Emotion, Age and Gender Extraction from Human Faces in Raspberry Pi based Video Surveillance with Low Cost Webcams.

Department of Information Technology,
Indian Institute of Engineering Science and Technology, Shibpur

4th Semester Mini Project (IT2291)
Under Supervision of Dr.Ruchira Naskar

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Contents

- Introduction
- Use Cases
- Workflow of the system
- Raspberry Pi setup
- deepface
- Emotion, Gender and Age extraction from video stream
- References

Objective

- To implement a real-time video surveillance using webcam/ CCTV, connected with a Raspberry pi, which forms an edge device.
- To extract the information like age, emotion and gender of the captured face using the light weight edge computation unit.

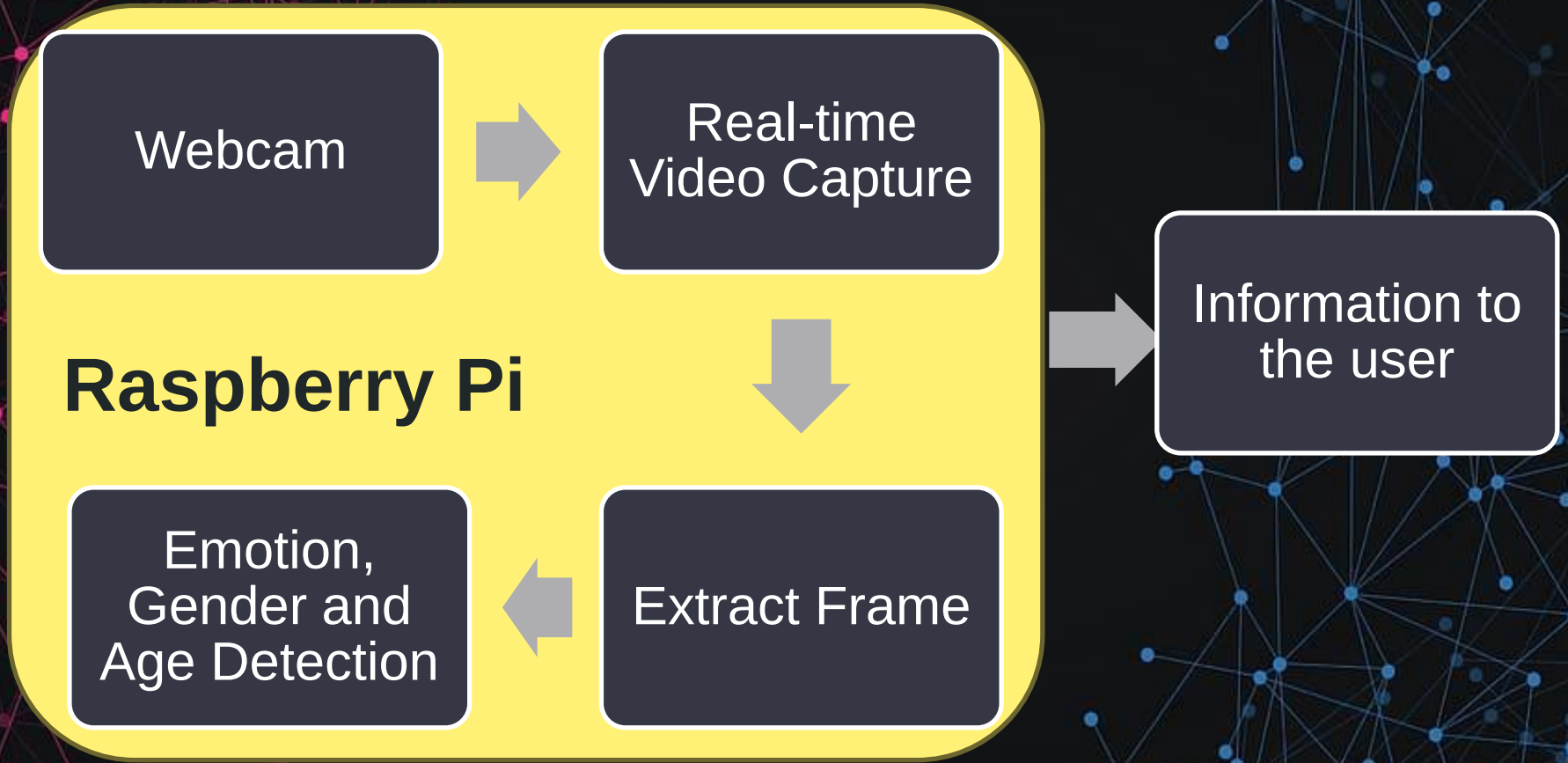
Uses Cases:

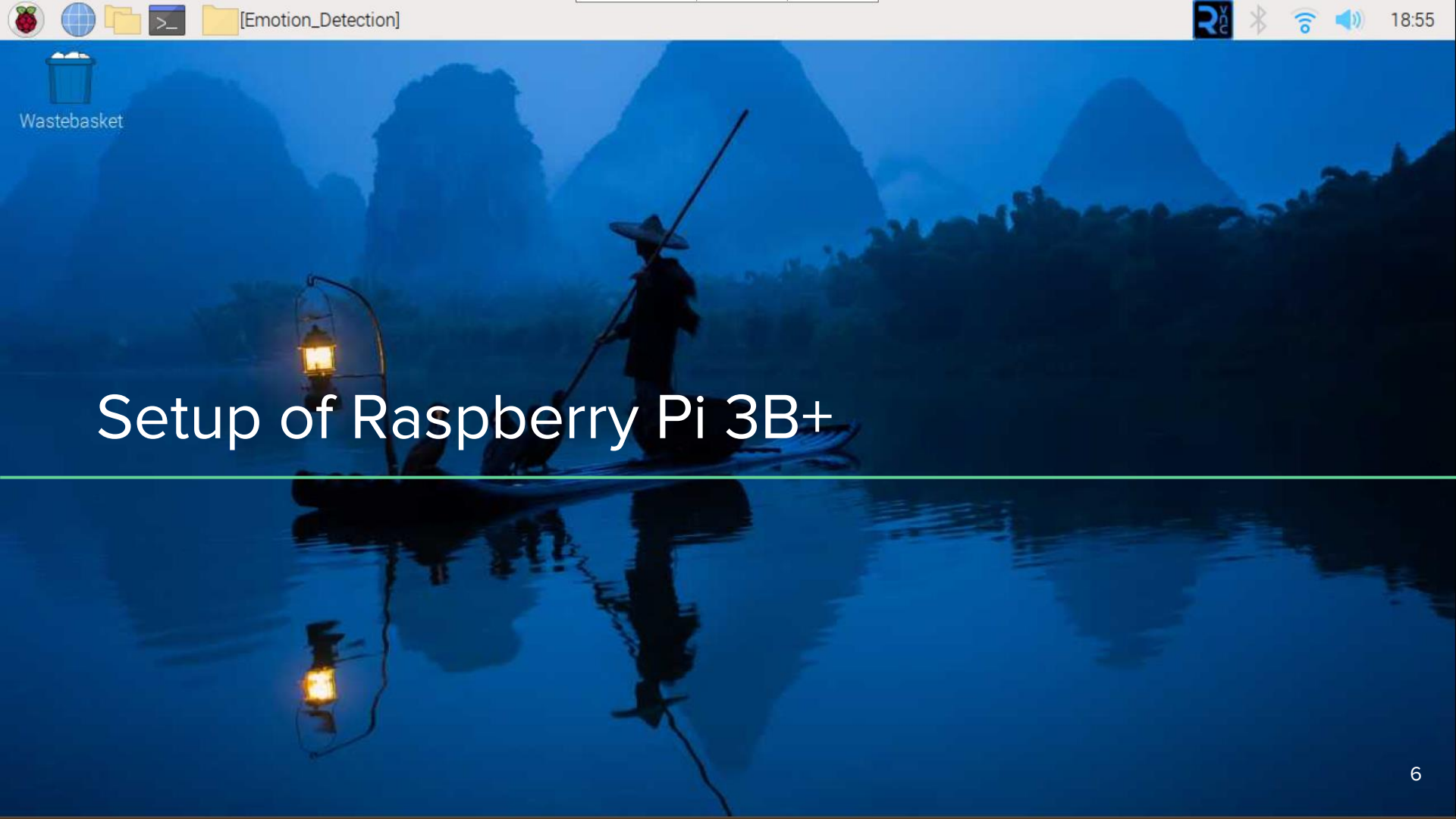
- Use Case: Monitoring entry points (doors, windows) for unauthorized access.
- Scenario: Receive alerts when unknown faces are detected, along with their estimated age, gender, and emotional state.

