Day79_Haar_Cascade_Face_Eye_Smile_Detection

September 3, 2025

1 Haar Cascade classifier

1.1 Introduction

In this lab we use **OpenCV's Haar Cascade classifiers** to detect **faces, eyes, and smiles** in images.
These classifiers are **pre-trained XML files** that you can load and run quickly on images.

1.2 Why we do this?

Haar Cascades are a **simple and fast way** to detect objects (faces, eyes, smiles).
They are useful for:

- Learning object detection basics
- Real-time / low-resource applications

1.3 What is a Haar Cascade?

- Haar cascade detectors follow the **Viola–Jones framework**.
- They compute **simple rectangular Haar features** on an image.
- They use **integral images** for speed.
- A cascade of classifiers quickly decides if a region is a face.
- The cascade rejects most non-face regions early → **fast detection**.

1.4 Where to get the cascade XML files?

- OpenCV already provides many cascades (via `cv2.data.haarcascades`).
- Examples:
  - `haarcascade_frontalface_default.xml` → Human face
  - `haarcascade_eye.xml` → Eyes
  - `haarcascade_smile.xml` → Smiles

- More cascades can be found in the OpenCV Haarcascades repo.

1.5 Notes on Parameters (`detectMultiScale`)

- **scaleFactor** → How much the image size is reduced at each scale.
  (e.g. `1.1` = smaller steps, slower but more accurate)

- **minNeighbors** → How many neighbours each detection needs to keep it.
  Higher = fewer false positives, but may miss real faces.

- **minSize** → Minimum object size (e.g. `(30,30)`).

2 Import libraries

[1]:
```python
# Step 1: Import libraries
import cv2
import matplotlib.pyplot as plt

# Helper function to display images in notebook
def show_image(img, title="Image"):
    img_rgb = cv2.cvtColor(img, cv2.COLOR_BGR2RGB)  # Convert BGR -> RGB
    plt.imshow(img_rgb)
    plt.title(title)
    plt.axis("off")
    plt.show()
```

3 Load Haar Cascade Classifiers

OpenCV comes with many pre-trained XML files.

- Face: `haarcascade_frontalface_default.xml`

- Eyes: `haarcascade_eye.xml`

- Smile: `haarcascade_smile.xml`

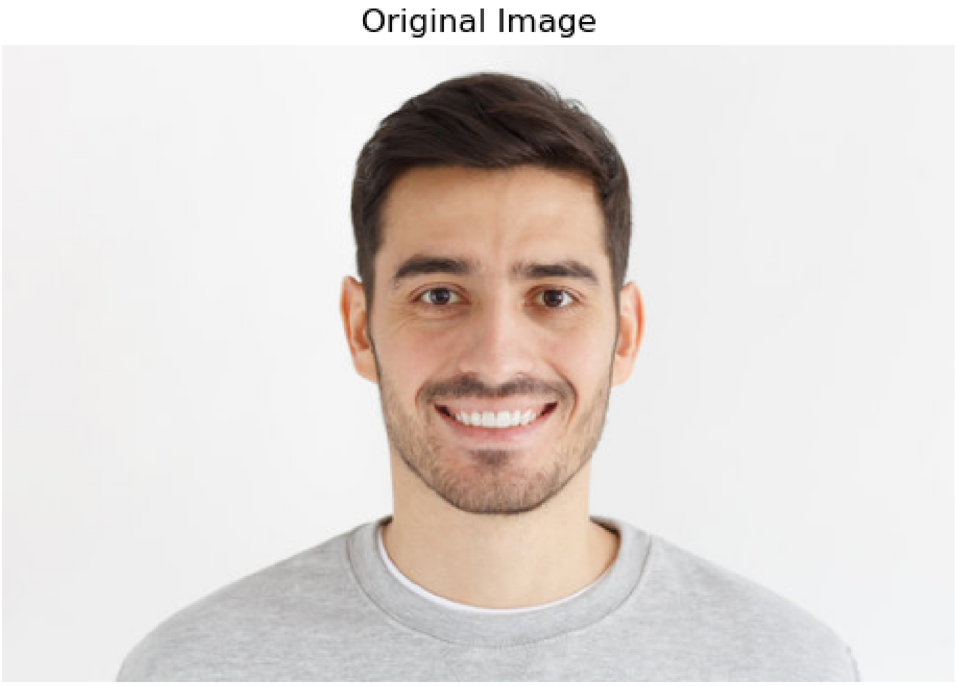
[2]:
```python
# Load Haar Cascades
face_cascade = cv2.CascadeClassifier(cv2.data.haarcascades +␣
 ↪'haarcascade_frontalface_default.xml')
eye_cascade = cv2.CascadeClassifier(cv2.data.haarcascades + 'haarcascade_eye.
 ↪xml')
smile_cascade = cv2.CascadeClassifier(cv2.data.haarcascades +␣
 ↪'haarcascade_smile.xml')
```

