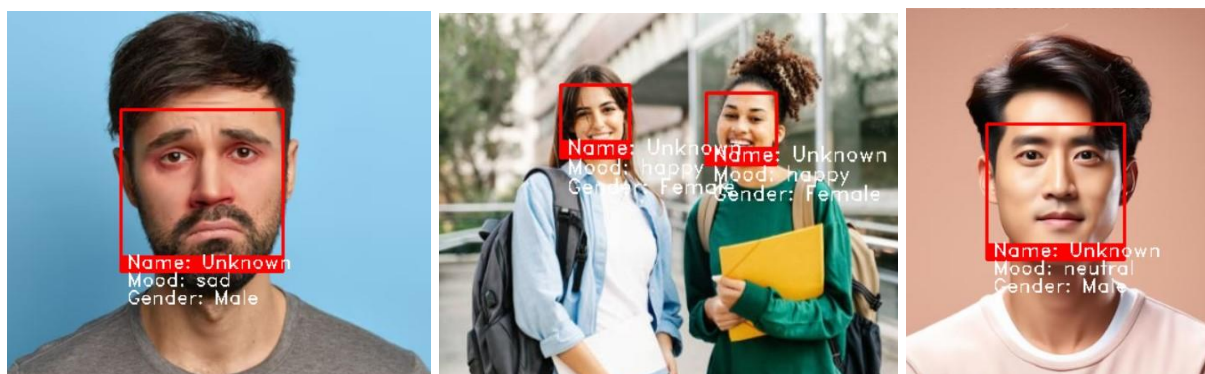
Authorized Results





Unauthorized Results

Name: Unknown



5. Debugging and Analysis with print Statements

Known Names

Known Names: ['Barak obama', 'Bill gates', 'Courteney', 'Cr ronaldo', 'David', 'Elle fanning', 'Elon musk', 'Emma watson', 'Jack ma', 'Jeff bezos', 'Jennifer', 'Kamala harris', 'Larry page', 'Leblanc', 'Lionel messi', 'Lisa', 'Mark zuckerberg', 'Matthew', 'Melinda gates', 'Michelle obama', 'Nr murthy', 'Reed hastings', 'Satya nadella', 'Sheryl sandberg', 'Steve jobs', 'Sundar pichai', 'Tom cruise']

Processing Test Image

Processing test image: ./test/img7.jpg

Detected face locations: [(104, 342, 211, 235)]

Recognition Matches

Face distances: [0.9689992, 0.91152752, 0.90524955, 0.90704342, 0.95363309, 0.84229316, 0.78423032, 0.90910142, 0.75750841, 0.78974931, 0.9276891, 0.811968, 0.86150225, 0.96743362, **1.04739956**, 0.79443268, 0.95349978, 0.85426911, 0.82480954, 0.79877382, 0.77754371, 1.00187645, 0.94780385, 0.48943469, 0.93316006, 0.89026838, 0.92634961]

Best match index: **23**

Is the match valid? **True**

Emotion Detection

Detected emotions: [{'box': [-30, -66, 139, 176], 'emotions': {'angry': 0.0, 'disgust': 0.0, 'fear': 0.0, 'happy': **0.99**, 'sad': 0.0, 'surprise': 0.0, 'neutral': 0.01}}]

Dominant emotion: **happy**

Gender Prediction

Gender prediction scores: [[0.00952094 **0.99047905**]]

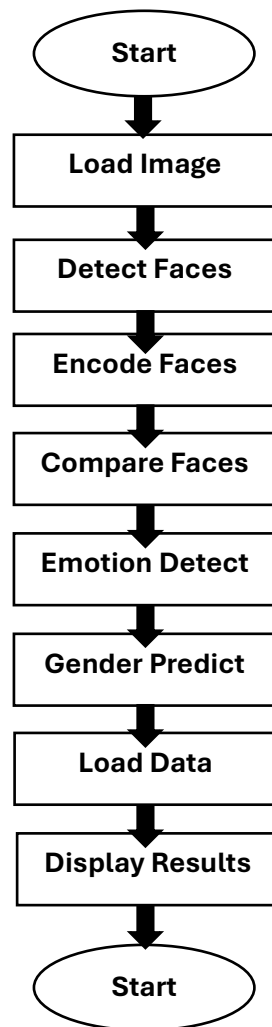
Predicted gender: **Female**

Excel Logging

New entry logged:

```
{  
'Name': 'Sheryl sandberg',  
'Time': '2024-11-25 23:19:47',  
'Access': 'Authorized',  
'Emotion': 'happy',  
'Gender': 'Female'  
}
```

6. Flow Chart



7. Limitations and Future Enhancements

Enhancements such as integrating an age estimation model and utilizing advanced emotion detection models or multi-frame analysis could improve the accuracy of emotional insights. Storing logs and outputs on a cloud server would ensure scalability and easy accessibility for larger datasets or multiple deployment scenarios. Additionally, extending the system to support real-time video streams would unlock applications like live surveillance, significantly broadening its utility.

8. Conclusion

The face recognition system, integrating facial recognition, emotion detection, gender classification, and real-time data logging, showcases the power of AI and computer vision in creating a versatile solution for practical applications beyond basic face detection.