Lambton College | In Mississauga

LAB 4

Students Name:

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Part 1: Basics of OpenCV

We will load an image, display it, convert color spaces, print its shape, and save the grayscale version. Variables and functions include the suffix to make them unique.

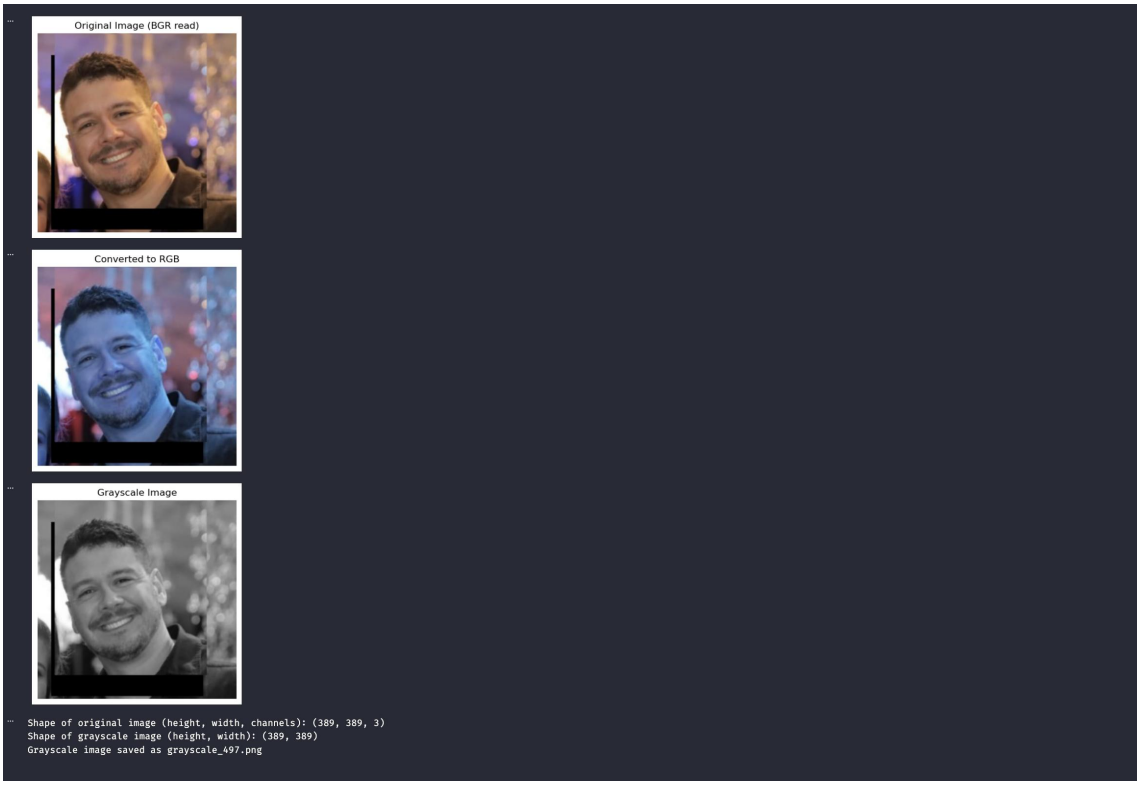
```
!python -m pip install --upgrade pip
!pip install opencv-python matplotlib numpy nbformat
import cv2
from matplotlib import pyplot as plt
import os

# Student-specific suffix to avoid collision
suffix_497 = "497"

# -- Step 1: Load image --
# Replace 'profile.jpg' with your uploaded image filename in Colab.
```

```
!python -m pip install --upgrade pip
!pip install opencv-python matplotlib numpy nbformat
import cv2
from matplotlib import pyplot as plt
import os

# Student-specific suffix to avoid collision
suffix_497 = "497"

# -- Step 1: Load image --
# Replace 'profile.jpg' with your uploaded image filename in Colab.
img_path_497 = "profile.jpg"
if not os.path.exists(img_path_497):
    print(f"WARNING: {img_path_497} not found. Please upload your profile image to the runtime and name it 'profile.jpg'.")
# Read image using OpenCV (BGR format)
image_bgr_497 = cv2.imread(img_path_497)

# Display original image using matplotlib (convert BGR to RGB for proper colors)

def show_image_497(img, title, cmap=None):
    plt.figure(figsize=(6,4))
    if len(img.shape) == 3:
        # assume BGR -> convert to RGB for display
        img_disp = cv2.cvtColor(img, cv2.COLOR_BGR2RGB)
        plt.imshow(img_disp)
    else:
        plt.imshow(img, cmap=cmap)
    plt.title(title)
    plt.axis('off')
    plt.tight_layout()
    plt.show()
```

```python
if image_bgr_497 is not None:
    show_image_497(image_bgr_497, "Original Image (BGR read)")
    # Convert BGR to RGB explicitly
    image_rgb_497 = cv2.cvtColor(image_bgr_497, cv2.COLOR_BGR2RGB)
    show_image_497(image_rgb_497, "Converted to RGB")

    # Convert to grayscale
    image_gray_497 = cv2.cvtColor(image_bgr_497, cv2.COLOR_BGR2GRAY)
    show_image_497(image_gray_497, "Grayscale Image", cmap='gray')
    print("Shape of original image (height, width, channels):", image_bgr_497.shape)
    print("Shape of grayscale image (height, width):", image_gray_497.shape)

    # Save grayscale image
    out_gray_filename_497 = f"grayscale_497.png"
    cv2.imwrite(out_gray_filename_497, image_gray_497)
    print(f"Grayscale image saved as {out_gray_filename_497}")
else:
    print("Image not loaded; cannot proceed with Part 1.")
```