4 Load an Image

We will use `cv2.imread(path)` to read an image from disk.

[3]:

```
# Load image (update path to your image)
image_path = r"C:\Users\Lenovo\Downloads\image.JPG"
image = cv2.imread(image_path)

if image is None:
    print("Error: Image not found!")
else:
    show_image(image, "Original Image")
```

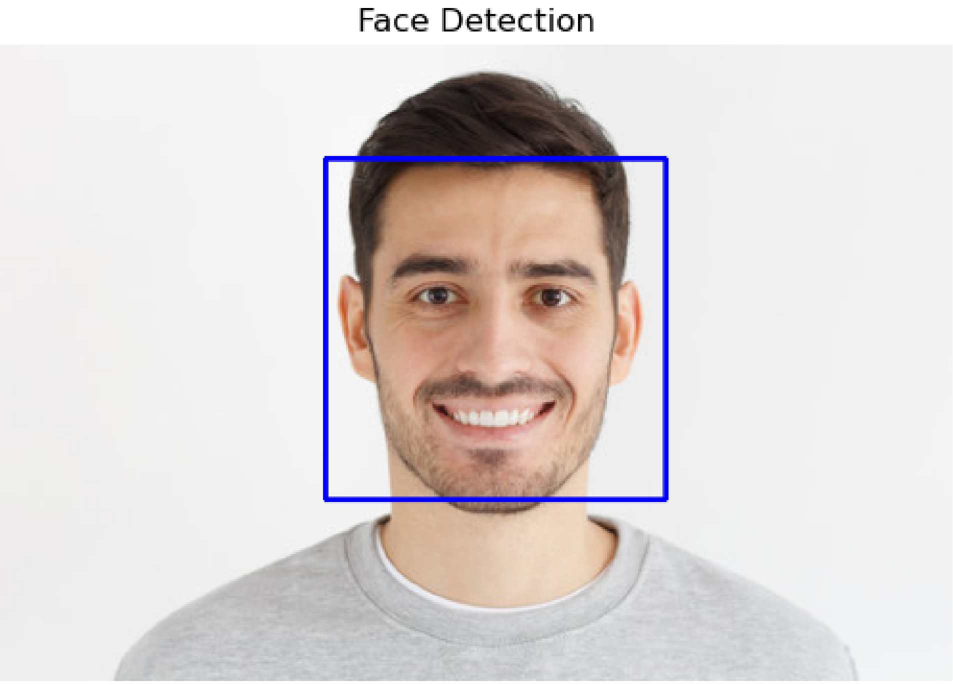


5 Face Detection (Simple)

Steps:
1. Convert to grayscale
2. Detect faces with `detectMultiScale()`
3. Draw rectangles around faces

[4]:

```
# Convert image to grayscale
gray = cv2.cvtColor(image, cv2.COLOR_BGR2GRAY)

# Detect faces
faces = face_cascade.detectMultiScale(gray, scaleFactor=1.3, minNeighbors=5)

# Draw rectangles
for (x, y, w, h) in faces:
    cv2.rectangle(image, (x, y), (x+w, y+h), (255, 0, 0), 2)

show_image(image, "Face Detection")
```



