

## Lab03 (Image) Screenshots

### 1. Introduction (10 minutes)

Computer vision has been a very popular field since the advent of digital systems. However, computer vision on the edge devices such as Raspberry Pi is challenging due to resource constraints. Edge Computer Vision (ECV) has emerged as a transformative technology, with Gartner recognizing it as one of the top emerging technologies of 2023. ECV offers several benefits such as 1) they can operate in real-time or near-real-time, providing instant insights and enabling immediate actions, 2) they offer enhanced privacy and security and 3) It reduces dependency on network connectivity or relaxes the bandwidth requirements as some processing will be done within. In this lab, few basic and advanced image processing tasks on edge devices is introduced.

### 2. Setting up the Raspberry Pi

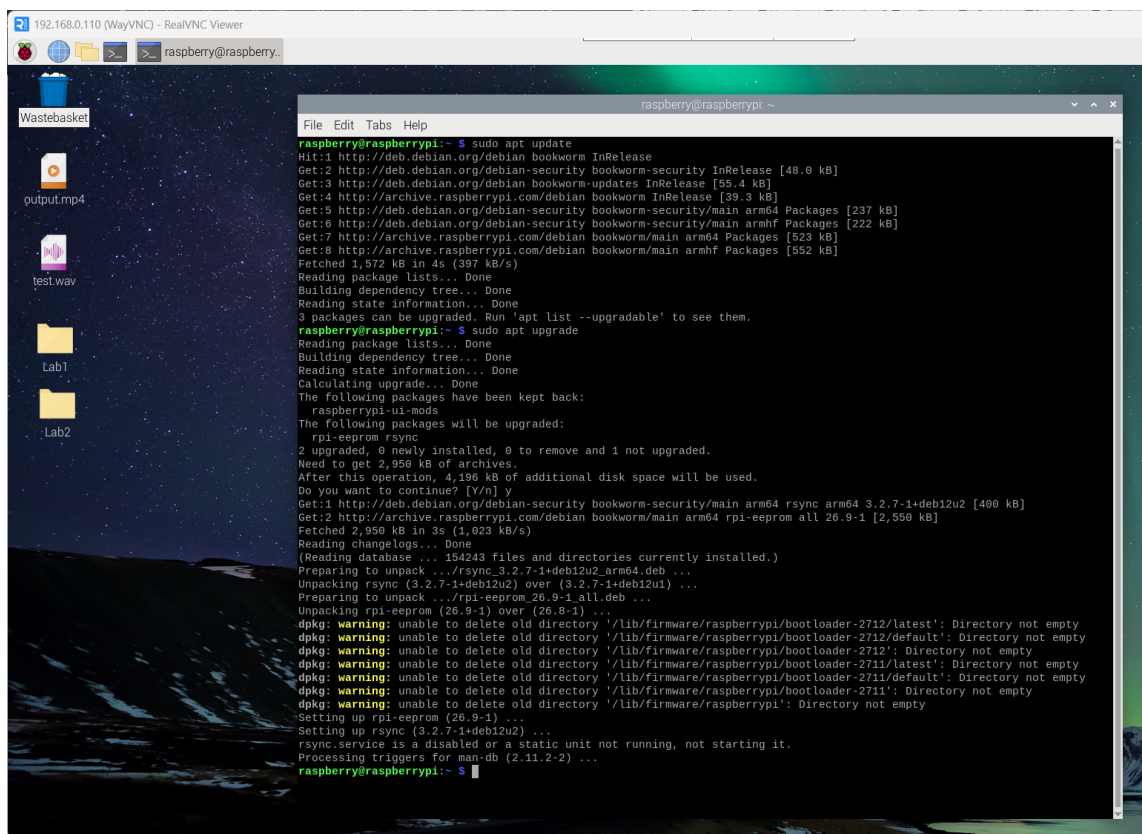


Figure 1. Screenshot of system update of Raspberry Pi OS.

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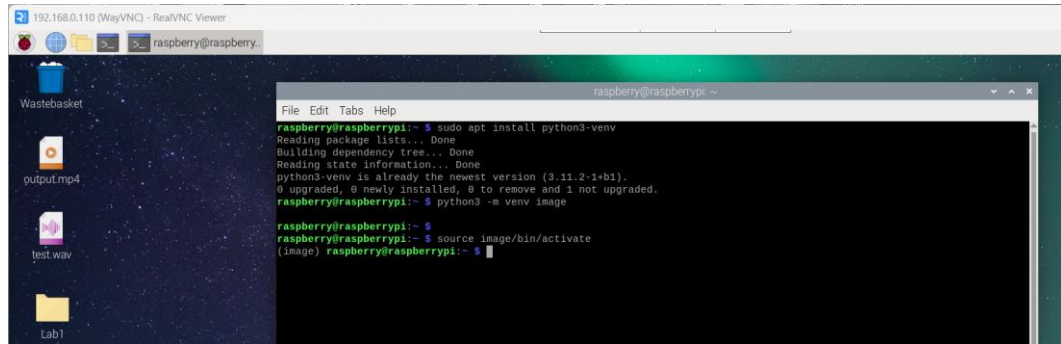


Figure 2. Screenshot of activating a virtual environment named “image” to avoid conflicts in libraries.