- Customer sentiment analysis: Emotion detection can gauge customer satisfaction during interactions with staff, prompting interventions if negativity is detected.

- Targeted Advertising: By recognizing recurring customers and their demographics (age, gender), the system can display targeted promotions on nearby screens.

Workflow of the system




[Emotion_Detection]
18:55
Wastebasket
Setup of Raspberry Pi 3B+

Step-wise Setup Process

- Downloaded the latest Raspberry Pi OS : 64 bit Debian version: 12 (Bookworm)

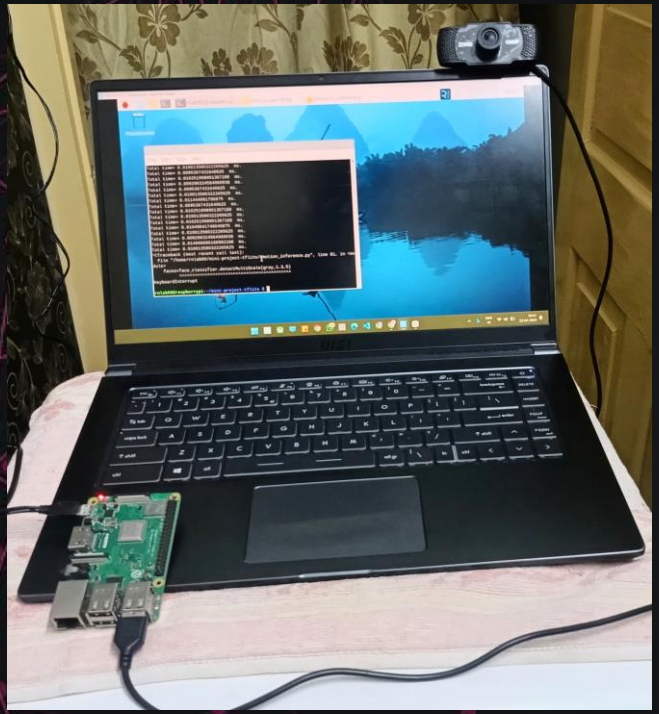
- Used the Raspberry Pi Imager for writing the OS image to a SD card.

- Inserted the SD card into the Raspberry Pi and connected peripherals:
  - Keyboard, mouse, webcam in USB ports
  - Display cable in HDMI port
  - Provided power cord

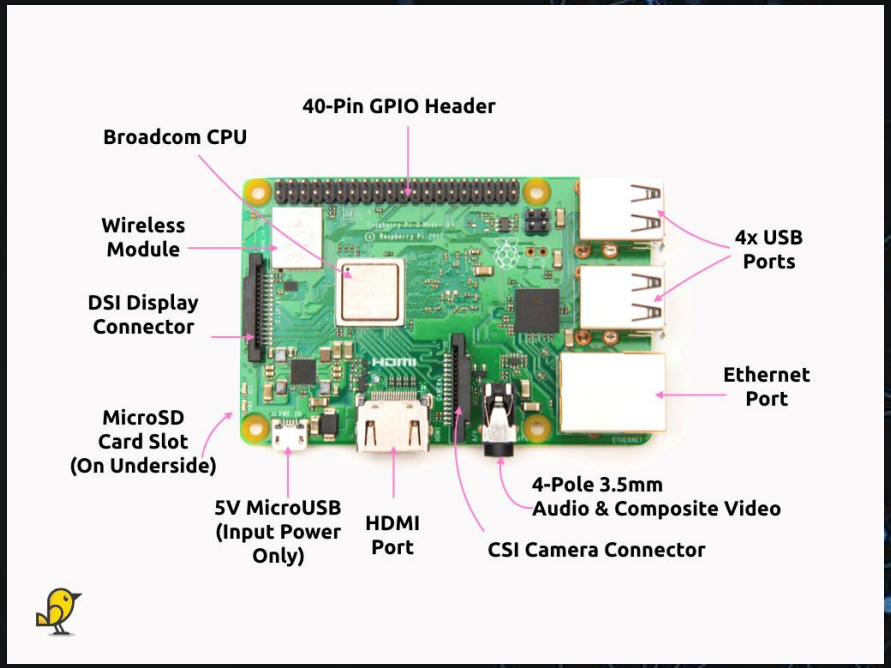
- Powered up the Raspberry Pi and did some initial setup steps: language, username / password, connect to the network, etc.
- Performed a full system update & upgrade.

- Did the required steps for accessing Raspberry Pi via SSH (only terminal) and VNC (GUI with full access) for headless operation (accessing through laptop/ desktop w/o physically connecting Pi to it).