6.4s Python

```
Requirement already satisfied: pip in /opt/anaconda3/lib/python3.11/site-packages (25.2)
Requirement already satisfied: opencv-python in /opt/anaconda3/lib/python3.11/site-packages (4.12.0.88)
Requirement already satisfied: matplotlib in /opt/anaconda3/lib/python3.11/site-packages (3.10.0)
Requirement already satisfied: numpy in /opt/anaconda3/lib/python3.11/site-packages (2.2.6)
Requirement already satisfied: nbformat in /opt/anaconda3/lib/python3.11/site-packages (5.9.2)
Requirement already satisfied: contourpy≥1.0.1 in /opt/anaconda3/lib/python3.11/site-packages (from matplotlib) (1.3.3)
Requirement already satisfied: cycler≥0.10 in /opt/anaconda3/lib/python3.11/site-packages (from matplotlib) (0.11.0)
Requirement already satisfied: fonttools≥4.22.0 in /opt/anaconda3/lib/python3.11/site-packages (from matplotlib) (4.51.0)
Requirement already satisfied: kiwisolver≥1.3.1 in /opt/anaconda3/lib/python3.11/site-packages (from matplotlib) (1.4.4)
Requirement already satisfied: packaging≥20.0 in /opt/anaconda3/lib/python3.11/site-packages (from matplotlib) (24.1)
Requirement already satisfied: pillow≥8 in /opt/anaconda3/lib/python3.11/site-packages (from matplotlib) (10.4.0)
Requirement already satisfied: pyparsing≥2.3.1 in /opt/anaconda3/lib/python3.11/site-packages (from matplotlib) (3.0.9)
Requirement already satisfied: python-dateutil≥2.7 in /opt/anaconda3/lib/python3.11/site-packages (from matplotlib) (2.9.0.post0)
```