### 3. Connecting and Testing the Web Camera (15 minutes)



Figure 3. Screenshot of physically connect the web camera to the Raspberry Pi via USB connection.

### 4. Introduction to Real-time Image Processing with Python (25 minutes)

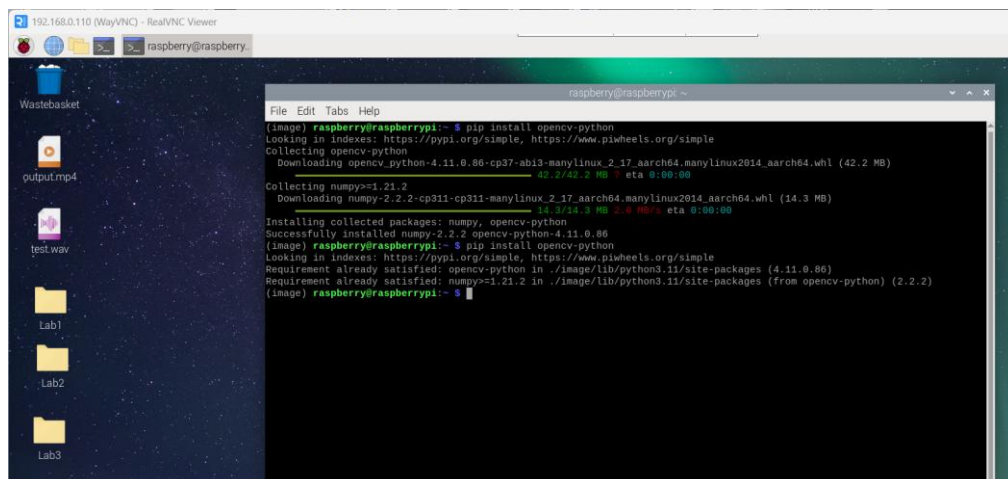


Figure 3. Screenshot of installation of OpenCV library.

