

# Face Detection and Recognition System Using Raspberry Pi

Project report submitted in partial fulfilment of the requirement for  
the degree of Bachelor of Technology

in

**Computer Science and Engineering/Information Technology**

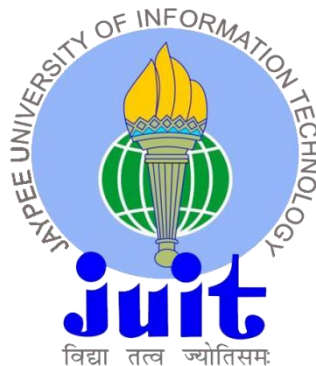
By

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## Candidate's Declaration

I hereby declare that the work presented in this report entitled “**Face Recognition System using Raspberry Pi**” in partial fulfillment of the requirements for the award of the degree of **Bachelor of Technology in Computer Science and Engineering** submitted in the Department of Computer Science & Engineering and Information Technology, Jaypee University of Information Technology Waknaghat is an authentic record of my own work carried out over a period from August 2016 to December 2016 under the supervision of **Prof.Nishtha Ahuja, Assistant Professor (Grade-I), Department of Computer Science & Engineering and Information Technology**.

The matter embodied in the report has not been submitted for the award of any other degree or diploma.

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This is to certify that the above statement made by the candidate is true to the best of my knowledge.

(Supervisor Signature)

Nishtha Ahuja

Assistant Professor (Grade-I)

Department of Computer Science & Engineering and Information Technology

Dated:

## CERTIFICATE

We hereby declare that the work presented in this report **Face Detection and Recognition System Using Raspberry PI** in partial fulfilment of the requirements for the award of the degree of **Bachelor of Technology in Computer Science and Engineering** submitted in the department of Computer Science & Engineering and Information Technology, Jaypee University of Information Technology Waknaghat is an authentic record of our own work carried out over a period from August 2016 to December 2016 under the supervision of **Miss Nishtha Ahuja**, (Assistant Professor, Department of Computer Science and Information Technology).

The matter embodied in the report has not been submitted for the award of any other degree or diploma.

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This is to certify that the above statement made by the candidates is true to the best of my knowledge.

Miss Nishtha Ahuja

Assistant Professor

Dated :

## ACKNOWLEDGEMENT

On the submission of our thesis report on “**Face Recognition System using Raspberry Pi**”, we would like to extend our gratitude and sincere thanks to our supervisor **Prof.Nishtha Ahuja, Assistant Professor (Grade-I), Department of Computer Science & Engineering and Information Technology** for her constant motivation and support during the course of our work in the last one year. We truly appreciate and value her esteemed guidance and encouragement from the beginning to the end of this thesis. We are indebted to her for having helped us shape the problem and providing insights towards the solution.

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Ankur Omer, 131256

# INDEX

1. Introduction.....	11
1.1 Background of Project.....	11
1.2 Problem Statement.....	12
1.3 OBJECTIVES .....	12
1.4 Project Scope.....	12
2. Literature Survey.....	14
2.1 Real Time face recognition using raspberry pi 2.....	14
2.1.1 Basic Concept.....	14
2.1.2 Working Principle.....	15
2.2 Image Based face detection and recognition.....	16
2.2.1 Basic Concept.....	15
2.2.2 Working Principle.....	17
2.3 Human Face Detection and Tracking Using Raspberry pi.....	19
2.3.1 Basic Concept.....	19
2.3.2 Working Principle.....	20
3. System Development.....	21
3.1 General Construction.....	22
3.2 HARDWARE TOOLS.....	22
3.2.1 RASPBERRY PI 3 MODEL B.....	22
3.2.2 CAMERA MODULE V2.....	24
3.2.3 SD Card.....	24
3.2 SOFTWARE DEVELOPMENT.....	24
3.3.1 SETTING UP RASPBIAN.....	25
3.3.2 INSTALLING OPENCV 3 ON A RASPBERRY PI.....	27

3.3.3 FACE DETECTION ALGORITHM.....	36
3.3.4 FACE RECOGNITION.....	45
4. Performance Analysis.....	52
4.1 Performance Comparison Between Identically Trained Cascades with Three Different Boosting Algorithms.....	52
4.2 Analysis of Photos.....	55
5. Conclusion.....	56
6. References.....	56
7. Appendix A.....	57

## **LIST OF ABBREVIATIONS**

ARM	Advanced RISC Machine
RISC	Reduced Instruction Set Computer
LAN	Local Area Network
BSD	Berkeley Software Distribution
GPU	Graphics Processing Unit
CPU	Central Processing Unit
SOC	System on Chip
PCA	Principal Component Analysis
LBP	Local Binary Patterns

## LIST OF FIGURES

- Fig. 1 Block diagram of real time face recognition
- Fig. 2 Creation of real time database
- Fig. 3 Real time faces recognition using raspberry pi II.
- Fig. 4 System's Overview
- Fig. 5 Block Diagram
- Fig. 6 Raspberry 3 Model B
- Fig. 7 Layout of Raspberry Pi Model B
- Fig. 8 Camera Module v2
- Fig. 9 Logo and Desktop interface of Raspbian
- Fig. 10 Expanding the file system on your Raspberry Pi 3
- Fig. 11 "(cv)" message on your provoke, demonstrating that you are in the cv virtual condition
- Fig. 12 Guaranteeing that Python 2.7 will be utilized when gathering OpenCV 3 for Raspbian Jessie on the Raspberry Pi 3
- Fig. 13 Affirming OpenCV 3 has been effectively introduced on my Raspberry Pi 3 running Raspbian Jessie
- Fig. 14 Flowchart for face detection for image files
- Fig. 15 Stages of the cascade classifier
- Fig. 16 Detected Objects: Face (white), Eyes (red), Nose (blue), and Mouth (green)  
Common Haar Features
- Fig. 17 Summed area of integral image
- Fig. 18 Summed area of rotated integral
- Fig. 19 Summed area of integral image
- Fig. 20 pixel values are bilinear interpolated
- Fig. 21 A facial image divided into 7 x 7, 5 x 5, and 3 x 3 rectangular regions.



Fig. 23 Facial regions

Fig. 24 Performance comparison between identically trained cascades with three different boosting algorithms. Only the basic feature set and stumps as weak classifiers (nsplit=1) were used.

Fig. 25 Face detected in average lighting

Fig. 26 Face detected in good lighting

## **LIST OF TABLES**

Table 1.	Face Detection Result Summary
Table 2.	Face Recognition Result Summary
Table 3.	Face Database Summary
Table 4.	Accuracy of Classifiers

## **ABSTRACT**

Traditional surveillance systems are rigid, infrastructure oriented and expensive. Surveillance system with Raspberry Pi and Python's flexible, adoptable and small in size. Raspberry Pi 3 model B module is used in this system to achieve high speed of operation. Pi Camera v2Module is interfaced to one camera interface of Raspberry Pi 3. Haar Cascade Classifier algorithm is used for face detection and Local Binary Pattern algorithm for recognition technology. These hardware components are cost effective, small in size and has sufficient computational power for application oriented components. The basic system consists of two parts: face detection and face recognition. The framework is modified utilizing Python programming dialect. Both ongoing face recognition and face identification from particular pictures, i.e. Protest Recognition, is done in the framework. In face identification, we have built up a calculation that can recognize human appearances from a picture. We have taken skin shading as a device for identification. This procedure functions admirably for Indian confronts which have a particular composition fluctuating under certain range. We have taken genuine illustrations and reenacted the calculations using python and OpenCV on Raspberry Pi successfully.

# CHAPTER 1

## INTRODUCTION

### 1.1 BACKGROUND OF PROJECT

The face is our fundamental grouping of thought in social life accepting a basic part in passing on character and sentiments. We can see different faces adapted all through our future and perceive confronts at first notwithstanding taking after a long time of segment. This capacity is extremely solid paying little respect to tremendous assortments in visual shock due to advancing condition, developing and redirections, for instance, facial hair, glasses or changes in haircut. In picture handling, there are a considerable measure applications, for example, confront acknowledgment, question recognition, standardized identification filtering, and so on. One of the primary interesting issue in picture handling is face acknowledgment. Be that as it may, to do confront acknowledgment, the framework must have the capacity to identify the face first then it can just decide data, for example, the nearness of appearances, the pivot and stances of countenances. Confront location is critical in observation framework as it is the initial phase in the acknowledgment framework. In biometrics framework, components of confronts, for example, eyes, iris and retina can be separated from pictures to be grouped, however with the fruitful discovery of confronts first. Thus, confront discovery is the essential of picture preparing identified with appearances. Confront discovery is utilized as a part of many places these days particularly the sites facilitating pictures like Google photographs, photograph basin and face book. The subsequently naming highlight adds estimation to sharing pictures among the all inclusive community who are in the photograph and besides gives the considered who the individual is in the photo. In our wander, we have analyzed and executed a completely fundamental however amazingly intense face area figuring which considers human skin shading.