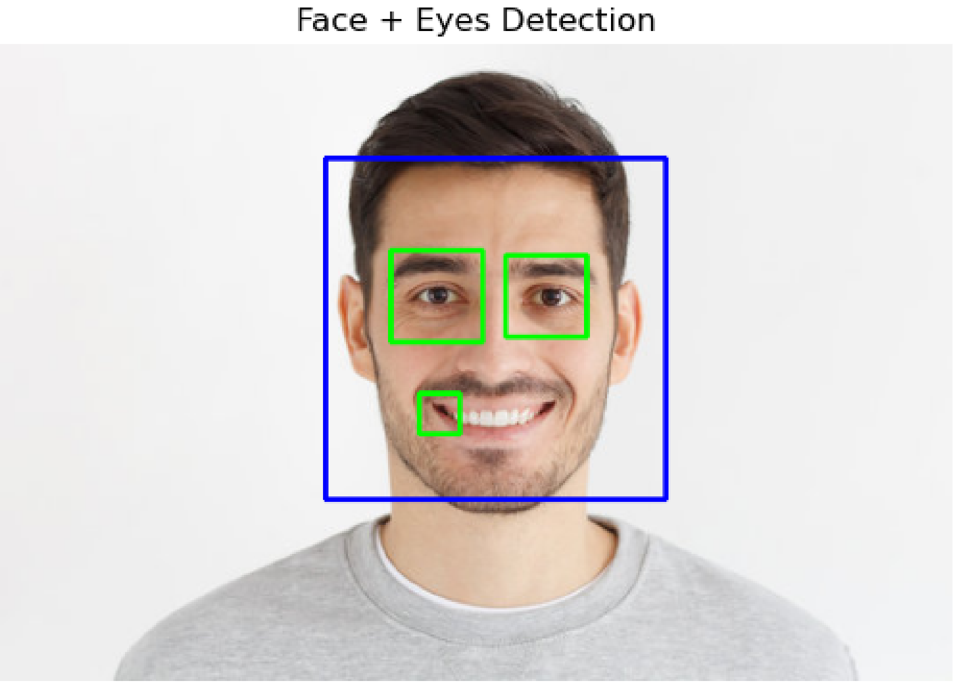
6 Face + Eyes Detection

We detect eyes **inside the face region**.

[5]:

```
# Reload original image
image = cv2.imread(image_path)
gray = cv2.cvtColor(image, cv2.COLOR_BGR2GRAY)

faces = face_cascade.detectMultiScale(gray, 1.3, 5)

for (x, y, w, h) in faces:
    cv2.rectangle(image, (x, y), (x+w, y+h), (255, 0, 0), 2)

    # Region of Interest (ROI) for eyes inside face
    roi_gray = gray[y:y+h, x:x+w]
    roi_color = image[y:y+h, x:x+w]

    eyes = eye_cascade.detectMultiScale(roi_gray)
    for (ex, ey, ew, eh) in eyes:
        cv2.rectangle(roi_color, (ex, ey), (ex+ew, ey+eh), (0, 255, 0), 2)
```

```
show_image(image, "Face + Eyes Detection")
```



Note: Haar Cascade is not perfect. Sometimes it makes mistakes.

In our test, it mistakenly predicted the **left part of the smile as an eye**.
This happens because Haar features are simple and can confuse similar patterns (like dark areas in a smile or eyebrows).

For more accurate results in real projects, we can: - Adjust parameters (`scaleFactor`, `minNeighbors`)
- Use better cascades (like `haarcascade_eye_tree_eyeglasses.xml`)
- Or switch to deep learning-based detectors (more advanced).