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```
1  # Reference: https://pyimagesearch.com/2014/08/04/opencv-python-color-detection/
2  import cv2
3  import numpy as np
4
5  #%% Defining a list of boundaries in the RGB color space
6  # (or rather, BGR, since OpenCV represents images as NumPy arrays in reverse order)
7  # Refer to https://docs.opencv.org/3.4/da/d97/tutorial_threshold_inRange.html
8  boundaries = [
9      ([17, 15, 100], [50, 56, 200]), # For Red
10     ([86, 31, 4], [220, 88, 50]), # For Blue
11     ([25, 90, 4], [62, 200, 50]), # For Green
12     ([0, 190, 190], [80, 255, 255]) # For Yellow ←
13 ]
14
15 #%% Normalize the Image for display (Optional)
16 def normalizeImg (img):
17     img = np.float64(img) #Converting to float to avoid errors due to division
18     norm_img = (img - np.min(img))/(np.max(img) - np.min(img))
19     norm_img = np.uint8(norm_img*255.0)
20     return norm_img
21
22 #%% Open CV Video Capture and frame analysis
23 cap = cv2.VideoCapture(0)
24
25 # Check if the webcam is opened correctly
26 if not cap.isOpened():
27     raise IOError("Cannot open webcam")
28
29 # The loop will break on pressing the 'q' key
30 while True:
31     try:
32         # Capture one frame
33         ret, frame = cap.read()
34
35         output=[]
36
37         # loop over the boundaries
38         for (lower, upper) in boundaries:
39             # create NumPy arrays from the boundaries
40             lower = np.array(lower, dtype = "uint8")
41             upper = np.array(upper, dtype = "uint8")
42
43             # find the colors within the specified boundaries and apply the mask (basically segmenting for colours)
44             mask = cv2.inRange(frame, lower, upper)
45             output.append(cv2.bitwise_and(frame, frame, mask = mask)) #Segmented frames are appended