Part 2: Image Manipulations

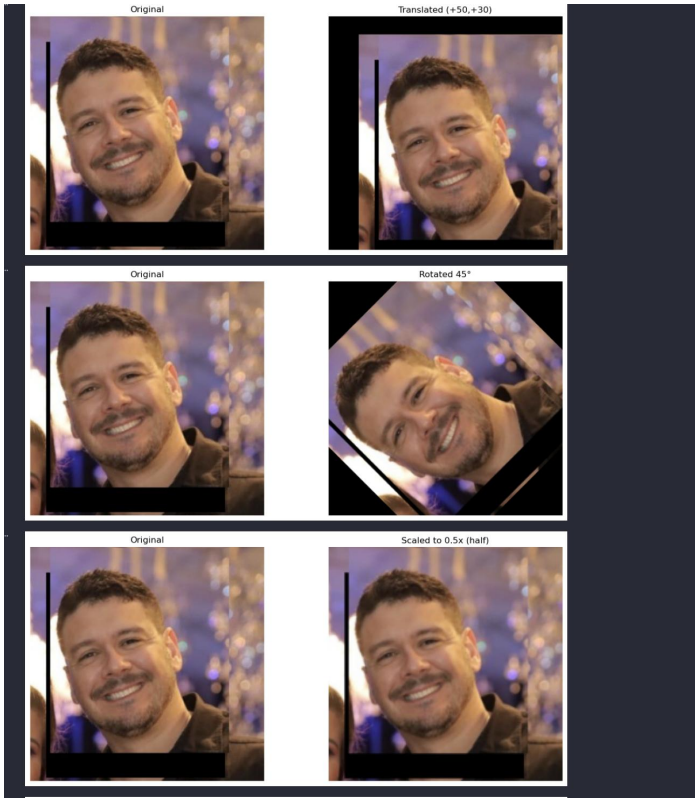
Apply translation, rotation, scaling, smoothing (Gaussian and median), and edge detection. Display original vs transformed images side by side and explain each in comments.