7 Face + Eyes + Smile Detection

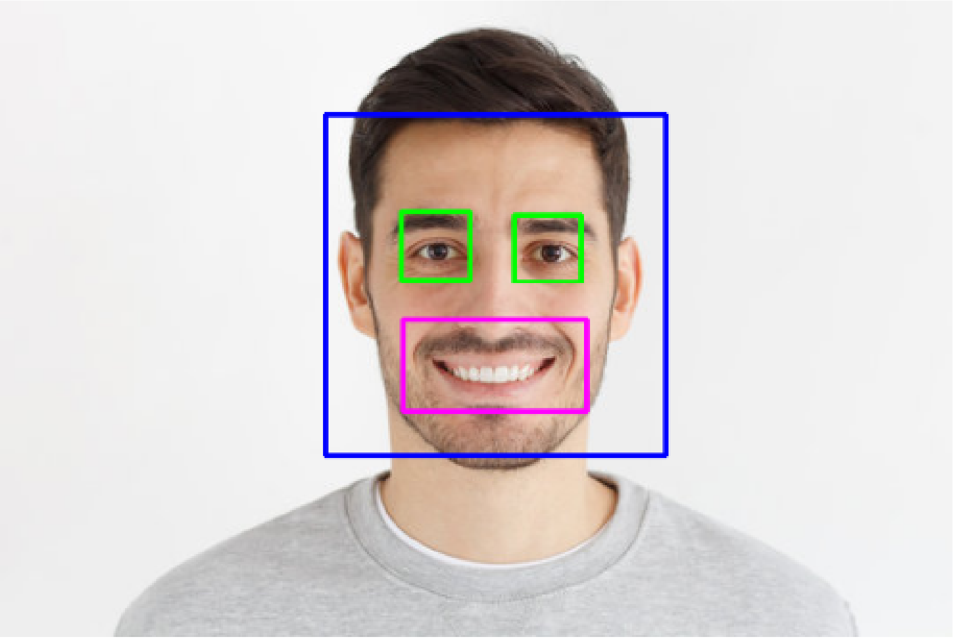
We split the face into two parts:

- Upper half → detect **eyes**
- Lower half → detect **smiles**

[6]:
```
# Reload original image
image = cv2.imread(image_path)
gray = cv2.cvtColor(image, cv2.COLOR_BGR2GRAY)
```

```
faces = face_cascade.detectMultiScale(gray, 1.3, 5)

for (x, y, w, h) in faces:
    cv2.rectangle(image, (x, y), (x+w, y+h), (255, 0, 0), 2)

    # Eyes in upper half
    roi_gray_eyes = gray[y:y+h//2, x:x+w]
    roi_color_eyes = image[y:y+h//2, x:x+w]
    eyes = eye_cascade.detectMultiScale(roi_gray_eyes, 1.1, 10, minSize=(30,30))
    for (ex, ey, ew, eh) in eyes:
        cv2.rectangle(roi_color_eyes, (ex, ey), (ex+ew, ey+eh), (0, 255, 0), 2)

    # Smiles in lower half
    roi_gray_smile = gray[y+h//2:y+h, x:x+w]
    roi_color_smile = image[y+h//2:y+h, x:x+w]
    smiles = smile_cascade.detectMultiScale(roi_gray_smile, 1.7, 20,␣
 ↪minSize=(25,25))
    for (sx, sy, sw, sh) in smiles:
        cv2.rectangle(roi_color_smile, (sx, sy), (sx+sw, sy+sh), (255, 0, 255),␣
 ↪2)

show_image(image, "Face + Eyes + Smile Detection")
```

Face + Eyes + Smile Detection



8 Summary

- We learned how to use **Haar Cascade Classifiers** in OpenCV.
- These are **pre-trained XML files** that can detect objects like faces, eyes, and smiles.
- Steps we followed:
  1. Imported libraries
  2. Loaded Haar Cascade XMLs
  3. Loaded an image
  4. Detected **faces**
  5. Detected **faces + eyes**
  6. Detected **faces + eyes + smiles**
- We also saw the **limitations**:
  - Sometimes false detections (e.g., part of a smile detected as an eye).
  - Works best on **human faces**, not animals or drawing.
  - Parameters (`scaleFactor`, `minNeighbors`) strongly affect results.

  Key takeaway: Haar Cascade is a **fast, beginner-friendly method** for object detection.
  It's great for learning, but for higher accuracy we can move to **deep learning-based detectors** (like DNN, YOLO, SSD).