Our point, which we believe we have come to, was to develop a methodology for face affirmation that is speedy, lively, and sensibly essential and correct with respectably fundamental and clear computations and procedures.

## **1.2 PROBLEM STATEMENT**

As embedded systems are widely used in modern life, image processing can be implemented on them as well. A face detector can be implemented on a small size and low cost system. However the performance of a face detector on an embedded system can be affected as embedded system has limited computation power and memory storages. A good face detector must be fast and robust. A fast system can detect faces in an image in a short time. A robust face detector has high true positive rate and very low false positive and negative rates. Thus, the performance of a face detector should be analyzed in terms of speed and detection rate.

In video processing, every frames captured from the video is processed by the detector. As such, the detector must be fast enough to process each frame as the longer the processing, the more latency is shown. If a fast algorithm is used, the result displayed should have high frames per second.

## **1.3 OBJECTIVES**

Based on the aforementioned problem statements, the objectives have been derived as following:

1. To detect and recognize the faces from image files from Raspberry Pi.

## **1.4 PROJECT SCOPE**

This venture intends to identify faces from pictures in Raspberry Pi. In face discovery, the calculation ought to be powerful and quick. In this venture, the calculation utilized is proposed by Viola and Jones which has high identification rate, low false positive and negative rates and short computational time. Utilizing the proposed calculation, a face indicator is based on a Raspberry Pi Model B. After detection, we recognize the faces from the recognition algorithm. IN the recognition part we recognize the different different faces which are captured from pi cam.

## **CHAPTER 2**

### **LITERATURE SURVEY**

This chapter describes the past and current researches that have been carried out and the papers that have been published which are related to the project. This review investigates from various aspects of sensors, microcontrollers, indicators and the overall working system of the related projects.

#### **2.1 REAL TIME FACE RECOGNITION USING RASBERRY PI 2**

A Viji and A Pavithra have suggested the application of real time face recognition detect the faces. The overall project is discussed as below.

##### **2.1.1 BASIC CONCEPT**

There are heaps of decades in which this exploration chips away at acknowledgment and investigation have been completed for different applications identified with human machine connection. Just few methodologies have been utilized as a part of constant face acknowledgment. Confront identification is the initial phase in face acknowledgment of pictures. Viola Jones proposed a calculation that utilizes haar course classifier, course classifier. Wan-Hung Liao utilized the nearby paired example (LBP) administrator which is an effective neighborhood surface descriptor and it is utilized as a part of different applications. Tim Ahonen, 2006 utilized a novel and proficient facial picture portrayal which depends on nearby paired example and texture features. The LBP feature descriptor is extracted by dividing facial images into various regions. In 2014 kamlesh used active appearance model and local binary pattern where AAM is generic based approach and local binary pattern is hybrid approach. After the extraction of features different classifiers are used for face recognition, such as support vector model SVM, neural networks, adaboost classifier ,least mean square etc. the software testing is done by creating real time databases

.Each directory contains 30 images of individual. Later hardware implementation is performed by raspberry pi along with hardware set up.

### 2.1.2 WORKING PRINCEPLE

The objective is to develop the real time face recognition from the facial images. it is performed using real time database which is collection of images from 10 subjects. The images of each subject is stored in specific directory with 30 images .Each image size is of about 100\*130pixels. The viola Jones detection algorithm is used for face detection whereas PCA algorithm is used for feature extraction and then Adaboost classifier is used for face recognition. Raspberry pi II is the credit card sized computer which contains system on chip Broadcom BCM 2836 with CPU, GPU, DSP, SDRAM .The CPU is made up of quad core ARM cortex running at 200 MHz The architecture of proposed system is displayed in Figure b and explained as follows: The input image is captured from web camera and fed into the real time face recognition system as input. The real time face recognition is deployed with the Raspberry pi II which gives the identified image as output.This output is displayed in the monitor of the system

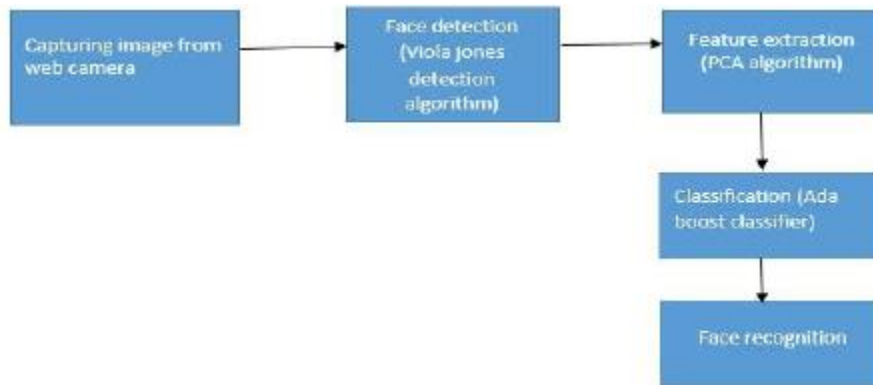


Figure 1. Block diagram of real time face recognition

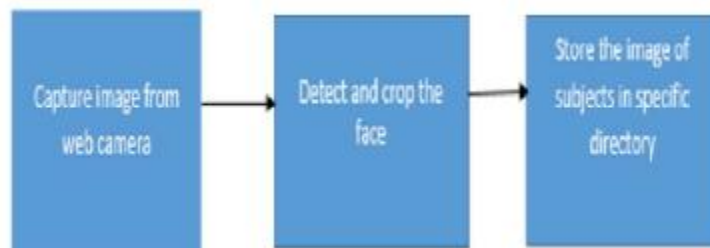


Figure 2. Creation of real time database

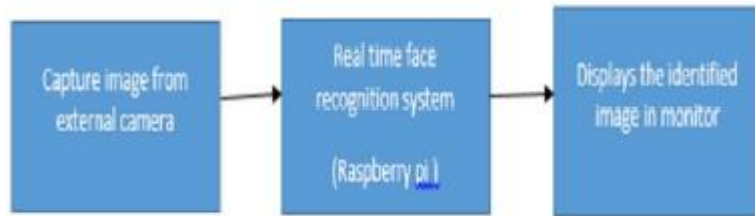


Figure 3. Real time face recognition using raspberry pi II.

## 2.2 Image-based Face Detection and Recognition: “State of the Art”

Faizan Ahmad, Aaima Najam and Zeeshan Ahmed have recommended the application Image-based Face Detection and Recognition. The general venture is talked about as underneath.

### 2.2.1 BASIC CONCEPT

In current paper we built up a framework for the said strategy's assessment as a first point of reference for video based face discovery and acknowledgment for observation. The diagram of current framework is exhibited in figure.

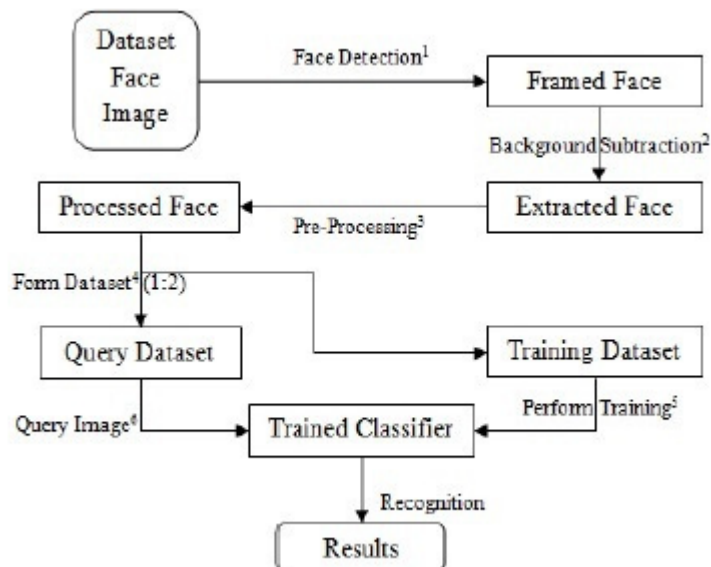


Figure 4. System's Overview



## 2.2.2 WORKING PRINCEPLE

### 2.2.2.1 FACE DETECTION

AdaBoost classifier is used with Haar and Local Binary Pattern highlights however Support Vector Machine classifier is used with Histogram of Oriented Gradients highlights for face revelation evaluation. Haar-like components are surveyed utilizing another photo depiction that creates an extensive plan of parts and usages the boosting computation AdaBoost to lessen degenerative tree of the helped classifiers for fiery and fast impedances simply direct rectangular Haar like components are used that gives different focal points like sort of uniquely delegated space learning is deduced and furthermore a speed increase over pixel based systems, suggestive to Haar commence limits practically identical to compel qualification readings are extremely easy to enroll. Execution of a system that used such parts would give a rundown of capacities that was outrageously broad, in this manner the rundown of abilities must be quite recently bound to couple of essential components which is refined by boosting computation, Adaboost. The primary LBP overseer names the pixels of a photo by thresholding the 3-by-3 neighbourhood of each pixel with the centre pixel regard and considering the result as a twofold number. Each face picture can be considered as a production of littler scale outlines which can be suitably perceived by the LBP chairman. To consider the shape information of goes up against, they detached face pictures into N little non-covering territories  $T_0, T_1 \dots T_N$ . The LBP histograms isolated from each sub-territory are then connected into a singular, spatially overhauled highlight histogram described as:  $H_i$ ,  $j = \_x ,y I(f_l(x,y)=i)I((x,y)\_Tj)$  Where  $i = 0, \dots , L-1$ ;  $j = 0, \dots, N-1$ . The removed element histogram portrays the neighborhood surface and worldwide state of face pictures.