- Raspberry Pi 3B+
- 1GB RAM
- 128GB SD card storage

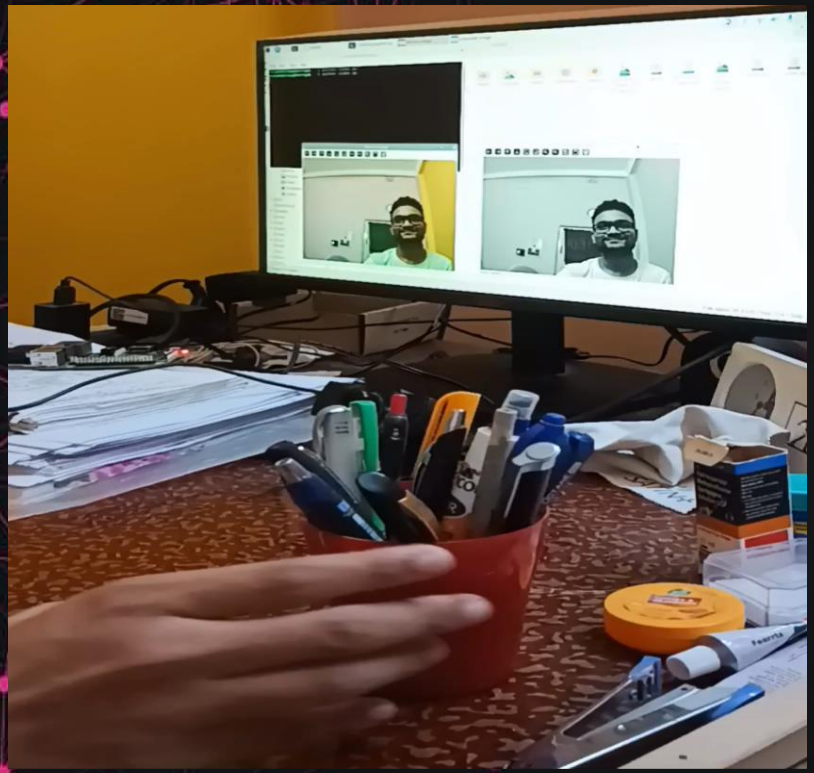


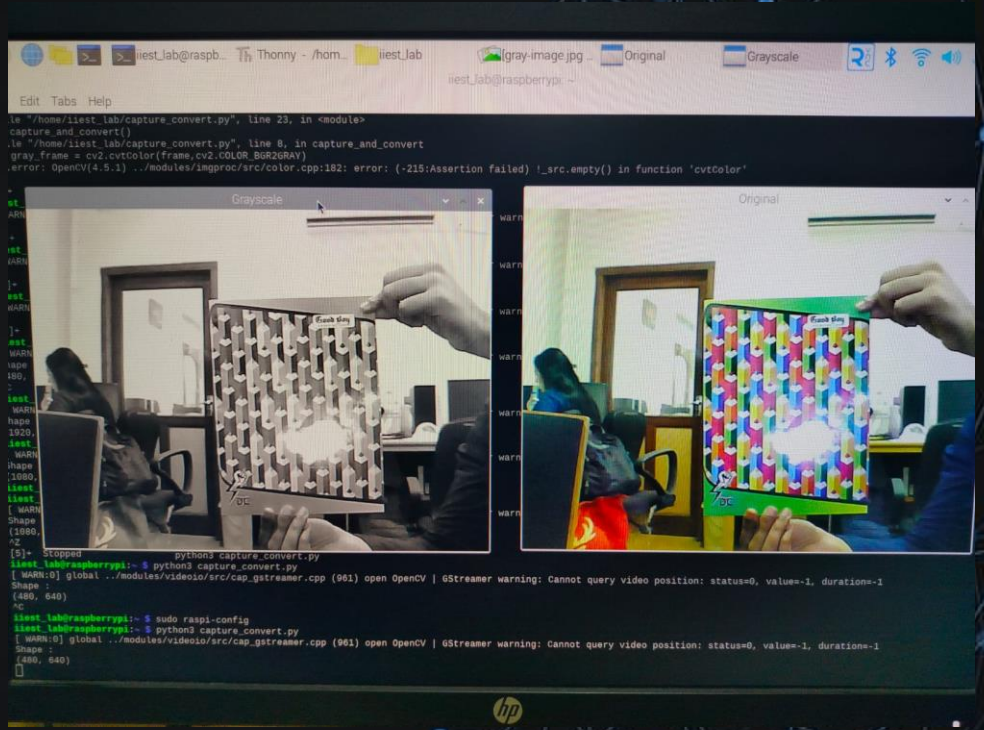
Raspberry Pi connected with USB webcam and connected to laptop wirelessly via VNC



Raspberry Pi 3B+

Preliminary Performance Tests





Realtime RGB to grayscale video conversion

Emotion, Age and Gender Extraction from Human Faces at Edge

Edge Computing

Edge computing offers lower latency, faster data processing, reduced bandwidth usage, and improved security by processing data closer to the source or end-user device

deepface and its Limitations in RPi

- We tried to run ‘deepface’ on Raspberry Pi using different models available in the framework but Raspberry Pi 3B+ (1GB RAM) couldn’t support the real-time facial attribution computations.
- As a result, the RPi hanged every time we tested a model with the CPU chip becoming excessively heated up.
- Hence our mentor asked us to find a model which must be lightweight and could run within the resource constraints.

README MIT license

deepface

pypi downloads 2M | conda downloads 14k | stars 10k | license MIT | Tests and Linting passing

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DOI 10.1109/ASYU50717.2020.9259802 DOI 10.1109/ICEET53442.2021.9659697

Deepface is a lightweight face recognition and facial attribute analysis (age, gender, emotion and race) framework for python. It is a hybrid face recognition framework wrapping **state-of-the-art** models: VGG-Face, FaceNet, OpenFace, DeepFace, DeepID, ArcFace, Dlib, SFace and GhostFaceNet.

Experiments show that human beings have 97.53% accuracy on facial recognition tasks whereas those models already reached and passed that accuracy level.

Installation pypi v0.0.90 conda-forge v0.0.89

deepface running on Laptop with 8GB RAM

Age_Gender.ipynb | real-time.py | 240_train_age_gender_detection.py | MNIST_(

real-time.py

```
1  from deepface import DeepFace
2
3  DeepFace.stream("database", model_name="Facenet512")
4
```

PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS JUPYTER

```
PS D:\Mini Project> python -u "d:\Mini Project\real-time.py"
24-04-23 16:57:33 - facial recognition model Facenet512 is just built
24-04-23 16:57:36 - Age model is just built
24-04-23 16:57:41 - Gender model is just built
24-04-23 16:57:42 - Emotion model is just built
24-04-23 16:57:42 - Searching [[[0. 0. 0.]
```

Model	Declared LFW Score
VGG-Face	98.9%
Facenet	99.2%
Facenet512	99.6%
OpenFace	92.9%
DeepID	97.4%
Dlib	99.3 %
SFace	99.5%
ArcFace	99.5%
GhostFaceNet	99.7%
Human-beings	*97.5%*

Models we tested along with their declared Labeled Faces in the Wild (LFW) scores