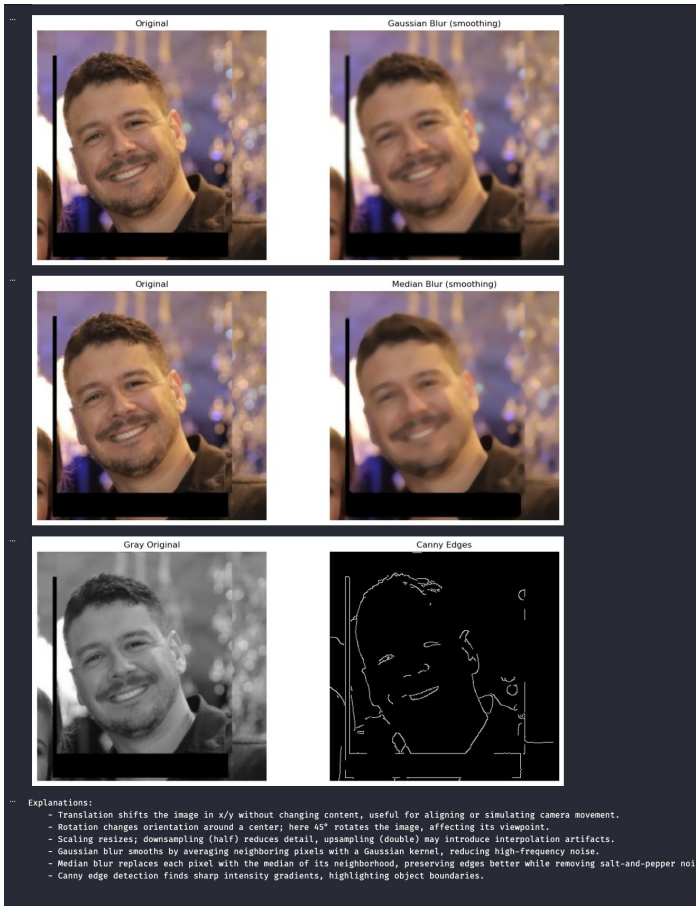
```python
import numpy as np

# Ensure the grayscale and color images exist from Part 1
if 'image_bgr_497' in globals() and image_bgr_497 is not None:
    orig = image_bgr_497

    # Translation: shift horizontally and vertically

    def translate_497(img, x_shift, y_shift):
        height, width = img.shape[:2]
        M = np.float32([[1, 0, x_shift], [0, 1, y_shift]])
        translated = cv2.warpAffine(img, M, (width, height))
        return translated

    trans_img_497 = translate_497(orig, x_shift=50, y_shift=30)  # shift right 50, down 30

    # Rotation: rotate by 45 degrees around center

    def rotate_497(img, angle):
        height, width = img.shape[:2]
        center = (width // 2, height // 2)
        M = cv2.getRotationMatrix2D(center, angle, 1.0)
        rotated = cv2.warpAffine(img, M, (width, height))
        return rotated
```

```python
    rot_img_497 = rotate_497(orig, 45)

    # Scaling: half and double size
    half_497 = cv2.resize(orig, (0,0), fx=0.5, fy=0.5, interpolation=cv2.INTER_AREA)
    double_497 = cv2.resize(orig, (0,0), fx=2.0, fy=2.0, interpolation=cv2.INTER_CUBIC)

    # Smoothing: Gaussian blur vs median blur
    gaussian_497 = cv2.GaussianBlur(orig, (11,11), sigmaX=0)
    median_497 = cv2.medianBlur(orig, 11)

    # Edge detection: Canny
    edges_497 = cv2.Canny(cv2.cvtColor(orig, cv2.COLOR_BGR2GRAY), threshold1=100, threshold2=200)

    # Display comparisons side by side function

    def compare_two_497(img1, img2, title1, title2, cmap1=None, cmap2=None):
        plt.figure(figsize=(12,5))
        plt.subplot(1,2,1)
        if img1.ndim == 3:
            plt.imshow(cv2.cvtColor(img1, cv2.COLOR_BGR2RGB))
        else:
            plt.imshow(img1, cmap=cmap1)
        plt.title(title1)
        plt.axis('off')

        plt.subplot(1,2,2)
        if img2.ndim == 3:
            plt.imshow(cv2.cvtColor(img2, cv2.COLOR_BGR2RGB))
        else:
            plt.imshow(img2, cmap=cmap2)
        plt.title(title2)
        plt.axis('off')
        plt.tight_layout()
```

```python
    compare_two_497(orig, trans_img_497, "Original", "Translated (+50,+30)")
    compare_two_497(orig, rot_img_497, "Original", "Rotated 45°")
    compare_two_497(orig, half_497, "Original", "Scaled to 0.5x (half)")
    compare_two_497(orig, double_497, "Original", "Scaled to 2x (double)")
    compare_two_497(orig, gaussian_497, "Original", "Gaussian Blur (smoothing)")
    compare_two_497(orig, median_497, "Original", "Median Blur (smoothing)")
    compare_two_497(cv2.cvtColor(orig, cv2.COLOR_BGR2GRAY), edges_497, "Gray Original", "Canny Edges", cmap1='gray', cmap2='gr

    # Brief textual explanations (these should be paraphrased in user's own words when submitting)
    print("""Explanations:
    - Translation shifts the image in x/y without changing content, useful for aligning or simulating camera movement.
    - Rotation changes orientation around a center; here 45° rotates the image, affecting its viewpoint.
    - Scaling resizes; downsampling (half) reduces detail, upsampling (double) may introduce interpolation artifacts.
    - Gaussian blur smooths by averaging neighboring pixels with a Gaussian kernel, reducing high-frequency noise.
    - Median blur replaces each pixel with the median of its neighborhood, preserving edges better while removing salt-and-pep
    - Canny edge detection finds sharp intensity gradients, highlighting object boundaries.""")
else:
    print("""Skipping Part 2 because original image was not loaded in Part 1. Make sure to upload and read your image as 'prof
```