M

Table 1: Face detection results summary

Dataset	Detection		
	Adaboost		SVM
	Haar	LBP	HOG
[1]	99.31%	95.22%	92.68%
[2]	98.33%	98.96%	94.10%
[3]	98.31%	69.83%	87.89%
[4]	96.94%	94.16%	90.58%
[5]	90.65%	88.31%	89.19%
<b>Mean</b>	<b>96.70%</b>	<b>89.30%</b>	<b>90.88%</b>

### 2.2.2.2 Face Recognition

Eigen faces considered as 2-D goes up against affirmation issue, faces will be for the most part upright and frontal. That is the reason 3-D information about the face is not required that abatements multifaceted nature by a basic piece. It change over the face pictures into a course of action of introduce limits which essentially are the main fragments of the face pictures searches for headings in which it is more beneficial to address the data. This is generally significant for reduction the computational effort. Straight discriminant examination is on a very basic level used here to decrease the amount of components to a more anageable number before affirmation since face is addressed by a generous number of pixel qualities. Each of the new estimations is an immediate mix of pixel qualities, which outline an emplate. The immediate mixes got using Fisher's straight discriminant are called Fisher faces . LBP is a demand set of matched relationships of pixel strengths between within pixel and its eight incorporating pixels.

Table 2: Face recognition results summary

Dataset	Recognition			
	PCA	LDA	LBP	Gabor
[1]	72.10%	79.39%	85.93%	93.49%
[2]	69.87%	76.61%	80.47%	89.76%
[3]	70.95%	78.34%	84.14%	92.68%
[4]	74.79%	81.93%	86.45%	96.91%
[5]	68.04%	73.21%	77.69%	88.93%
<b>Mean</b>	<b>71.15%</b>	<b>77.90%</b>	<b>82.94%</b>	<b>92.35%</b>

Table 3: Face database summary

Data Set	Sub-Division	Images	Resolution	Individuals	Image/Individual
A	Face 94	3078	180*200	153	~20
	Face 95	1440	180*200	72	20
	Face 96	3016	196*196	152	~20
	Grimace	360	180*200	18	20
B	Pain Expressions	599	720*576	23	26

A: Face Recognition Data, University of Essex

B: Psychological Image Collection at Stirling (PICS)

## 2.3 Human Face Detection and Tracking Using Raspberry PI Processor

K. Shiva Prasad and M. Shirisha have suggested the application on Human Face Detection and Tracking Using Raspberry PI Processor. The overall project is discussed as below.

### 2.3.1 BASIC CONCEPT

This paper depicts the strategy for ongoing human face identification and following utilizing an altered variant of the calculation recommended by Paul viola and Michael Jones. The paper begins with the prologue to human face location and following, trailed by fear of the Vila Jones calculation and after that examining about the execution in genuine video applications. Viola Jones calculation depended on question discovery by extricating some particular elements from the picture. We utilized a similar approach for continuous human face location and following. Recreation after-effects of this created calculation demonstrate

the Real time human face recognition and following supporting up to 50 human appearances. This calculation figures information and create brings about only a negligible portion of seconds. Here we are utilizing Raspberry Pi board as our stage. It has an ARM-11 SOC with incorporated peripherals like USB, Ethernet and serial and so on. On this board we are introducing Linux working framework with vital drivers for every single fringe gadget and client level programming stack which incorporates a light weight GUI in view of Server, XOrg centre product for associating with show gadgets like screens and show drivers, TCP/IP stack to communicate with system gadgets and some standard framework libraries for framework level general IO operations. By utilizing USB sort camera that is interfaced to the implanted board we can catch the live video of the specific area. The camera will ceaselessly catch the pictures and send it to ARM board.

### **2.2.2 WORKING PRINCEPLE**

With the fast advancement of human–machine interaction, full of feeling figuring is as of now picking up ubiquity in research and thriving in the business space. It expects to outfit figuring gadgets with easy and normal correspondence. The capacity to perceive human full of feeling state will enable the smart PC to translate, comprehend, and react to human. This is like the way that people depend on their faculties to evaluate each other’s full of feeling state. Numerous potential applications, for example, clever car frameworks, diversion and media outlets, intelligent video, ordering and recovery of picture or video databases, can profit by this ability. Our framework is composed by utilizing ARM 32-bit miniaturized scale controller which underpins distinctive components and calculations for improvement of first facial acknowledgment. The webcam consolidates video detecting, video handling and communication inside a solitary gadget. It catches a video stream registers the data and exchanges the video stream to the ARM miniaturized scale controller. The picture it got is handled by utilizing picture preparing calculations and processed picture is grouped. In grouping Human is detected by utilizing Haar calculation and identified people are shown in plain view unit in particular format. Our framework is outlined by utilizing BSC2836 smaller scale processor created by BROADCOM which was called as Raspberry Pi.

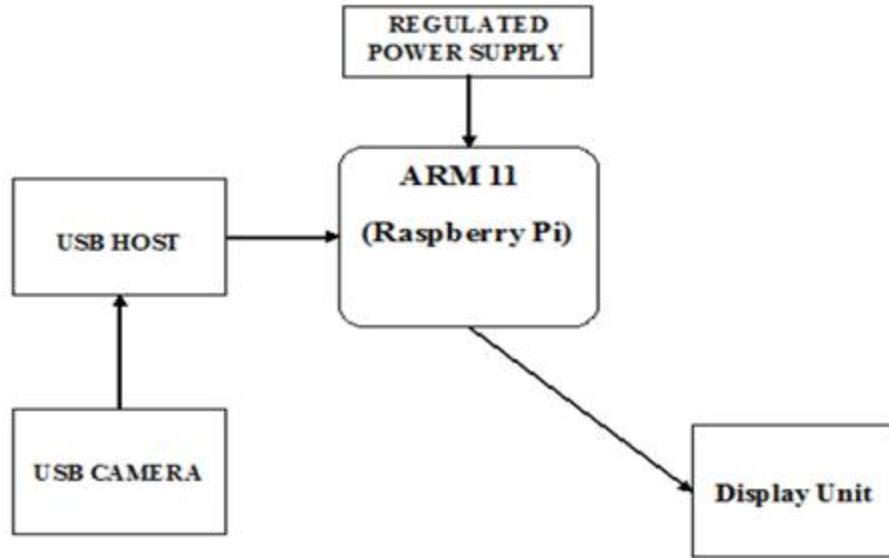


Figure 5. Block Diagram

## **CHAPTER 3**

### **SYSTEM DEVELOPMENT**

This section talks about the general venture advancement and combination of various modules. It comprises of four sections, to be specific the physical improvement, extend review, circuit outline and programming advancement.

#### **3.1 GENERAL CONSTRUCTION**

This venture means to outline a face locator on Raspberry Pi and its execution is assessed in view of identification rates and speed of recognitions the essential time of the wander is to grasp the count to do go up against recognizable proof. There are heaps of counts that can be used to do stand up to acknowledgment and this wander uses the falling Haar classifier proposed by Viola and Jones in 2001 . To get the venture working the entire calculations must be caught on. The second period of the venture is acknowledgment of the distinguished picture which is caught by pi cam.

#### **3.2 HARDWARE TOOLS**

##### **3.2.1 RASPBERRY PI 3 MODEL B**

The Raspberry Pi 3 is the third time Raspberry Pi. It has a 1.2GHz 64-bit quad-focus ARMv8 CPU, 802.11n Wireless LAN, Bluetooth 4.1, Bluetooth Low Energy (BLE), 1GB RAM, 4 USB ports, 40 GPIO pins, Full HDMI port, Ethernet port, united 3.5mm sound jack and composite video, Camera interface (CSI), Display interface (DSI), Micro SD card opening (now drive pull rather than push-push), Video Core IV 3D outlines focus. It is endorsed for some generally valuable use and in many wander based utilization.