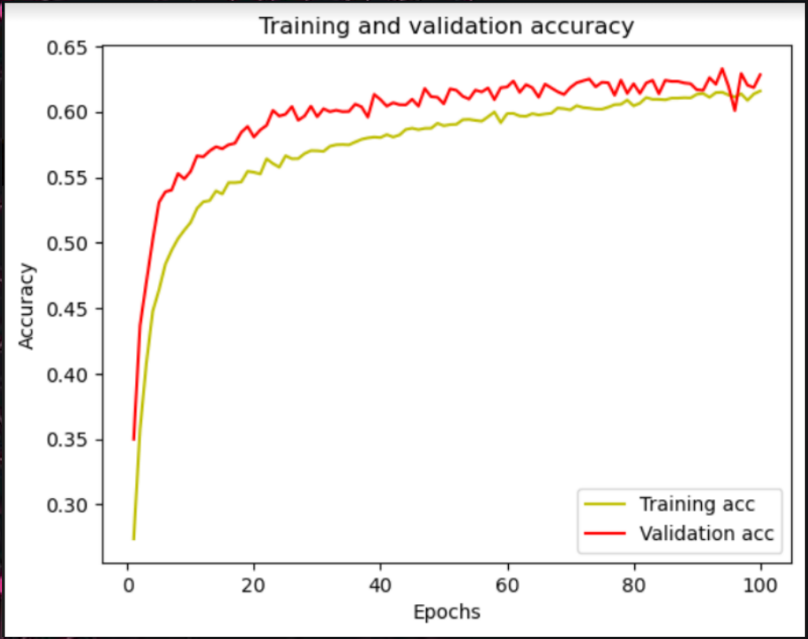
Emotion Extraction from Human Faces

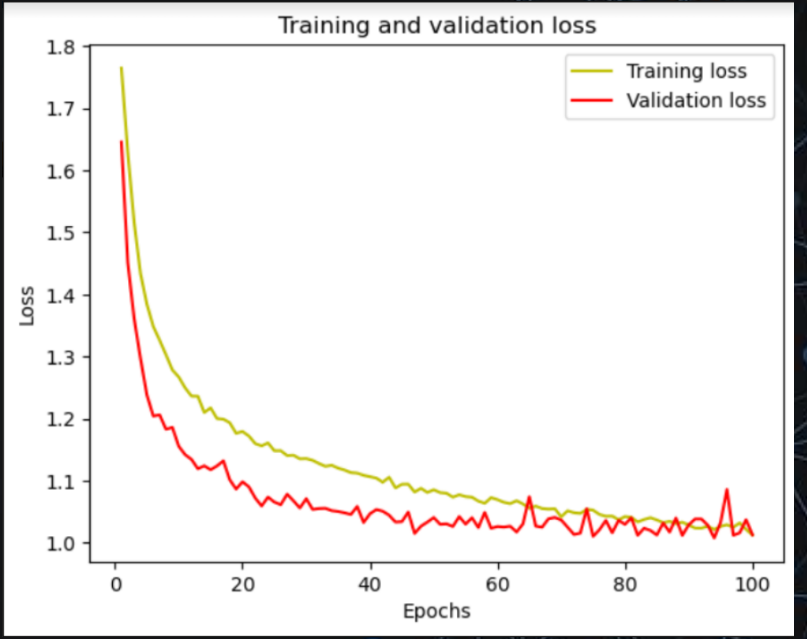
Model architecture

```
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d (Conv2D)              (None, 46, 46, 32)        320
_________________________________________________________________
conv2d_1 (Conv2D)            (None, 44, 44, 64)        18496
_________________________________________________________________
max_pooling2d (MaxPooling2D) (None, 22, 22, 64)        0
_________________________________________________________________
dropout (Dropout)            (None, 22, 22, 64)        0
_________________________________________________________________
conv2d_2 (Conv2D)            (None, 20, 20, 128)       73856
_________________________________________________________________
max_pooling2d_1 (MaxPooling2 (None, 10, 10, 128)       0
_________________________________________________________________
dropout_1 (Dropout)          (None, 10, 10, 128)       0
_________________________________________________________________
conv2d_3 (Conv2D)            (None, 8, 8, 256)         295168
_________________________________________________________________
max_pooling2d_2 (MaxPooling2 (None, 4, 4, 256)         0
_________________________________________________________________
dropout_2 (Dropout)          (None, 4, 4, 256)         0
_________________________________________________________________
flatten (Flatten)            (None, 4096)              0
_________________________________________________________________
dense (Dense)                (None, 512)               2097664
_________________________________________________________________
dropout_3 (Dropout)          (None, 512)               0
_________________________________________________________________
dense_1 (Dense)              (None, 7)                 3591
=================================================================
Total params: 2,489,095
Trainable params: 2,489,095
Non-trainable params: 0
```

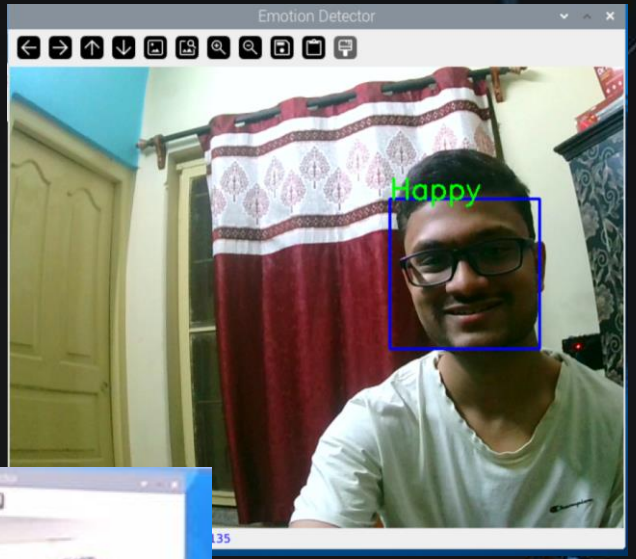
- The model uses Convolutional Neural Networks (CNNs) in order to predict the classes.
- Face datasets used: UTKFace
- Model is converted to TFLite (.tflite) format before being used in Raspberry Pi.