✓ 2.5s Python



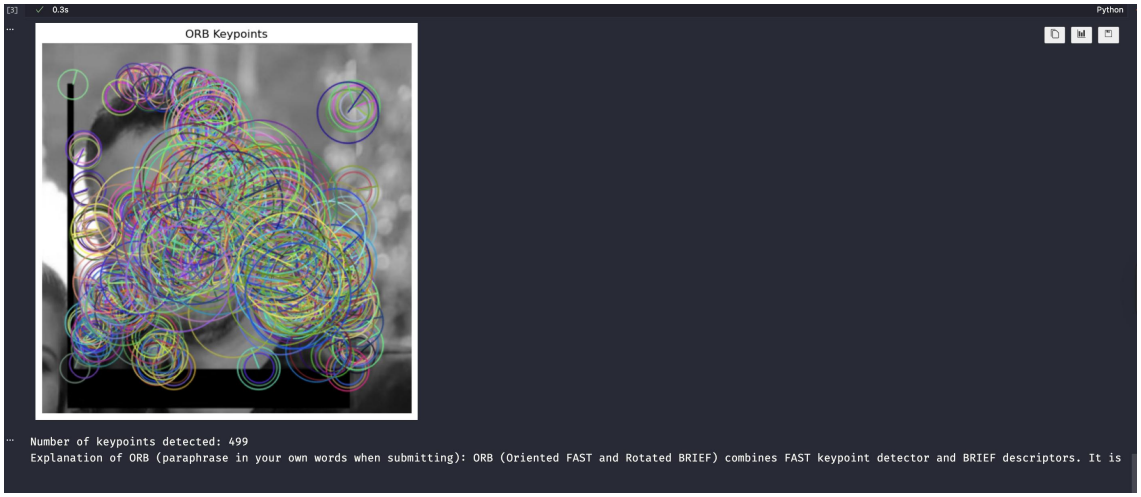


Explanations:
- Translation shifts the image in x/y without changing content, useful for aligning or simulating camera movement.
- Rotation changes orientation around a center; here 45° rotates the image, affecting its viewpoint.
- Scaling resizes; downsampling (half) reduces detail, upsampling (double) may introduce interpolation artifacts.
- Gaussian blur smooths by averaging neighboring pixels with a Gaussian kernel, reducing high-frequency noise.
- Median blur replaces each pixel with the median of its neighborhood, preserving edges better while removing salt-and-pepper noi
- Canny edge detection finds sharp intensity gradients, highlighting object boundaries.

Part 3: Extracting Features using ORB

Use ORB to detect keypoints on the grayscale image, visualize them, and explain how ORB works and its benefits.

```python
# ORB feature detection
if 'image_gray_497' in globals():
    orb_497 = cv2.ORB_create(nfeatures=500)
    keypoints_497, descriptors_497 = orb_497.detectAndCompute(image_gray_497, None)
    # Draw keypoints on the image
    orb_visual_497 = cv2.drawKeypoints(image_gray_497, keypoints_497, None, flags=cv2.DRAW_MATCHES_FLAGS_DRAW_RICH_KEYPOINTS)
    # Show
    plt.figure(figsize=(8,6))
    plt.imshow(orb_visual_497, cmap='gray')
    plt.title("ORB Keypoints")
    plt.axis('off')
    plt.tight_layout()
    plt.show()
    print(f"Number of keypoints detected: {len(keypoints_497)}")

    # Short explanation placeholder
    explanation_orb = """ORB (Oriented FAST and Rotated BRIEF) combines FAST keypoint detector and BRIEF descriptors. It is scale and rotation invariant to a degre
    print("Explanation of ORB (paraphrase in your own words when submitting):", explanation_orb)
else:
    print("Grayscale image not available; cannot run ORB feature extraction.")
```