Figure 6 – Raspberry 3 Model B

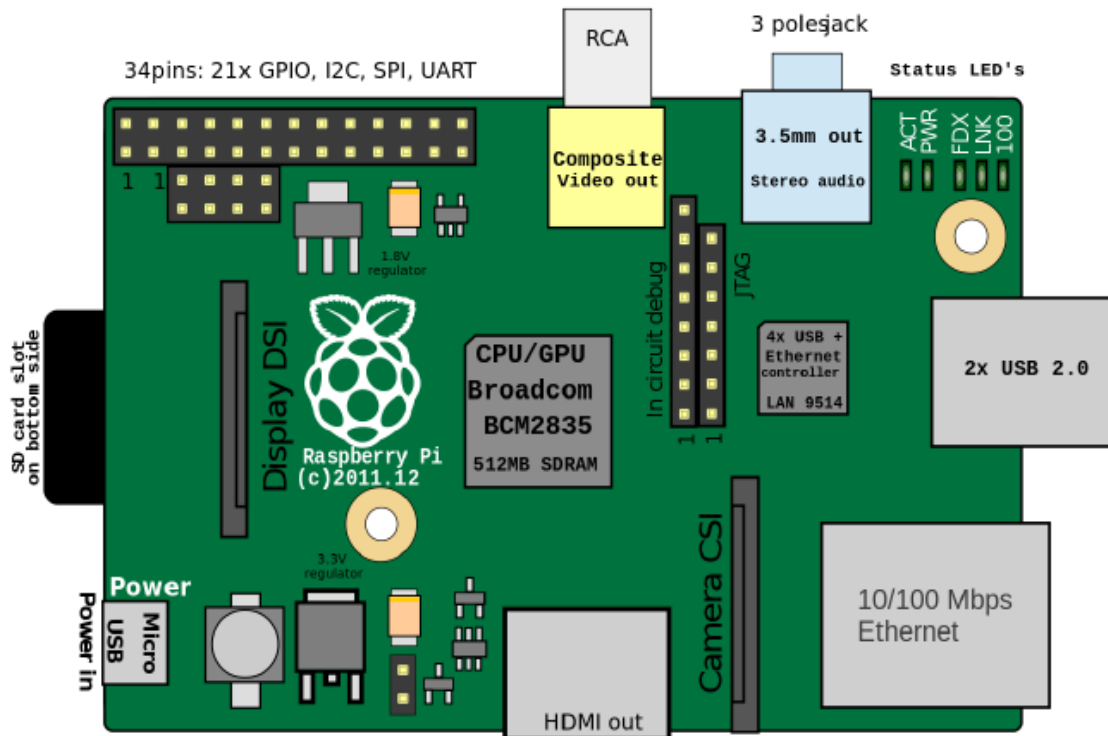


Figure 7. Layout of Raspberry Pi Model B

### 3.2.2 CAMERA MODULE V2

The v2 camera module has a Sony imx219 eight-megapixel sensor. The advanced camera module might be utilized to take superior quality video, and stills pix. It's smooth to use for fledglings, however has masses to offer propelled clients in the event that you're hoping to grow your know-how. There are masses of cases online of individuals the utilization of it for time-slip by, steady development, and diverse video astuteness. You may moreover utilize the libraries we bundle manage the computerized camera to make comes about. The digital cam works with all designs of raspberry pi 1, 2, and three. It can be gotten to by means of the mmal and v4l APIs, and there are different 0.33-festival libraries worked for it, alongside the picamera python library.



Figure 8– Camera Module v2

### 3.2.3 SD Card

A SD card is utilized to store the working arrangement of the Raspberry Pi. It likewise fills in as the capacity for all the bolster documents and programming for the face indicator and in addition stockpiling for info pictures to be tried.



SD CARD



### 3.3 SOFTWARE DEVELOPMENT

#### 3.3.1 SETTING UP RASPBIAN

Downloaded the most recent adaptation of Raspbian. Required a picture author to compose the downloaded OS into the little scale SD card. So downloaded the "win32 circle imager". Embedded the SD card into the tablet/pc and run the picture essayist. When open, peruse and chose the downloaded Raspbian picture document. Chosen the right gadget that is the drive speaking to the SD card. On the off chance that the drive (or gadget) chose is unique in relation to the SD card, then the other chose drive will end up noticeably adulterated. So be watchful. Once the compose is finished, launch the SD card and insert it into the Raspberry Pi and turn it on. It should start booting up. in the wake of booting the Pi, there might be conditions when the customer capabilities like the "username" and mystery key will be asked. Raspberry Pi goes with a default customer name and mystery key therefore constantly use it at whatever point it is being asked. The accreditations are:

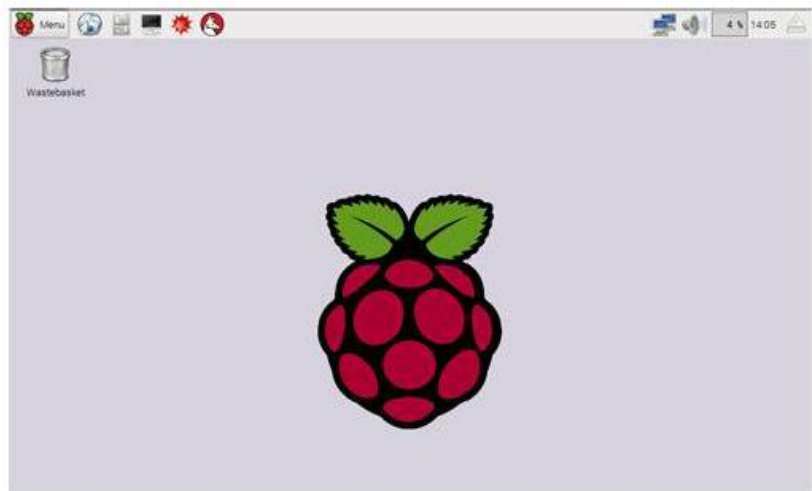


Figure 9. Logo and Desktop interface of Raspbian

**login: pi**

**Password: raspberry**

At the point when the Pi has been booted surprisingly, an arrangement screen called the "Setup Options" ought to show up and it will resemble the picture underneath. In the event that you have missed the "Setup Options" screen, it's not an issue, you can simply get it by writing the accompanying summon in the terminal.

**\$ sudo raspi-config**

Since the Setup Options window is up, we set a couple of things. The main thing we did was to choose the principal choice in the rundown of the setup alternatives window, that is select the "Grow File system" choice and hit the enter key. We do this to make utilization of all the space introduce on the SD card as a full segment. This does is, grow the OS to fit the entire space on the SD card which can then be utilized as the capacity memory for the Pi. The second thing we did was to choose the third choice in the rundown of the setup alternatives window, that is select the "Empower Boot to Desktop/Scratch" choice and hit the enter key. It will take you to another window called the "pick boot alternative" window that resembles the picture beneath. In the "pick boot elective window", select the second decision, that is, "Desktop Log in as customer "pi" at the graphical desktop" and hit the enter get. e it at whatever point it is being asked. Once done you will be reclaimed to the "Setup Options" page, if not choose the "alright" catch at the base of this window and you will be reclaimed to the past window. We do this since we need to boot into the desktop condition which we know about. On the off chance that we don't do this progression, then the Raspberry Pi boots into a terminal each time with no GUI alternatives.

Once, both the means are done, select the "complete" catch at the base of the page and it ought to reboot consequently. On the off chance that it doesn't, then utilize the accompanying summon in the terminal to reboot. \$ sudo reboot

After the reboot from the past walk, if everything went right, then you will end up on the desktop. When you are on the desktop, open a terminal and enter the going with charge to revive the firmware of the Pi.

**\$ sudo reboot**

After the reboot from the past walk, if everything went right, then you will end up on the desktop. When you are on the desktop, open a terminal and enter the going with charge to revive the firmware of the Pi.**\$ sudo rpi-update**

**\$ sudo apt-get update**

**\$ sudo apt-get upgrade**

**\$ sudo reboot**

The most recent firmware may have the settle to those bugs, in this way it's essential to refresh it in the first place itself.

### **3.3.2 INSTALLING OPENCV 3 ON A RASPBERRY PI**

#### **OPENCV**

OpenCV is released under a BSD allow and thus it's free for both insightful and business use. It has C++, C, Python and Java interfaces and support Windows, Linux, Mac OS, iOS and Android. OpenCV was proposed for computational capability and with a strong focus on continuous applications. Written in upgraded C/C++, the library can abuse multi-focus taking care of. Enabled with OpenCL, it can abuse the hardware accelerating of the fundamental heterogeneous process organize. Gotten all around the world, OpenCV has more than 47 thousand people of customer gathering and surveyed number of downloads outperforming 9 million. Usage ranges from instinctive craftsmanship, to mines examination, sewing maps on the web or through forefront robotics.