Accuracy & Loss curves





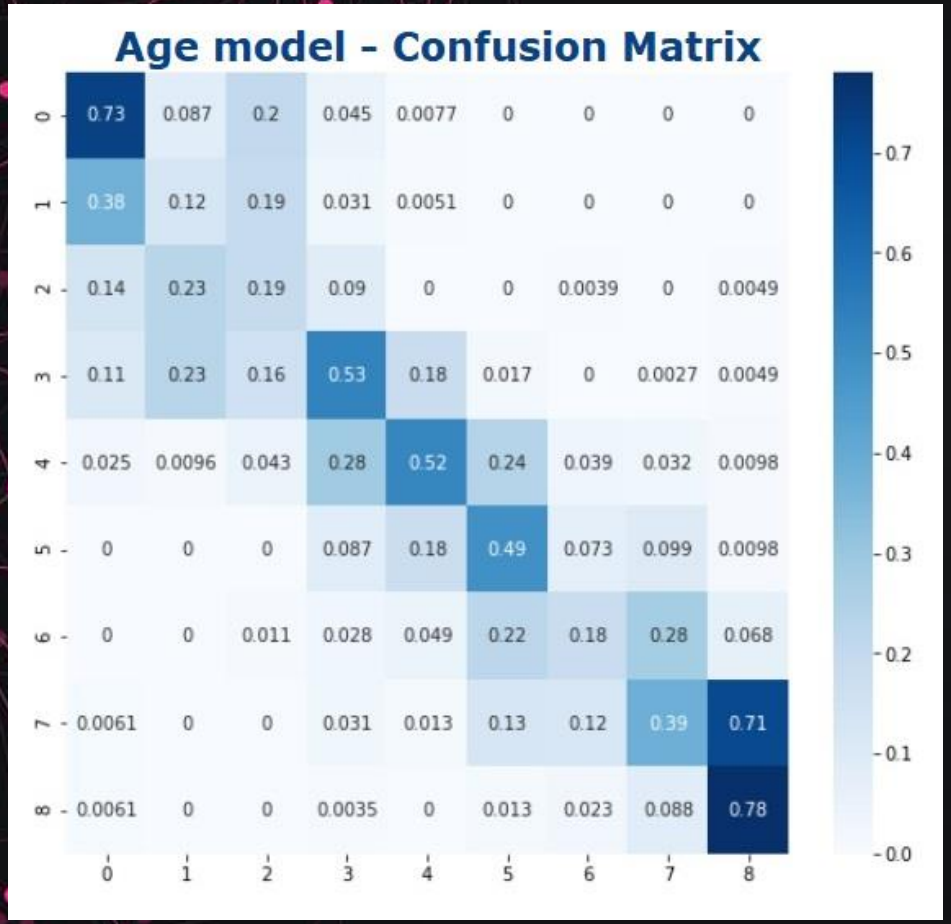
Real-time predictions

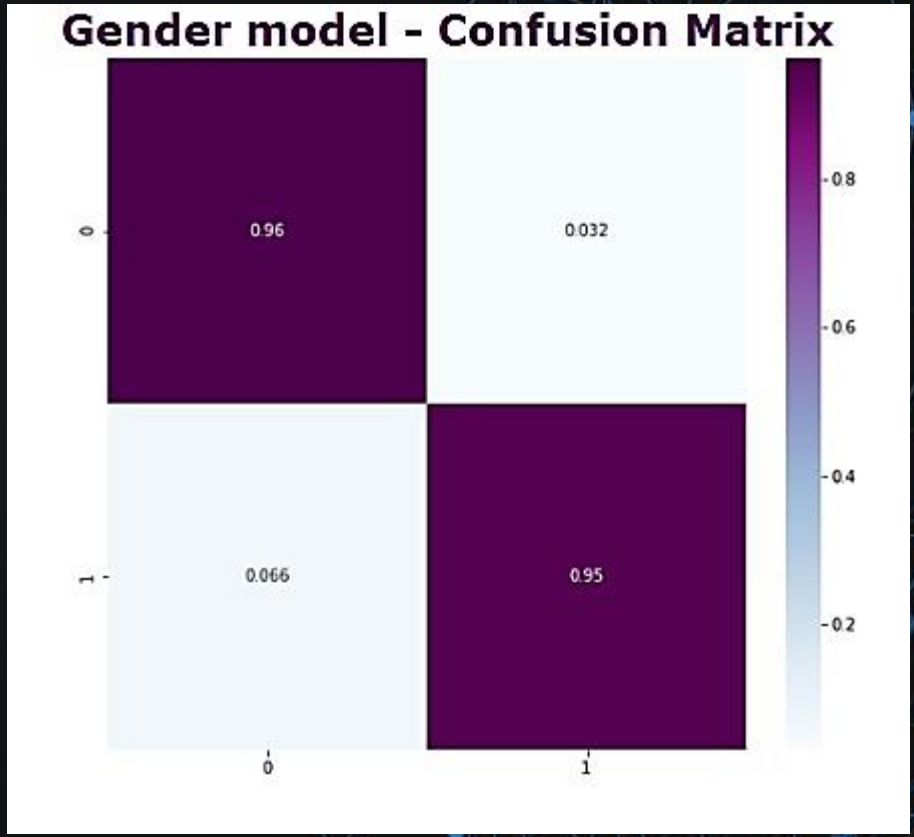


Age and Gender Extraction from Human Faces

- The model uses Convolutional Neural Networks (CNNs) in order to predict the classes. The network used is MobileNet v1.
- Face datasets used: UTKFace combined with Appa-Real.
- Model is converted to TFLite (.tflite) format before being used in Raspberry Pi.