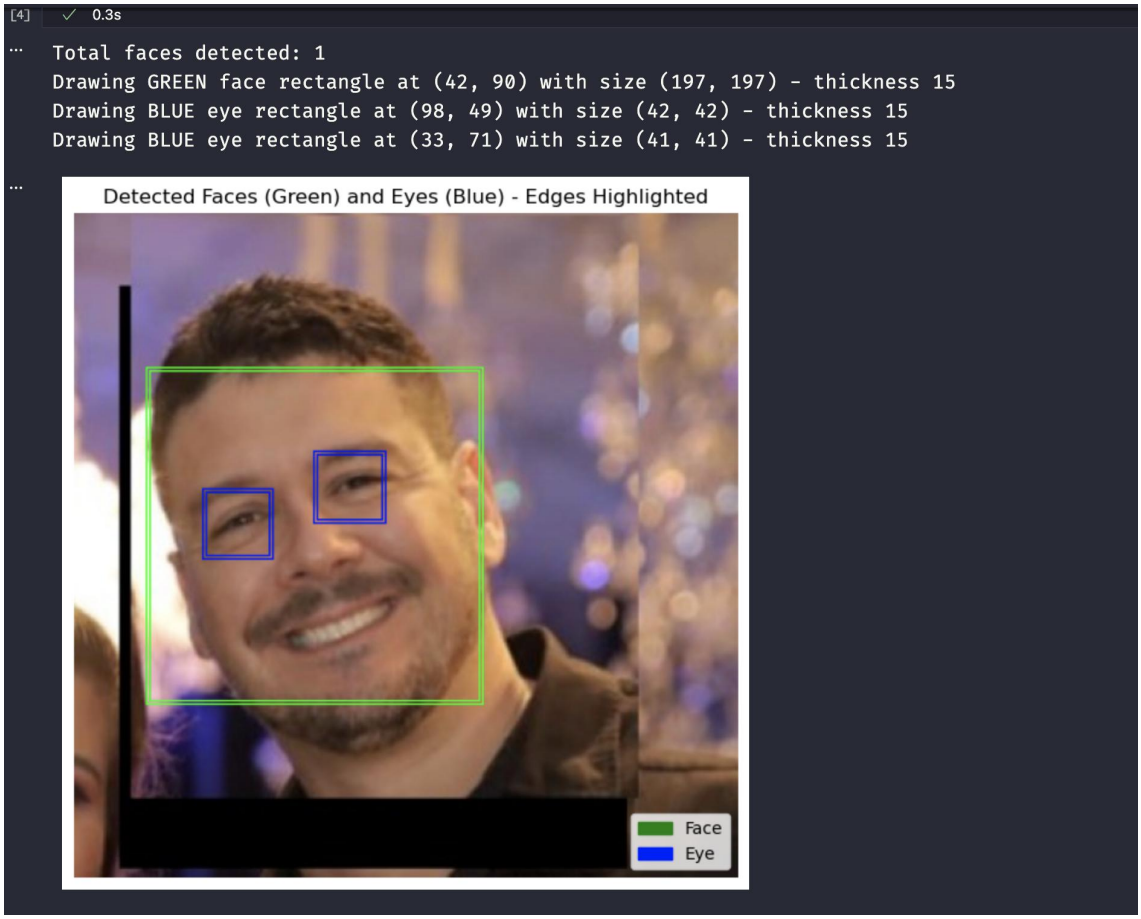


Part 4: Face and Eye Detection (Haar Cascade Classifier)