46
47             # Output is appended to be of size Pixels X 4 (for R, G, B and Y)
48             red_img = normalizeImg(output[0])
49             green_img = normalizeImg(output[1])
50             blue_img = normalizeImg(output[2])
51             yellow_img = normalizeImg(output[3]) ←
52
53             # horizontal Concatination for displaying the images and colour segmentations
54             catImg = cv2.hconcat([frame, red_img, green_img, blue_img, yellow_img]) ←
55             cv2.imshow("Images with Colours", catImg)
56
57             if cv2.waitKey(1) & 0xFF == ord('q'):
58                 break
59
60     except KeyboardInterrupt:
61         break
62
63 cap.release()
64 cv2.destroyAllWindows()
65
66 #end
```

Figure 4. Screenshot of expanding the sample code to segment the colour yellow, on top of the Red-Green-Blue (RGB) colour channels.

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### 5. Real-time Image Analysis (25 minutes)

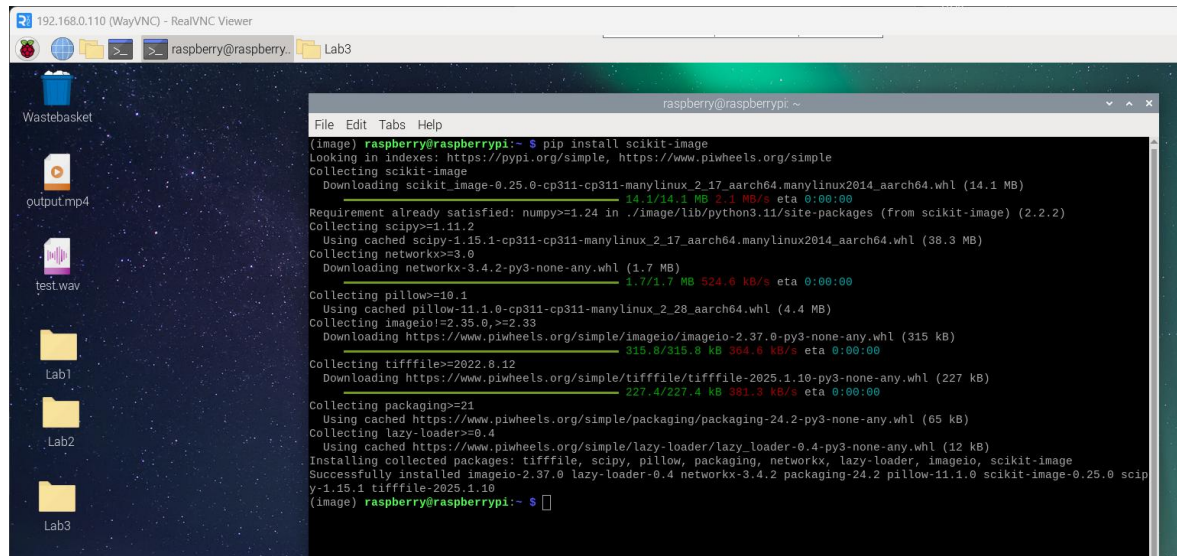


Figure 5. Screenshot of installation of scikit-image library

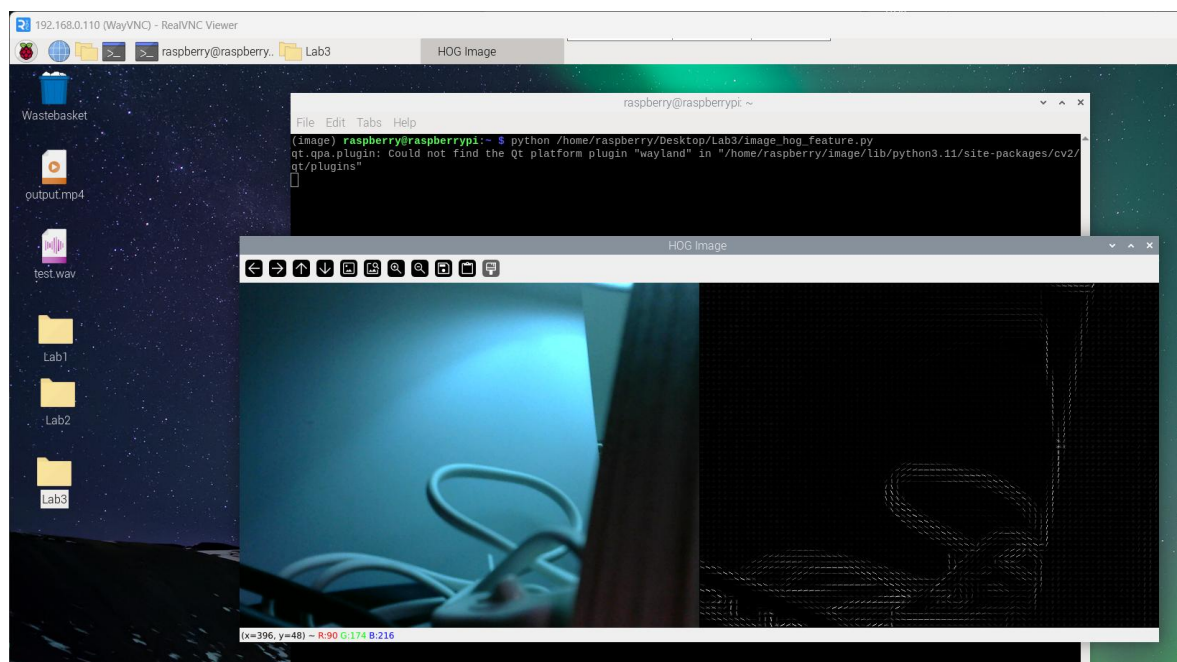


Figure 6. Screenshot of running the image\_hog\_feature.py file without resizing the image



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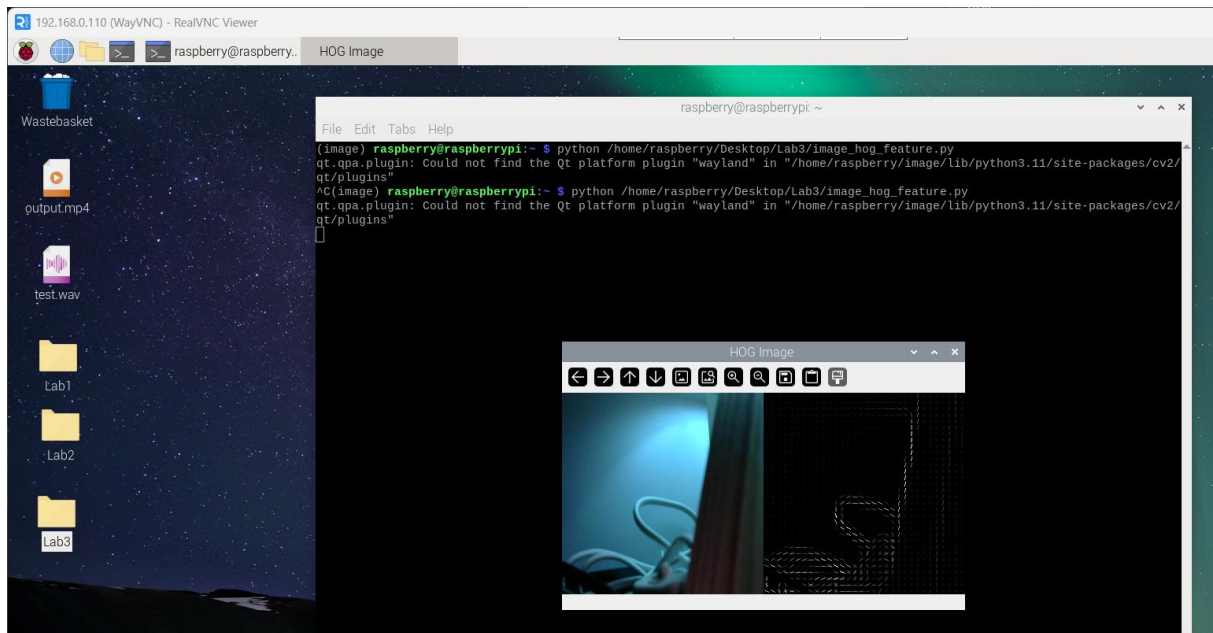


Figure 7. Screenshot of running the image\_hog\_feature.py file after resizing the image to 256 x 256 resolution for faster detection

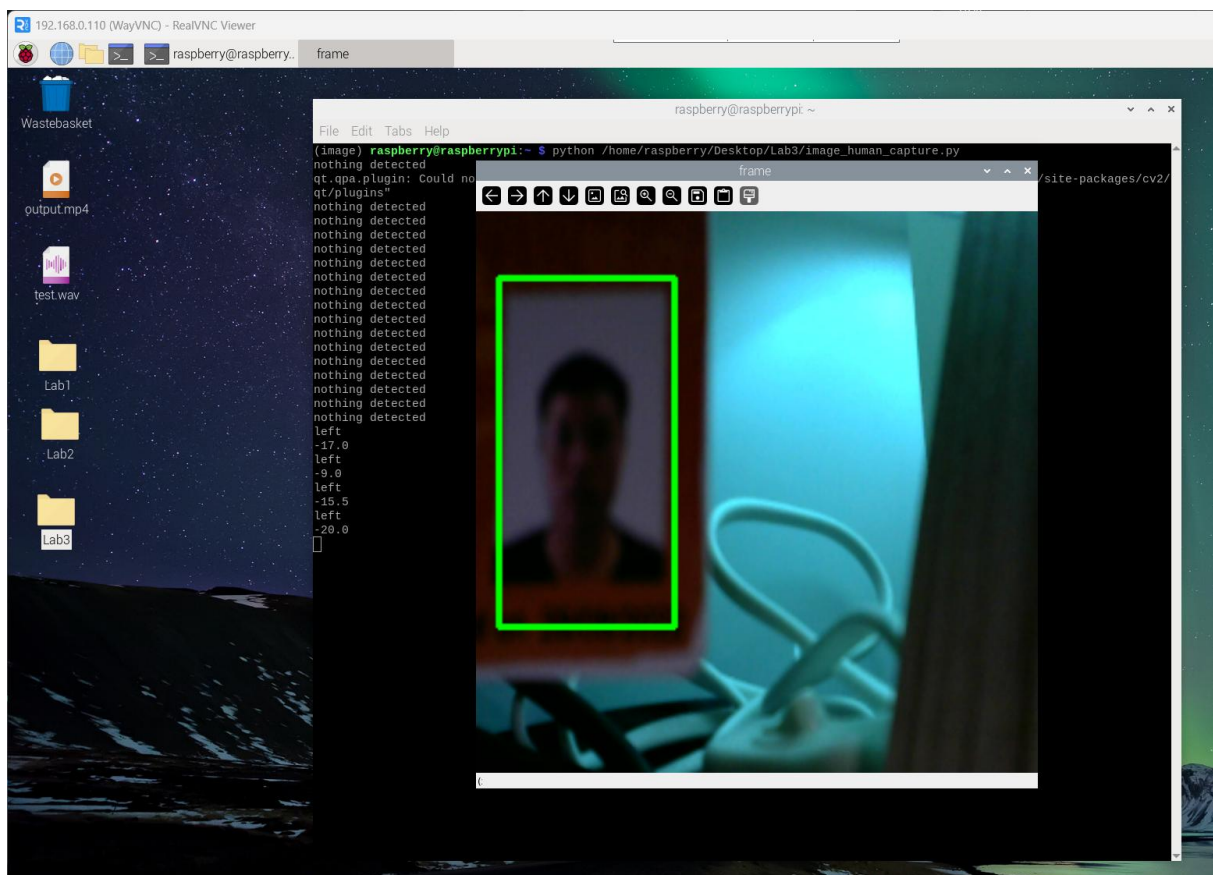
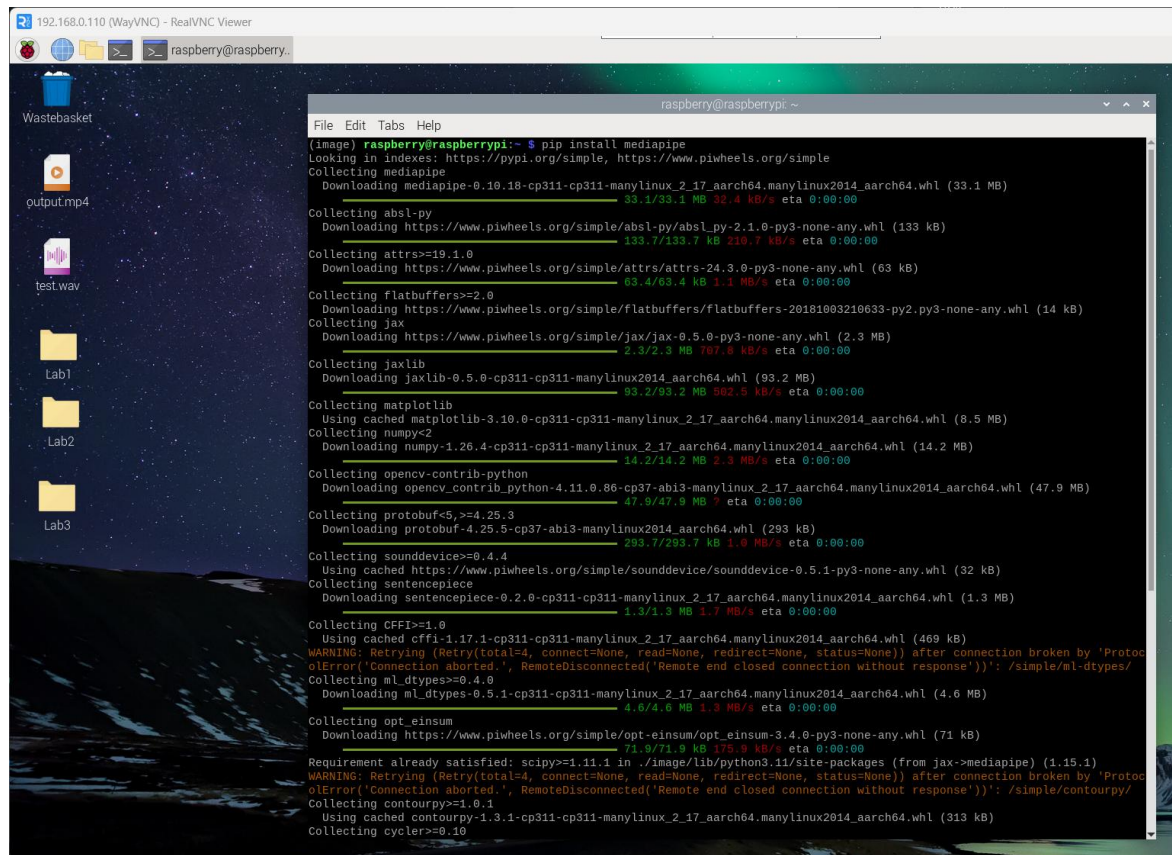


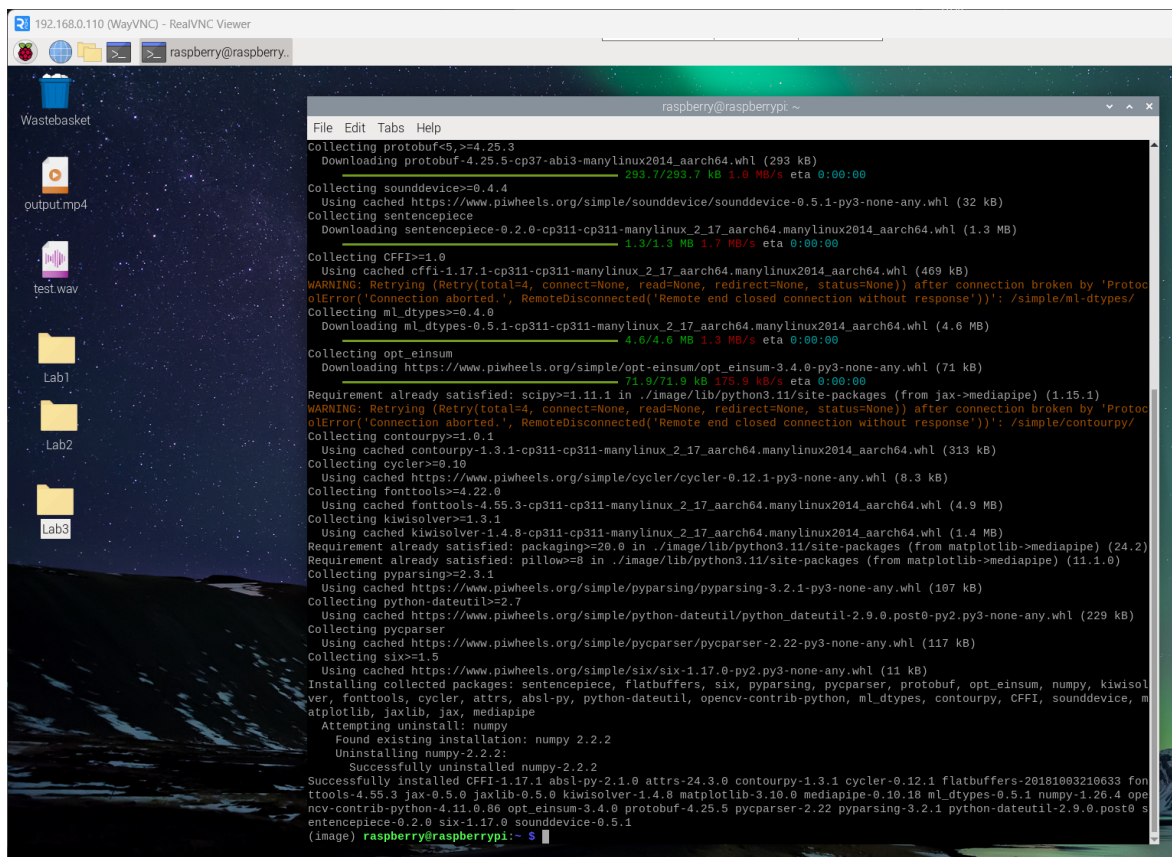
Figure 8. Screenshot of running the image\_human\_capture.py file to identify presence of face

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### 6. Real-time Image Feature Analysis for Face Capture and Facial Landmark Extraction (20 minutes)