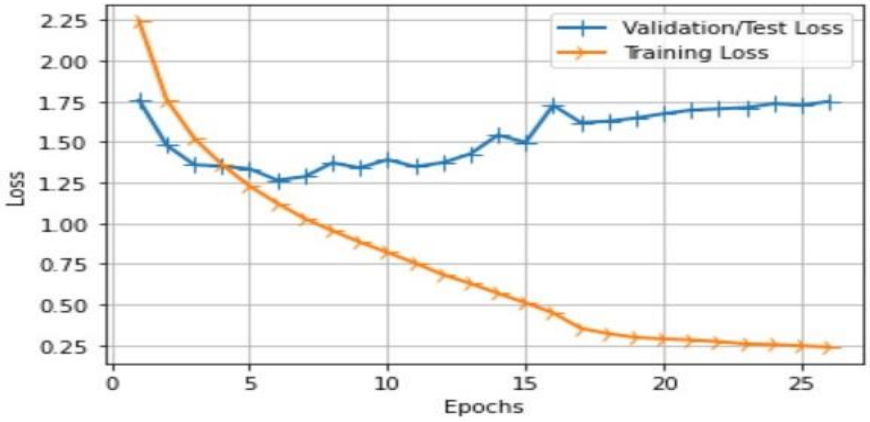
Confusion Matrices

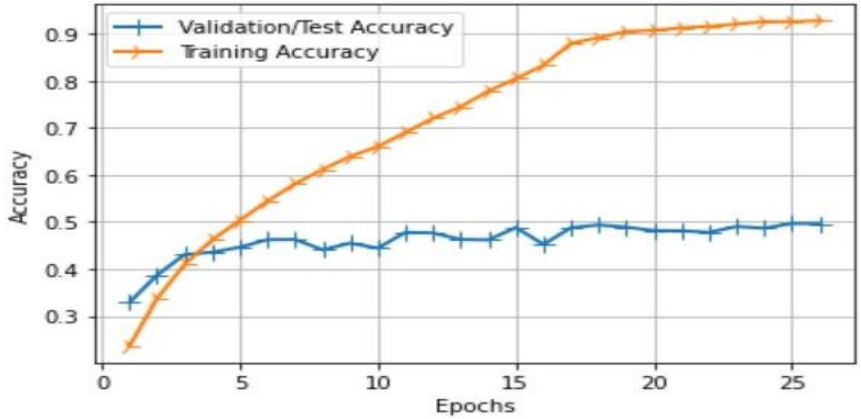




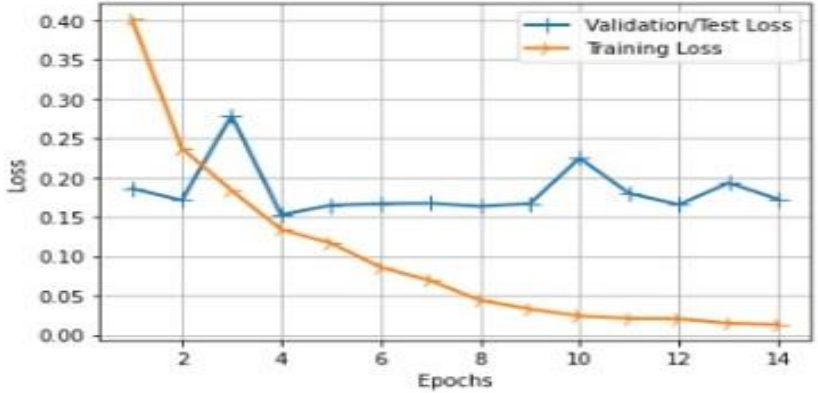
Accuracy & Loss curves

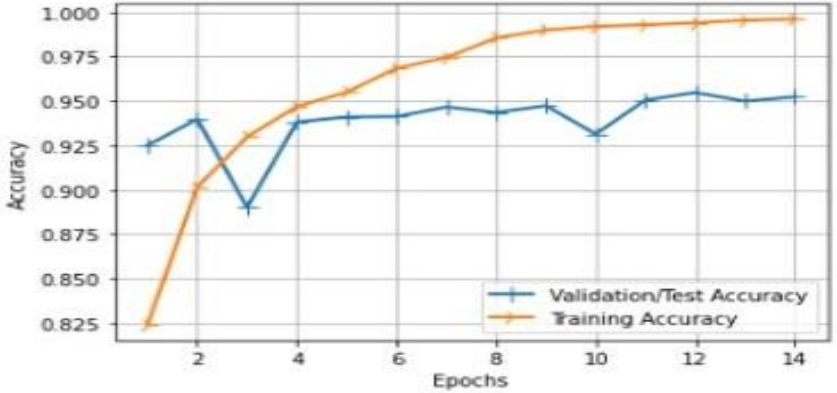
Age model



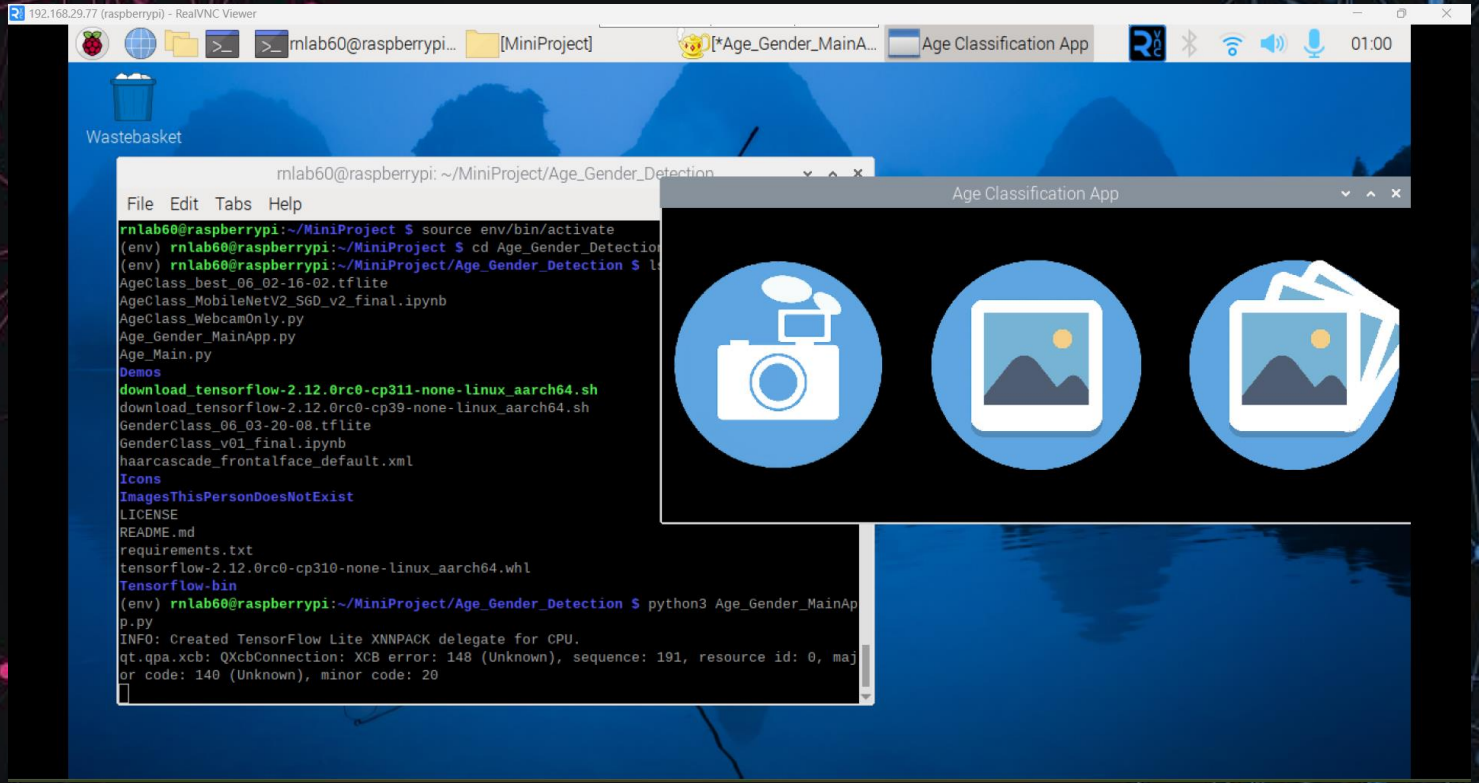


Gender model

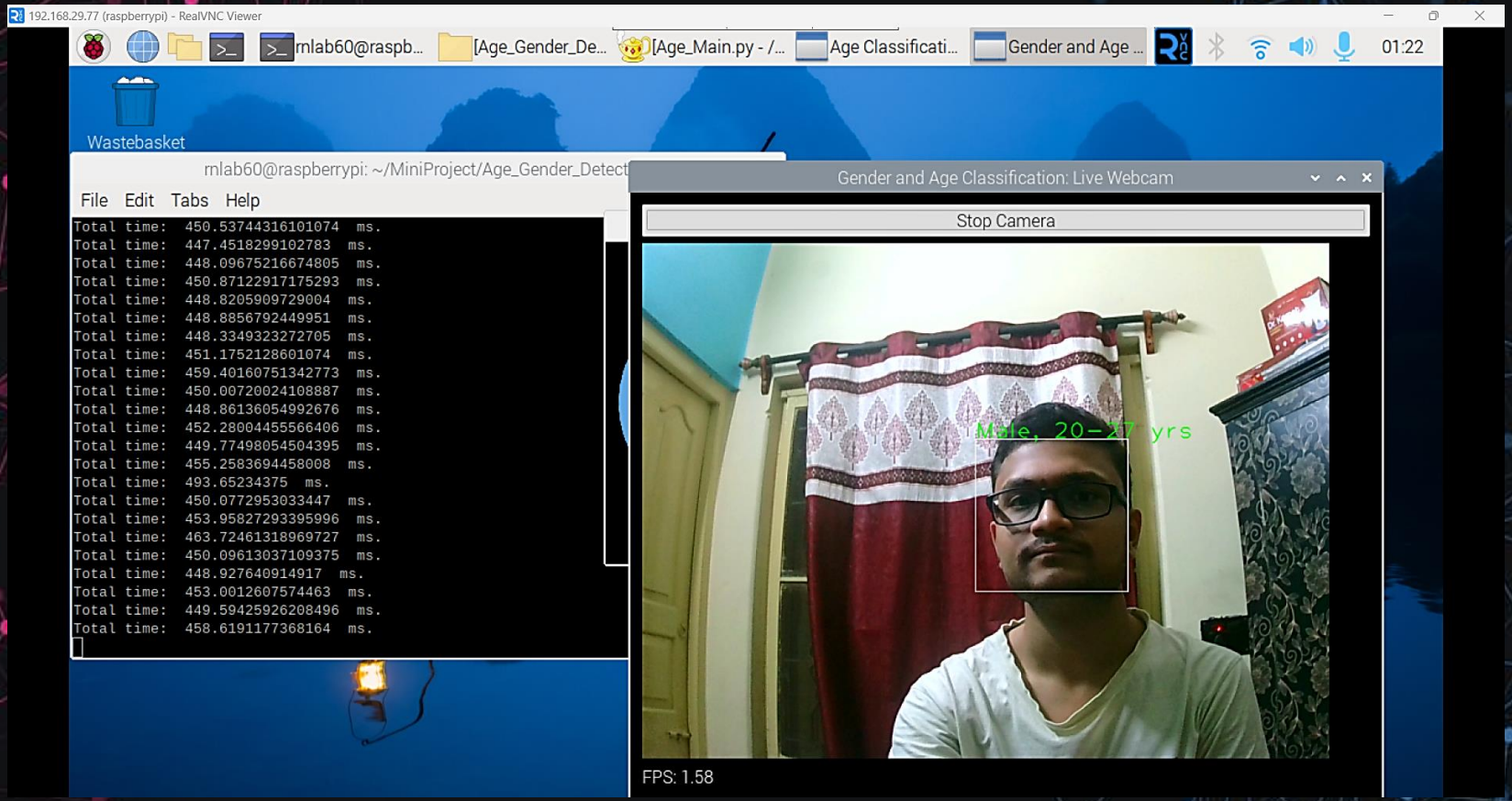