Detect faces and eyes on the image and discuss real-world applications.

```python
# Load Haar cascades from OpenCV's data (should be available in standard installation)
face_cascade_497 = cv2.CascadeClassifier(cv2.data.haarcascades + 'haarcascade_frontalface_default.xml')
eye_cascade_497 = cv2.CascadeClassifier(cv2.data.haarcascades + 'haarcascade_eye.xml')

if 'image_bgr_497' in globals() and image_bgr_497 is not None:
    gray_for_detection_497 = cv2.cvtColor(image_bgr_497, cv2.COLOR_BGR2GRAY)
    all_faces = face_cascade_497.detectMultiScale(gray_for_detection_497, scaleFactor=1.05, minNeighbors=3, minSize=(30,3
    # Keep only the largest face
    faces_497 = sorted(all_faces, key=lambda f: f[2]*f[3], reverse=True)[:1]
    annotated_497 = image_bgr_497.copy()
    #translate to english espessura
    #translate to english espessura

    line_thickness = 1

    # Draw rectangles for detected faces and eyes
    print(f"Total faces detected: {len(faces_497)}")
    for (x, y, w, h) in faces_497:
        # Green rectangle for face
        print(f"Drawing GREEN face rectangle at ({x}, {y}) with size ({w}, {h}) - thickness 15")
        cv2.rectangle(annotated_497, (x, y), (x+w, y+h), (0,255, 1), 1)
        cv2.rectangle(annotated_497, (x+2, y+2), (x+w-2, y+h-2), (0,255, 1), line_thickness)
        cv2.rectangle(annotated_497, (x+2, y+2), (x+w-2, y+h-2), (0,255, 1), line_thickness)
        roi_gray_497 = gray_for_detection_497[y:y+h, x:x+w]
        roi_color_497 = annotated_497[y:y+h, x:x+w]
        all_eyes = eye_cascade_497.detectMultiScale(roi_gray_497, scaleFactor=1.05, minNeighbors=3, minSize=(15,15))
        # Keep only the two most prominent eyes
        eyes_497 = sorted(all_eyes, key=lambda e: e[2]*e[3], reverse=True)[:2]
```

```python
    # Draw rectangles for detected faces and eyes
    print(f"Total faces detected: {len(faces_497)}")
    for (x, y, w, h) in faces_497:
        # Green rectangle for face
        print(f"Drawing GREEN face rectangle at ({x}, {y}) with size ({w}, {h}) - thickness 15")
        cv2.rectangle(annotated_497, (x, y), (x+w, y+h), (0,255, 1), 1)
        cv2.rectangle(annotated_497, (x+2, y+2), (x+w-2, y+h-2), (0,255, 1), line_thickness)
        cv2.rectangle(annotated_497, (x+2, y+2), (x+w-2, y+h-2), (0,255, 1), line_thickness)
        roi_gray_497 = gray_for_detection_497[y:y+h, x:x+w]
        roi_color_497 = annotated_497[y:y+h, x:x+w]
        all_eyes = eye_cascade_497.detectMultiScale(roi_gray_497, scaleFactor=1.05, minNeighbors=3, minSize=(15,15))
        # Keep only the two most prominent eyes
        eyes_497 = sorted(all_eyes, key=lambda e: e[2]*e[3], reverse=True)[:2]
        for (ex, ey, ew, eh) in eyes_497:
            # Blue rectangle for eyes
            print(f"Drawing BLUE eye rectangle at ({ex}, {ey}) with size ({ew}, {eh}) - thickness 15")
            cv2.rectangle(annotated_497, (x+ex, y+ey), (x+ex+ew, y+ey+eh), (255,0, 1), 1)
            cv2.rectangle(annotated_497, (x+ex+2, y+ey+2), (x+ex+ew-2, y+ey+eh-2), (255,0, 1), line_thickness)
            cv2.rectangle(annotated_497, (x+ex+2, y+ey+2), (x+ex+ew-2, y+ey+eh-2), (255,0, 1), line_thickness)
    # Display result with legend for rectangle colors
    plt.figure(figsize=(8,6))
    plt.imshow(cv2.cvtColor(annotated_497, cv2.COLOR_BGR2RGB))
    plt.title("Detected Faces (Green) and Eyes (Blue) - Edges Highlighted")
    plt.axis('off')
    # Add custom legend for rectangles
    import matplotlib.patches as mpatches
    green_patch = mpatches.Patch(color='green', label='Face')
    blue_patch = mpatches.Patch(color='blue', label='Eye')
    plt.legend(handles=[green_patch, blue_patch], loc='lower right')
    plt.tight_layout()
    plt.show()
```



As we can see, the face and the eyes were detected by the model.