#### **OpenCV Library**

The open source PC vision library, OpenCV, started as an examination extends at Intel in 1998. It has been accessible since 2000 under the BSD open source permit. OpenCV is gone for giving the devices expected to tackle PC vision issues. It contains a blend of low-level picture handling capacities and abnormal state calculations, for example, confront location, person on foot identification, include coordinating, and following. OpenCV's GPU module incorporates countless, and numerous

of them have been actualized in various forms, for example, the picture sorts (scorch, short, drift), number of channels, and outskirts extrapolation modes. This makes it trying to report correct execution numbers. An additional wellspring of trouble in refining the execution

numbers down is the overhead of synchronizing and exchanging information. This implies best execution is acquired for extensive pictures where a great deal of preparing should be possible while the information lives on the GPU. To help the engineer make sense of the exchange offs; OpenCV incorporates an execution benchmarking suite that runs GPU capacities with various parameters and on various datasets. This gives a nitty gritty benchmark of how entirely different datasets are quickened on the client's equipment.

the main thing to do is to extend your file system to incorporate all accessible space on your small scale SD card.

### **\$ sudo raspi-config**

Once provoked, we chose the primary choice, "1. Extend File System", hit Enter on our console, bolt down to the "<Finish>" catch, and afterward reboot your Pi:

### **\$ sudo reboot**

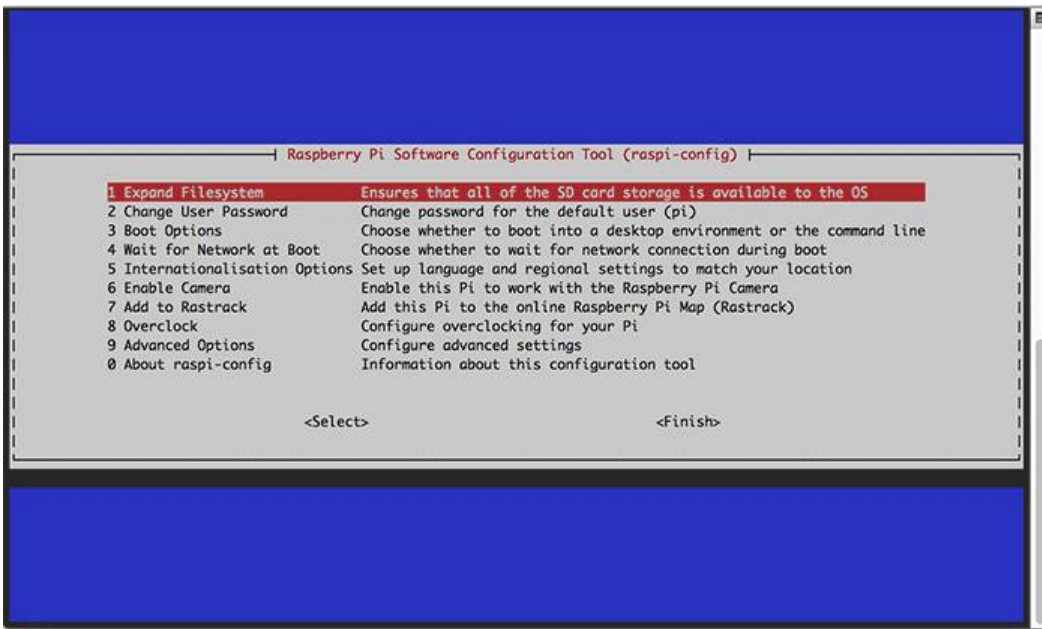


Figure 10 - Expanding the file system on your Raspberry Pi 3

In the wake of rebooting, your record structure should have been stretched out to join all available space on your littler scale SD card. You can watch that the plate has been reached out by executing `df - h` and taking a gander at the yield:

**\$ df -h**

OpenCV, alongside every one of its conditions, will require a couple of gigabytes amid the gather, so you ought to erase the Wolfram motor to free up some space on your Pi

**\$ sudo apt-get purge wolfram-engine**

The initial step is to refresh and update any current bundles:

**\$ sudo apt-get update**

**\$ sudo apt-get upgrade**

We then need to introduce some designer devices, including CMake, which helps us arrange the OpenCV assemble handle:

**\$ sudo apt-get install build-essential cmake pkg-config**

Next, we need to present some photo I/O packages that empower us to stack diverse picture archive outlines from circle. Instances of such record bunches fuse JPEG, PNG, TIFF, et cetera.

**\$ sudo apt-get install libjpeg-dev libtiff5-dev libjasper-dev libpng12-dev**

Essentially as we need picture I/O groups, we similarly require video I/O packs. These libraries empower us to scrutinize diverse video record bunches from hover and likewise work particularly with video streams:

**\$ sudo apt-get install libavcodec-dev libavformat-dev libswscale-dev libv4l-dev**

**\$ sudo apt-get install libxvidcore-dev libx264-dev**

The OpenCV library goes with a sub-module named high-up which is used to show pictures to our screen and make fundamental GUIs. Remembering the ultimate objective to arrange the highgui module, we need to present the GTK change library:

**\$ sudo apt-get install libgtk2.0-dev**

Numerous operations within OpenCV (to be specific grid operations) can be enhanced further by introducing a couple of additional conditions:

```
$ sudo apt-get install libatlas-base-dev gfortran
```

These upgrade libraries are especially crucial for resource obliged contraptions, for instance, the Raspberry Pi.

Eventually, we should present both the Python 2.7 and Python 3 header records so we can fuse OpenCV with Python ties:

```
$ sudo apt-get install python2.7-dev python3-dev
```

On the off chance that you skirt this progression, you may see a mistake identified with the Python.h header record not being found when running make to accumulate OpenCV.

Since we have our conditions introduced, how about we snatch the 3.1.0 file of OpenCV from the authority OpenCV archive. (Note: As future renditions of openCV are discharged, you can supplant 3.1.0 with the most recent adaptation number):

```
$ cd ~
```

```
$ wget -O opencv.zip https://github.com/Itseez/opencv/archive/3.1.0.zip
```

```
$ unzip opencv.zip
```

We'll need the full introduce of OpenCV 3 (to have entry to components, for example, SIFT and SURF, for example), so we likewise need to snatch the opencv\_contribution storehouse too:

```
$ wget -O opencv_contrib.zip https://github.com/Itseez/opencv_contrib/archive/3.1.0.zip
```

```
$ unzip opencv_contrib.zip
```

You may need to broaden the summon above using the "<=>" get in the midst of your copy and paste. The .speed in the 3.1.0.zip may have every one of the reserves of being cutoff in a couple programs. The full URL of the OpenCV 3.1.0 report is:

```
$ https://github.com/Itseez/opencv_contrib/archive/3.1.0.zip
```

Note: Make beyond any doubt your OpenCV and opencv\_contrib renditions are the same (for this situation, 3.1.0). On the off chance that the renditions numbers don't coordinate, then you'll likely keep running into either order time or runtime.

Before we can begin accumulating OpenCV on our Raspberry Pi 3, we initially need to introduce pip, a Python bundle chief:

```
$ wget https://bootstrap.pypa.io/get-pip.py
```

```
$ sudo python get-pip.py
```

At first, it's basic to appreciate that a virtual circumstance is a one of a kind gadget used to keep the conditions required by different exercises in parceled puts by making isolated, free Python circumstances for each of them.

Basically, it disentangles the "Amplify X depends on upon adjustment 1.x, yet Project Y needs 4.x" circumstance. It moreover keeps your overall site-groups flawless, clean, and free from chaos.

If you may need a full illumination on why Python virtual circumstances are awesome practice, absolutely give this shocking web journal section on Real Python a read.

It's standard practice in the Python society to use virtual circumstances or something to that effect, so I extremely endorse that you do in like manner:

```
$ sudo pip install virtualenv virtualenvwrapper
```

```
$ sudo rm -rf ~/.cache/pip
```

Since both virtualenv and virtualenvwrapper have been presented, we need to invigorate our ~/.profile report to fuse the going with lines at the base of

```
# virtualenv and virtualenvwrapper
```

```
export WORKON_HOME=$HOME/.virtualenvs
```

```
source /usr/local/bin/virtualenvwrapper.sh
```

In past instructional exercises, I've prescribed utilizing your most loved terminal-based content tool, for example, vim,emacs, or nano to refresh the ~/.profile document. In case you're alright with these editors, simply ahead and refresh the document to mirror the progressions specified previously. Else, you ought to just utilize feline and yield redirection to deal with refreshing.

```
$ echo -e "\n# virtualenv and virtualenvwrapper" >> ~/.profile
```

```
$ echo "export WORKON_HOME=$HOME/.virtualenvs" >> ~/.profile
```

```
$ echo "source /usr/local/bin/virtualenvwrapper.sh" >> ~/.profile
```

Since we have our ~/.profile refreshed, we have to reload it to ensure the progressions produce results. You can compel a reload of your ~/.profile document by:

Logging out and afterward logging back in.

Shutting a terminal occasion and opening up another one

Or, on the other hand my undisputed top choice, simply utilize the source order

```
$ Source ~/.profile
```

Next, we should make the Python virtual condition that we'll use for PC vision advancement:

```
$ mkvirtualenv cv -p python2
```

This order will make another Python virtual condition named cv utilizing Python 2.7.