```
File Edit Tabs Help
raspberrypi@raspberrypi: ~
$ pip install mediapipe
Looking in indexes: https://pypi.org/simple, https://www.piwheels.org/simple
Collecting mediapipe
  Downloading mediapipe-0.10.18-cp311-cp311-manylinux_2_17_aarch64.manylinux2014_aarch64.whl (33.1 MB)
    83.1/33.1 MB 32.4 KB/s eta 0:00:00
Collecting absl-py
  Downloading https://www.piwheels.org/simple/absl-py/absl_py-2.1.0-py3-none-any.whl (133 kB)
    133.7/133.7 KB 210.7 KB/s eta 0:00:00
Collecting attr==19.1.0
  Downloading https://www.piwheels.org/simple/attrs/attrs-24.3.0-py3-none-any.whl (63 kB)
    63.4/63.4 KB 1.1 MB/s eta 0:00:00
Collecting flatbuffers>=2.0
  Downloading https://www.piwheels.org/simple/flatbuffers/flatbuffers-20181003210633-py2.py3-none-any.whl (14 kB)
Collecting jax
  Downloading https://www.piwheels.org/simple/jax/jax-0.5.0-py3-none-any.whl (2.3 MB)
    2.3/2.3 MB 707.0 KB/s eta 0:00:00
Collecting jaxlib
  Downloading jaxlib-0.5.0-cp311-cp311-manylinux_2_17_aarch64.whl (93.2 MB)
    93.2/93.2 MB 502.5 KB/s eta 0:00:00
Collecting matplotlib
  Using cached matplotlib-3.10.0-cp311-cp311-manylinux_2_17_aarch64.manylinux2014_aarch64.whl (8.5 MB)
Collecting numpy<2
  Downloading numpy-1.26.4-cp311-cp311-manylinux_2_17_aarch64.manylinux2014_aarch64.whl (14.2 MB)
    14.2/14.2 MB 2.3 MB/s eta 0:00:00
Collecting opencv-contrib-python
  Downloading opencv_contrib_python-4.11.0.86-cp37-abi3-manylinux_2_17_aarch64.manylinux2014_aarch64.whl (47.9 MB)
    47.9/47.9 MB 7 eta 0:00:00
Collecting protobuf<5,>=4.25.3
  Downloading protobuf-4.25.5-cp37-abi3-manylinux2014_aarch64.whl (293 kB)
    293.7/293.7 KB 1.0 MB/s eta 0:00:00
Collecting sounddevice>=0.4.4
  Using cached https://www.piwheels.org/simple/sounddevice/sounddevice-0.5.1-py3-none-any.whl (32 kB)
Collecting sentencepiece
  Downloading sentencepiece-0.2.0-cp311-cp311-manylinux_2_17_aarch64.manylinux2014_aarch64.whl (1.3 MB)
    1.3/1.3 MB 1.7 MB/s eta 0:00:00
Collecting CFPI>=1.0
  Using cached cfpi-1.17.1-cp311-cp311-manylinux_2_17_aarch64.manylinux2014_aarch64.whl (469 kB)
WARNING: Retrying (Retry(total=4, connect=None, read=None, redirect=None, status=None)) after connection broken by 'ProtocolError('Connection aborted.', RemoteDisconnected('Remote end closed connection without response'))': /simple/ml-dtypes/
Collecting ml_dtypes>=0.4.0
  Downloading ml_dtypes-0.5.1-cp311-cp311-manylinux_2_17_aarch64.manylinux2014_aarch64.whl (4.6 MB)
    4.6/4.6 MB 1.3 MB/s eta 0:00:00
Collecting opt_einsum
  Downloading https://www.piwheels.org/simple/opt-einsum/opt_einsum-3.4.0-py3-none-any.whl (71 kB)
    71.9/71.9 KB 175.9 KB/s eta 0:00:00
Requirement already satisfied: scipy>=1.11.1 in ./image/lib/python3.11/site-packages (from jax->mediapipe) (1.15.1)
WARNING: Retrying (Retry(total=4, connect=None, read=None, redirect=None, status=None)) after connection broken by 'ProtocolError('Connection aborted.', RemoteDisconnected('Remote end closed connection without response'))': /simple/contourpy/
Collecting contourpy>=1.0.1