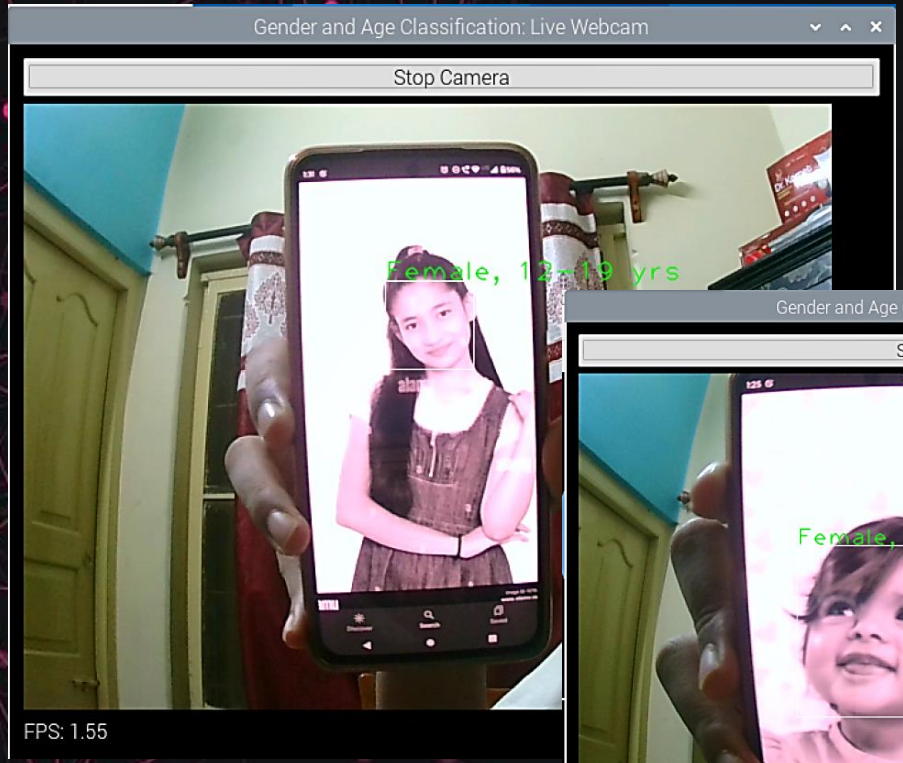
App Interface

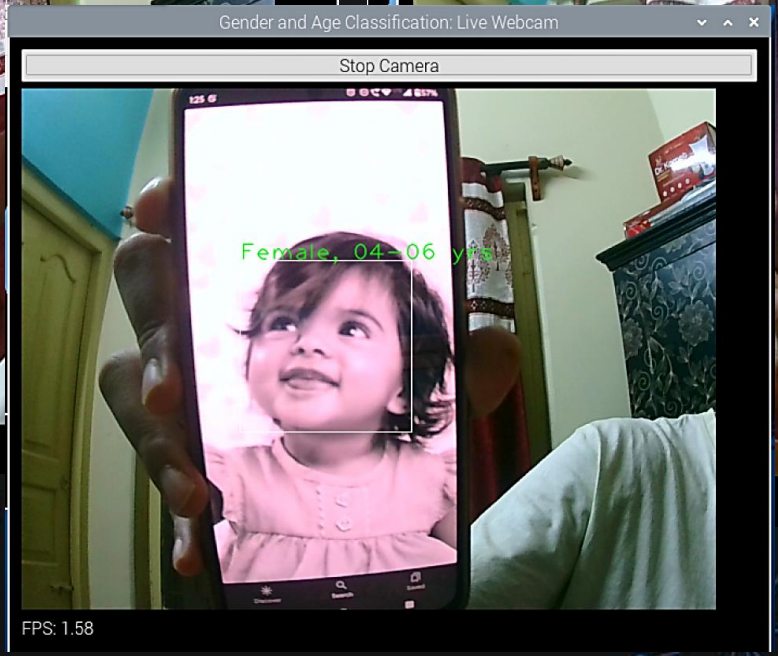


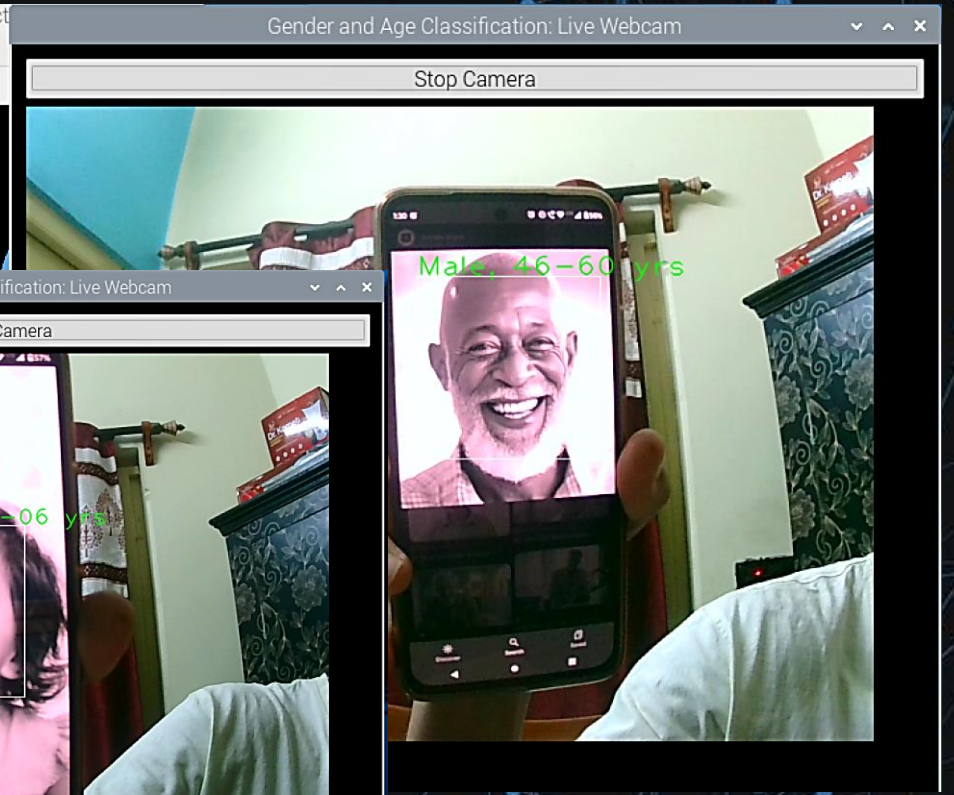
App Interface



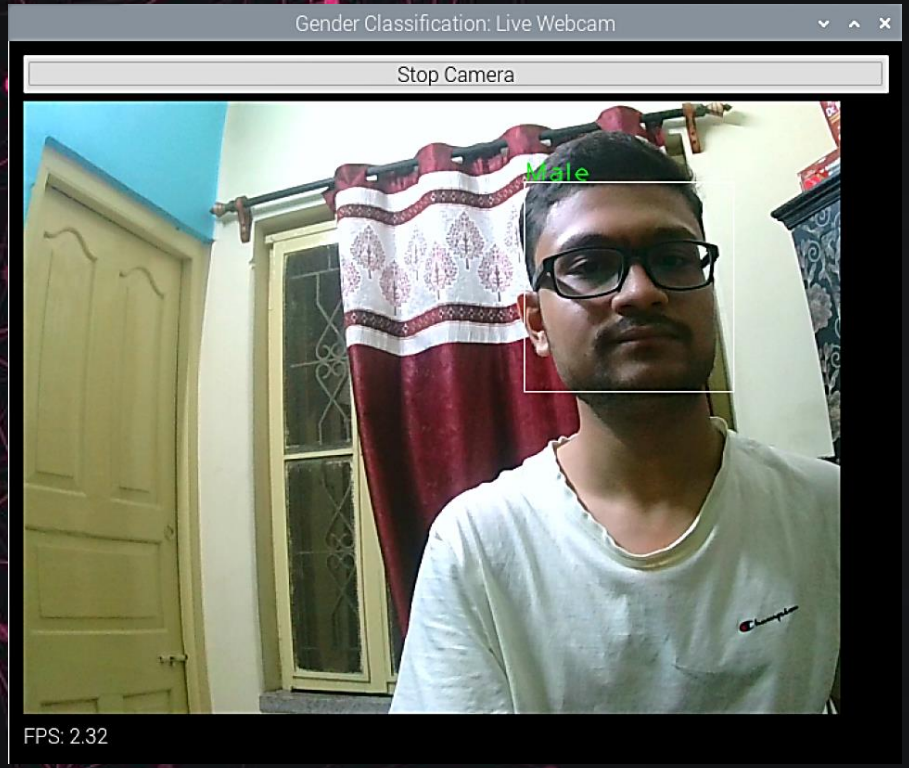
Predictions on random faces from the Internet

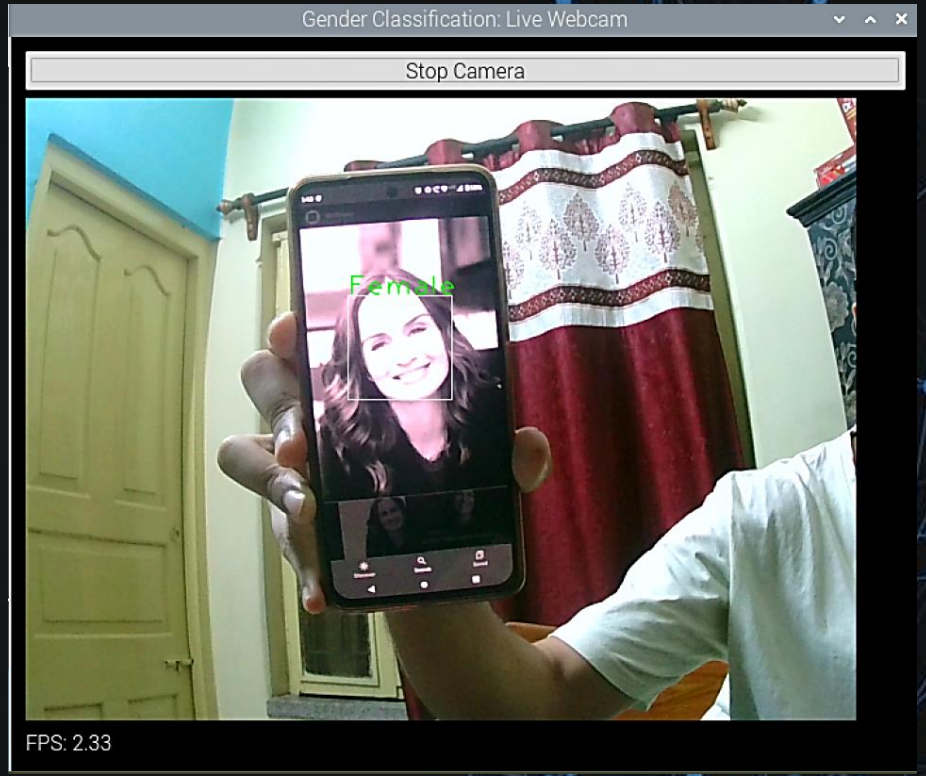






Predictions on random faces from the Internet





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- *Alexandru B, R. (2021). Age-Gender-Classification-on-RaspberryPi4-with-TFLite-PyQt5 https://github.com/radualexandrub/Age-Gender-Classification-on-RaspberryPi4-with-TFLite-PyQt5*

Thank You