In the event that you rather need to utilize Python 3, you'll need to utilize this charge:

```
$ mkvirtualenv cv -p python3
```

If you ever reboot your Raspberry Pi; log out and log back in; or open up another terminal, you'll need to use the workon request to re-get to the cv virtual condition. In past blog passages, I've seen perusers use the mkvirtualenv summon — this is totally unneeded! The mkvirtualenv request is planned to be executed only once: to truly make the virtual condition.



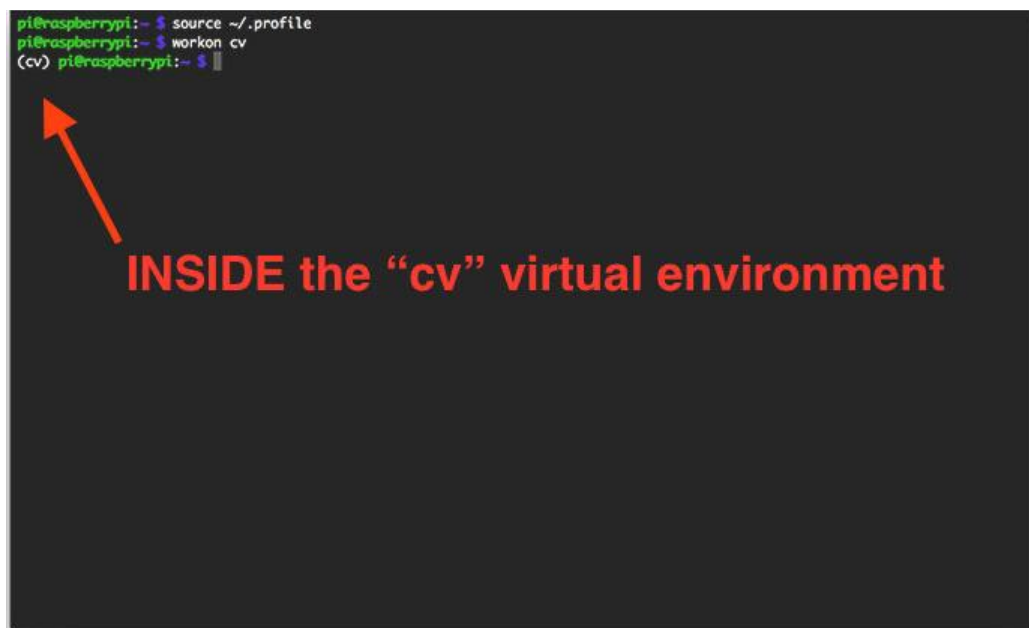
Starting there ahead, you can use deal with and you'll be dropped down into your virtual condition:

e of the record:

```
$ Source ~/.profile
```

```
$ workon cv
```

To approve and guarantee you are in the cv virtual condition, look at your summon line — in the event that you see the content (cv) going before your incite, then you are in the cv virtual condition:



```
pi@raspberrypi:~$ source ~/.profile
pi@raspberrypi:~$ workon cv
(cv) pi@raspberrypi:~$
```

**INSIDE the "cv" virtual environment**

Figure 11 - The "(cv)" message on your provoke, showing that you are in the cv virtual condition. Our exclusive Python reliance is NumPy, a Python bundle utilized for numerical handling:

```
$ pip install numpy
```

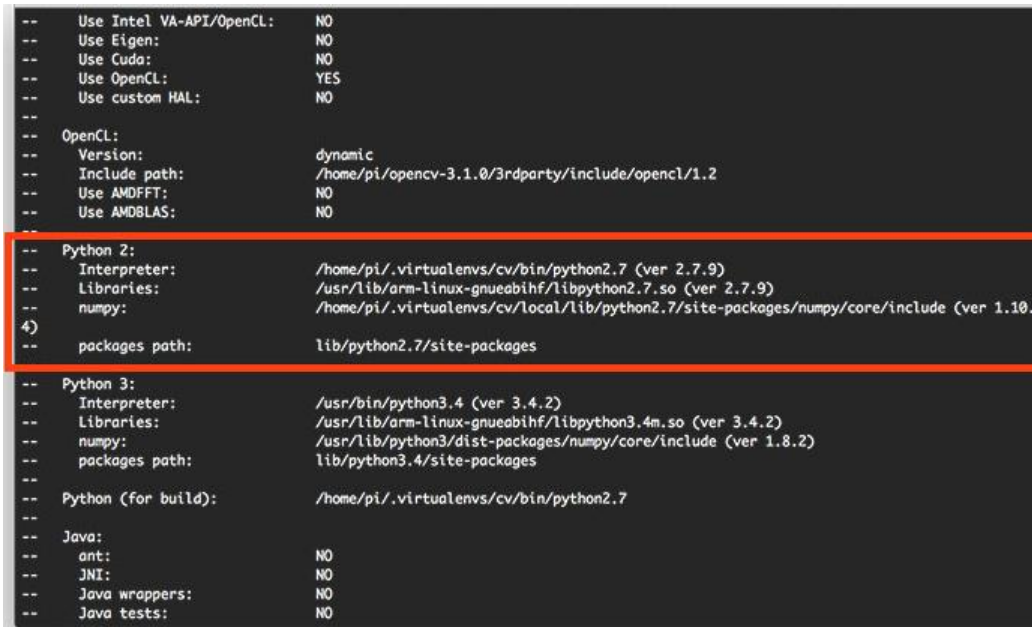
We are as of now arranged to arrange and present OpenCV! Twofold watch that you are in the cv virtual condition by taking a gander at your incite (you should see the (cv) content going before it), and if not, simply execute take a shot at:

```
$ workon cv
```

When you have promised you are in the cv virtual condition, we can setup our produce using CMake:

```
$ cd ~/opencv-3.1.0/
$ mkdir build
$ cd build
$ cmake -D CMAKE_BUILD_TYPE=RELEASE \
-D CMAKE_INSTALL_PREFIX=/usr/local \
-D INSTALL_PYTHON_EXAMPLES=ON \
-D OPENCV_EXTRA_MODULES_PATH=~/opencv_contrib-3.1.0/modules \
-D BUILD_EXAMPLES=ON
```

In the event that you are incorporating OpenCV 3 for Python 2.7, then ensure your Python 2 area incorporates substantial ways to the Interpreter, Libraries, numpy and bundles way, like my screenshot underneath:



```
-- Use Intel VA-API/OpenCL: NO
-- Use Eigen: NO
-- Use Cuda: NO
-- Use OpenCL: YES
-- Use custom HAL: NO
--
-- OpenCL:
-- Version: dynamic
-- Include path: /home/pi/opencv-3.1.0/3rdparty/include/opencv/1.2
-- Use AMDFFT: NO
-- Use AMDBLAS: NO
--
-- Python 2:
-- Interpreter: /home/pi/.virtualenvs/cv/bin/python2.7 (ver 2.7.9)
-- Libraries: /usr/lib/arm-linux-gnueabi/libpython2.7.so (ver 2.7.9)
-- numpy: /home/pi/.virtualenvs/cv/local/lib/python2.7/site-packages/numpy/core/include (ver 1.10.4)
-- packages path: lib/python2.7/site-packages
--
-- Python 3:
-- Interpreter: /usr/bin/python3.4 (ver 3.4.2)
-- Libraries: /usr/lib/arm-linux-gnueabi/libpython3.4m.so (ver 3.4.2)
-- numpy: /usr/lib/python3/dist-packages/numpy/core/include (ver 1.8.2)
-- packages path: lib/python3.4/site-packages
--
-- Python (for build): /home/pi/.virtualenvs/cv/bin/python2.7
--
-- Java:
-- ant: NO
-- JNI: NO
-- Java wrappers: NO
-- Java tests: NO
```

Figure 12 - Ensuring that Python 2.7 will be utilized when gathering OpenCV 3 for Raspbian Jessie on the Raspberry Pi 3.