  Using cached contourpy-1.3.1-cp311-cp311-manylinux_2_17_aarch64.manylinux2014_aarch64.whl (313 kB)
Collecting cycler>=0.10
  Using cached https://www.piwheels.org/simple/cycler/cycler-0.12.1-py3-none-any.whl (8.3 kB)
Collecting fonttools>=4.22.0
  Using cached fonttools-4.55.3-cp311-cp311-manylinux_2_17_aarch64.manylinux2014_aarch64.whl (4.9 MB)
Collecting kiwisolver>=1.3.1
  Using cached kiwisolver-1.4.8-cp311-cp311-manylinux_2_17_aarch64.manylinux2014_aarch64.whl (1.4 MB)
Requirement already satisfied: packaging>=20.0 in ./image/lib/python3.11/site-packages (from matplotlib->mediapipe) (24.2)
Requirement already satisfied: pillow>=8 in ./image/lib/python3.11/site-packages (from matplotlib->mediapipe) (11.1.0)
Collecting pyparsing>=2.3.1
  Using cached https://www.piwheels.org/simple/pyparsing/pyparsing-3.2.1-py3-none-any.whl (107 kB)
Collecting python-dateutil>=2.7
  Using cached https://www.piwheels.org/simple/python-dateutil/python_dateutil-2.9.0.post0-py2.py3-none-any.whl (229 kB)
Collecting pycparser
  Using cached https://www.piwheels.org/simple/pycparser/pycparser-2.22-py3-none-any.whl (117 kB)
Collecting six>=1.5
  Using cached https://www.piwheels.org/simple/six/six-1.17.0-py2.py3-none-any.whl (11 kB)
Installing collected packages: sentencepiece, flatbuffers, six, pyparsing, pycparser, protobuf, opt_einsum, numpy, kiwisolver, fonttools, cycler, attrs, absl-py, python-dateutil, opencv-contrib-python, ml_dtypes, contourpy, CFPI, sounddevice, mediapipe
Attempting uninstall: numpy
  Found existing installation: numpy 2.2.2
  Uninstalling numpy-2.2.2:
    Successfully uninstalled numpy-2.2.2
Successfully installed CFPI-1.17.1 absl-py-2.1.0 attrs-24.3.0 contourpy-1.3.1 cycler-0.12.1 flatbuffers-20181003210633 fonttools-4.55.3 jax-0.5.0 jaxlib-0.5.0 kiwisolver-1.4.8 matplotlib-3.10.0 mediapipe-0.10.18 ml_dtypes-0.5.1 numpy-1.26.4 opencv-contrib-python-4.11.0.86 opt_einsum-3.4.0 protobuf-4.25.5 pycparser-2.22 pyparsing-3.2.1 python-dateutil-2.9.0.post0 sentencepiece-0.2.0 six-1.17.0 sounddevice-0.5.1
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  Using cached fonttools-4.55.3-cp311-cp311-manylinux_2_17_aarch64.manylinux2014_aarch64.whl (4.9 MB)
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Attempting uninstall: numpy
  Found existing installation: numpy 2.2.2
  Uninstalling numpy-2.2.2:
    Successfully uninstalled numpy-2.2.2
Successfully installed CFPI-1.17.1 absl-py-2.1.0 attrs-24.3.0 contourpy-1.3.1 cycler-0.12.1 flatbuffers-20181003210633 fonttools-4.55.3 jax-0.5.0 jaxlib-0.5.0 kiwisolver-1.4.8 matplotlib-3.10.0 mediapipe-0.10.18 ml_dtypes-0.5.1 numpy-1.26.4 opencv-contrib-python-4.11.0.86 opt_einsum-3.4.0 protobuf-4.25.5 pycparser-2.22 pyparsing-3.2.1 python-dateutil-2.9.0.post0 sentencepiece-0.2.0 six-1.17.0 sounddevice-0.5.1
(image) raspberrypi@raspberrypi: ~
```

Figure 9. Screenshot of installation of mediapipe library

## Lab03 (Image) Screenshots

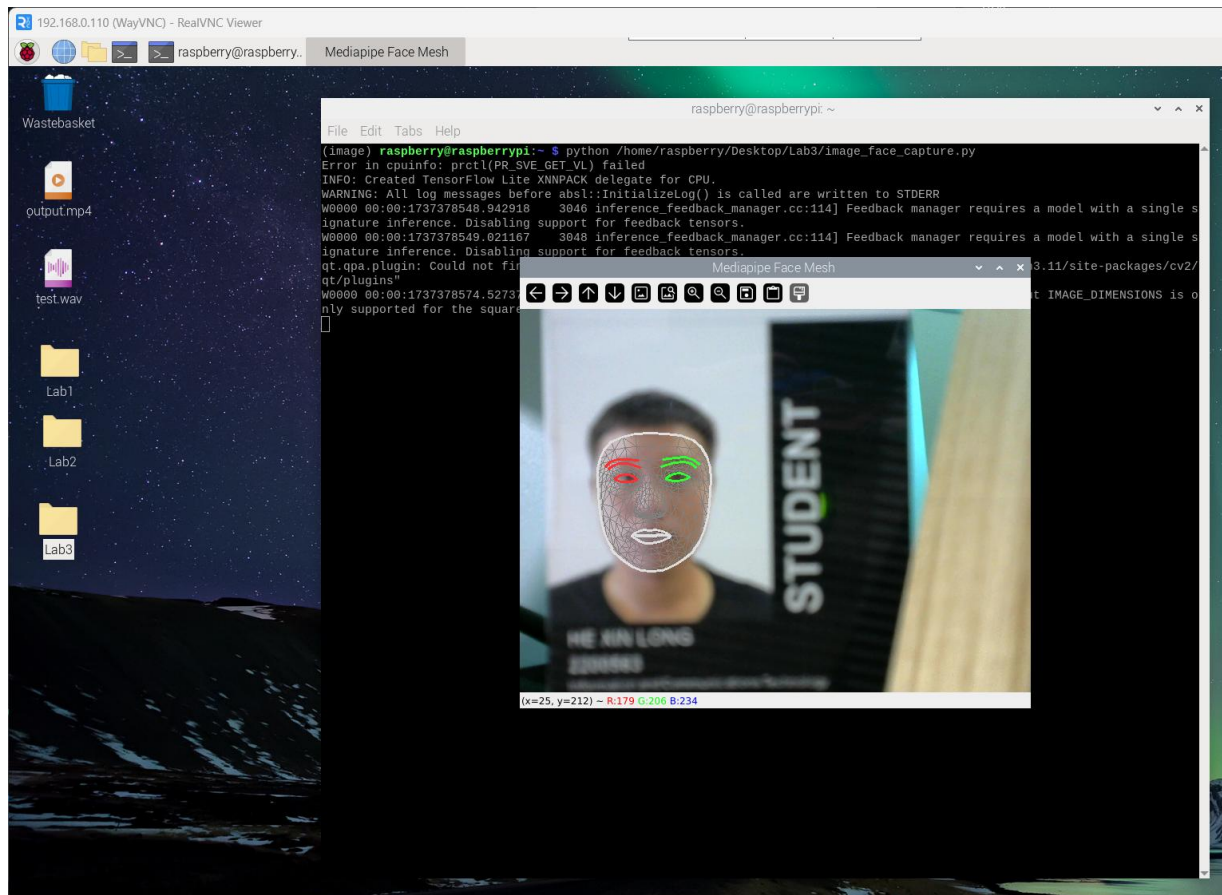


Figure 9. Screenshot of running the `image_face_capture.py` file to detect the face based on MediaPipe's approach