Provided that this is true, get to the cv virtual condition using workon cv and re-run the cmake arrange plot above. Finally, we are directly arranged to accumulate OpenCV:

```
$ make -j4
```

The `-j4` charge controls the amount of focuses to utilize when organizing OpenCV 3. The Raspberry Pi 3 has four focuses; along these lines we supply an estimation of 4 to empower OpenCV to total speedier. Notwithstanding, due to race conditions, there are times when make mistakes out when utilizing different centres. In the event that this transpires, I recommend beginning the aggregation once again and utilizing just a single centre::

```
$ make clean
```

```
$ make
```

From that point, you should simply introduce OpenCV 3 on your Raspberry Pi 3

```
$ sudo make install
```

```
$ sudo ldconfig
```

OpenCV ought to now be introduced in `/usr/neighborhood/lib/python2.7/site-pacakges`. You can confirm this utilizing the `ls` charge:

```
$ ls -l /usr/local/lib/python2.7/site-packages/
```

```
Total 1852
```

Our last stride is to sym-interface the OpenCV ties into our `cv` virtual condition for Python 2.7:

```
$ cd ~/. virtualenvs/cv/lib/python2.7/site-packages/
```

```
$ ln -s /usr/local/lib/python2.7/site-packages/cv2.so cv2.so
```

How about we initially confirm that your OpenCV establishment is working appropriately. Open up another terminal; execute the source andwork on charges, and after that at last endeavour to import the Python + OpenCV ties:

```
$ source ~/.profile
```

```
$ workon cv
```

```
pi@raspberrypi:~$ source ~/.profile
pi@raspberrypi:~$ workon cv
(cv) pi@raspberrypi:~$ python
Python 2.7.9 (default, Mar 8 2015, 00:52:26)
[GCC 4.9.2] on linux2
Type "help", "copyright", "credits" or "license" for more information.
>>> import cv2
>>> cv2.__version__
'3.1.0'
>>> |
```

Figure 13 - Affirming OpenCV 3 has been effectively introduced on my Raspberry Pi 3 running Raspbian

### 3.3.3 FACE DETECTION ALGORITHM

A Haar-like component considers neighboring rectangular areas at a specific region in an area window, adds up to up the pixel controls in each locale and figures the differentiation between these totals. This refinement is then used to request subsections of a picture. An instance of this would be the revelation of human appearances. For the most part, the districts around the eyes are darker than the extents on the cheeks. One instance of a Haar-like component for face acknowledgment is thus a plan of two neighboring rectangular locales over the eye and cheek ranges.

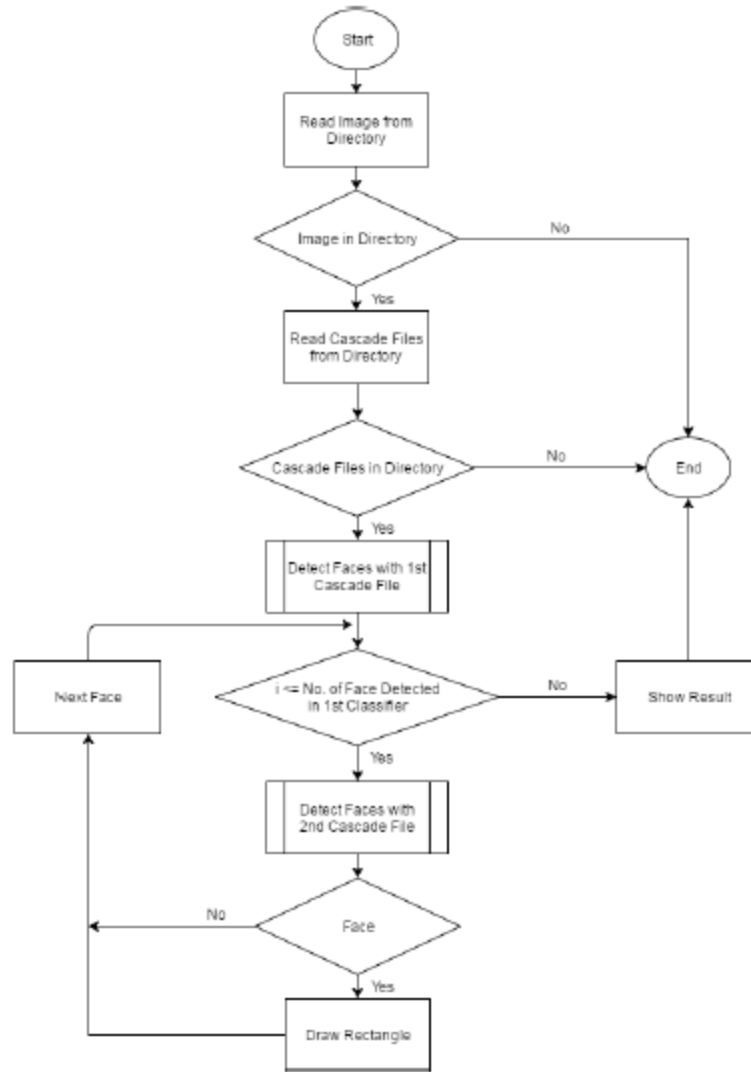


Figure 14. Flowchart for face detection for image files

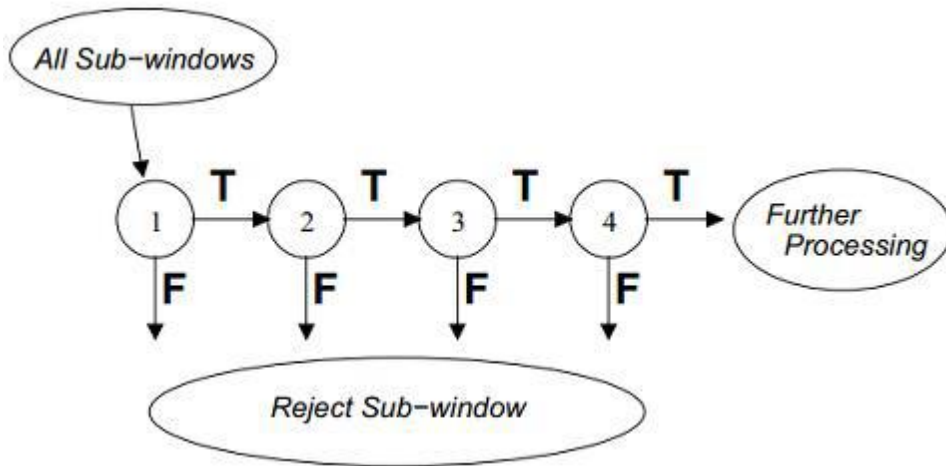
### Cascade classifier

The cascade classifier comprises of a rundown of stages, where each stage comprises of a rundown of feeble learners. The framework identifies protests being referred to by moving a window over the picture. Each phase of the classifier marks the particular district characterized by the present area of the window as either positive or negative – positive implying that a question was found or negative implies that the predetermined protest was not found in the picture. On the off chance that the naming yields a negative outcome, then the order of this particular locale is therefore total and the area of the window is moved to the following area. On the off chance that the naming gives a positive outcome, then the locale

moves of to the following phase of arrangement. The classifier yields a last decision of positive, when every one of the stages, including the last one, yield an outcome, saying that the question is found in the picture.

A genuine positive implies that the protest being referred to is to be sure in the picture and the classifier marks it all things considered – a positive outcome. A false positive implies that the marking procedure dishonestly establishes that the protest is situated in the picture, in spite of the fact that it is most certainly not. A false negative happens when the classifier can't distinguish the real protest from the picture and a genuine negative implies that a non-protest was accurately classifier as not being the protest being referred to.

Keeping in mind the end goal to function admirably, each phase of the course should have a low false negative rate, in light of the fact that if the real protest is named a non-question, then the characterization of those branch stops, with no real way to amend the oversight made. Be that as it may, each stage can have a generally high false positive rate, in light of the fact that regardless of the possibility that the n-th arrange orders the non-protest as really being the question, then this oversight can be settled in n+1-th and resulting phases of the



classifier.

Figure 15 - Stages of the cascade classifier

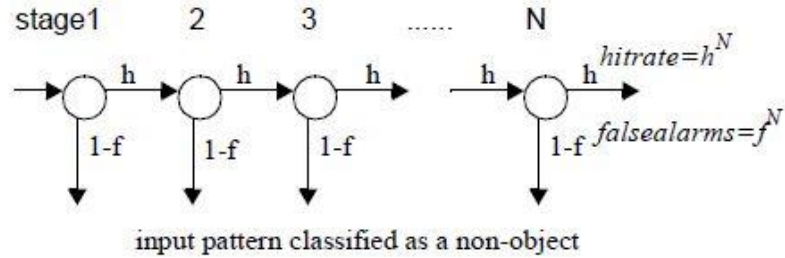


Figure 16 - Cascade of classifiers with  $N$  stages. At each stage a classifier is trained to achieve a hit rate of  $h$  and a false alarm rate of  $f$ .

The human face acts extensively a bigger number of issues than various things since the human face is a dynamic challenge that comes in many structures and shades. In any case, facial area and taking after gives many points of interest. Facial affirmation is unrealistic if the face is not segregated from the establishment. Human Computer Interaction (HCI) could altogether be improved by using feeling, stance, and movement affirmation, all of which require face and facial component acknowledgment and taking after. Yet an extensive variety of figuring's exist to perform stand up to distinguishing proof, each has its own specific inadequacies and qualities. Some use tissue tones, some usage shapes, and other are fundamentally more eccentric including formats, neural frameworks, or channels. These estimations encounter the evil impacts of a comparable issue; they are computationally exorbitant. A photo is only a social affair of shading or possibly light power values. Looking at these pixels for face revelation is monotonous and difficult to accomplish because of the wide assortments of shape and pigmentation inside a human face. Pixels as often as possible require reanalysis for scaling and precision. Viola and Jones imagined a figuring, called Haar Classifiers, to rapidly recognize any challenge, including human goes up against, using AdaBoost classifier falls that rely on upon Haar-like

### Haar Cascade Classifiers

The center clarification behind Haar classifier disagree revelation is the Haar-like segments. These portions, as opposed to utilizing the power estimations of a pixel, utilize the change of course values between adjoining rectangular social events of pixels. The qualification changes between the pixel parties are utilized to pick relative light and lessen ranges. Several coterminous social events with a relative multifaceted nature change shape a Haar-like part.

Haar-like parts, as appeared in Figure 3 are utilized to perceive a photograph. Haar parts can without a considerable measure of an augment be scaled by developing or diminishing the measure of the pixel get-together being inspected. This engages fragments to be utilized to see objects of different sizes.

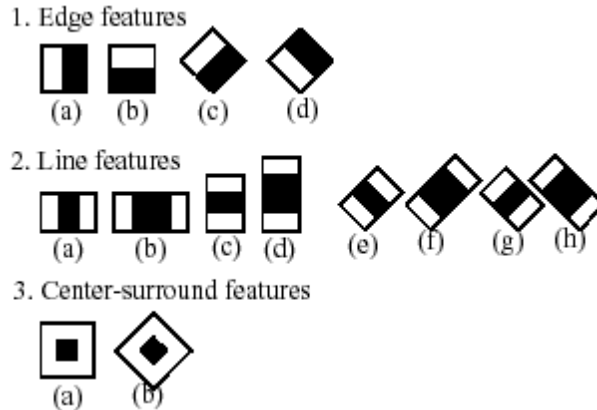


Figure 17 - Common Haar Features

### Integral Image

The straightforward rectangular components of a picture are computed utilizing a transitional portrayal of a picture, called the fundamental picture. The basic picture is a cluster containing the aggregates of the pixels' power values found straightforwardly to one side of a pixel and specifically over the pixel at area  $(x, y)$  comprehensive. So if  $A[x, y]$  is the first picture and  $AI[x, y]$  is the indispensable picture then the basic picture is registered as appeared in condition 1 and represented in Figure 4.

$$AI[x, y] = \sum_{x' \leq x, y' \leq y} A(x', y') \quad (1)$$

The components pivoted by forty-five degrees, similar to the line include appeared in Figure 3 2(e), as presented by Lienhart and Maydt, require another transitional portrayal called the turned basic picture or pivoted whole assistant picture. The pivoted essential picture is ascertained by finding the total of the pixels' force values that are situated at a forty-five-degree point to one side or more for the  $x$  esteem and beneath for the  $y$  esteem. So if  $A[x, y]$  is the first picture and  $AR[x, y]$  is the pivoted fundamental picture then the indispensable picture is processed as appeared in condition 2 a delineated in Figure 5.

$$AR[x, y] = \sum_{x' \leq x, x' \leq x - |y - y'|} A(x', y') \quad (2)$$



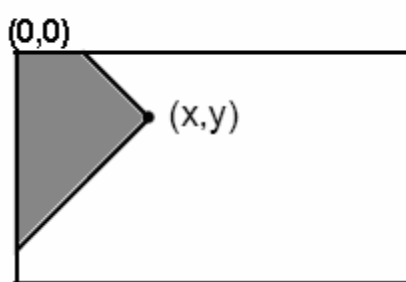
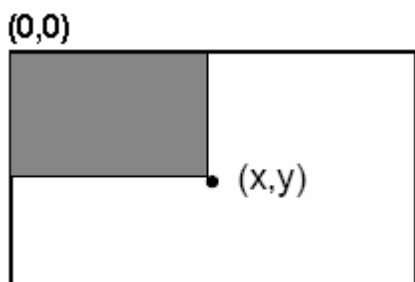


Figure 18 - Summed area of integral image

Figure 19 - Summed area of rotated integral image

It just takes two goes to enroll both essential picture shows, one for each group. Using the reasonable crucial picture and taking the differentiation between six to eight bunch segments encircling a couple related rectangles, a component of any scale can be figured. Along these lines learning a component is to an incredible degree speedy and gainful. It moreover suggests finding out components of various sizes requires an unclear effort from a component of only a couple of pixels. The revelation of various sizes of a comparative challenge requires a vague measure of effort and time from objects of tantamount sizes since scaling requires no additional effort.

### **Training Classifiers for Facial Features**

Recognizing human facial components, for instance, the mouth, eyes, and nose require that Haar classifier falls at first be readied. Remembering the ultimate objective to set up the classifiers, this fragile AdaBoost count and Haar incorporate estimations must be executed. Fortunately, Intel developed an open source library focused on encouraging the use of PC vision related activities called Open Computer Vision Library (OpenCV). The OpenCV library is proposed to be used as a piece of conjunction with applications that identify with the field of HCI, mechanical innovation, biometrics, picture dealing with, and diverse locales where portrayal is basic and joins an execution of Haar classifier acknowledgment and planning. To set up the classifiers, two game plans of pictures are required. One set contains a photo or scene that does not contain the question, for this circumstance a facial component, which will be recognized. This game plan of pictures is implied as the negative pictures. The other course of action of pictures, the positive pictures, contains no less than one events of the challenge. The region of the things inside the positive pictures is demonstrated by: picture

name, the upper left pixel and the height, and width of the challenge. For get ready facial components 5,000 negative pictures with no not as much as a super pixel assurance were used for get ready. These photos included common things, like paperclips, and of trademark scene, like photographs of woodlands and mountains. Remembering the ultimate objective to convey the most energetic facial part revelation possible, the principal valuable plan of pictures ought to be illustrative of the change between different people, including, race, sexual introduction, and age. An OK hotspot for these photos is National Institute of Standards and Technology's (NIST) Facial Recognition Technology (FERET) database. This database contains more than 10,000 pictures of more than 1,000 people under different lighting

Conditions, stances, and focuses . In setting up each facial component, 1,500 pictures were used. These photos were taken at focuses going from zero to forty-five degrees from a frontal view. This gives the required contrast required to allow distinguishing proof if the head is turned possibly. Three separate classifiers were readied, one for the eyes, one for the nose, and one for the mouth. Once the classifiers were readied, they were used to perceive the facial components inside another game plan of pictures from the FERET database. The exactness of the classifier was then handled as showed up in Table 1. Aside from the mouth classifier, the classifiers have a high rate of area. Nevertheless, as proposed by, the false positive rate is furthermore high.

Facial Feature	Positive Hit Rate	Negative Hit Rate
Eyes	93%	23%
Nose	100%	29%
Mouth	67%	28%

Table 4 - Accuracy of Classifiers

The underlying stage in facial component disclosure is distinguishing the face. This requires looking at the entire picture. The second step is using the detached face(s) to perceive every part. The result is showed up in Figure 4. Since each the piece of the photo used to distinguish a component is considerably more diminutive than that of the whole picture,

acknowledgment of each one of the three facial components takes less time things being what they are than perceiving the face itself. Using a 1.2GHz AMD processor to dismember a 320 by 240 picture, a packaging rate of 3 edges for each second was refined. Since an edge rate of 5 edges for each second was proficient in facial revelation just by using a considerably speedier processor, regionalization gives a colossal augmentation in efficiency in facial component ID. Regionalization also staggeringly extended the precision of the area. Every single false positive were wiped out, giving an area rate of around 95% for the eyes and nose. The mouth revelation has a lower rate due to the base size required for recognizable proof. By changing the height and width parameter to more definitely address the estimations of the mouth and retraining the classifier the precision should manufacture the precision to that of interchange components.

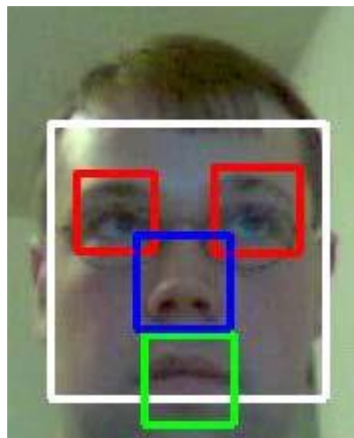


Figure 20 - Detected Objects: Face (white), Eyes (red), Nose (blue), and Mouth (green)

## **NUMPY ARRAYS**

In the Python world, Numpy shows are the standard depiction for numerical data. Here, we show how these bunches enable gainful utilization of numerical counts in an anomalous state lingo. By and large, three frameworks are associated with improve execution: vector sing estimations, refraining from copying data in memory, and constraining operation checks. The Python programming lingo gives a rich course of action of strange state data structures: records for posting a collection of articles, vocabularies to produce hash tables, et cetera. In any case, these structures are not ideally suited to prevalent numerical figuring. In the mid-90s, an all inclusive gathering of volunteers started to develop a data structure for beneficial display estimation. This structure progressed into what is by and by known as the N-

dimensional NumPy display. The NumPy package, which contains the NumPy display and furthermore a game plan of running with logical limits, has found extensive allocation in the academic world, national research focuses, and industry, with applications going from gaming

to space examination. A NumPy display is a multidimensional, uniform social event of segments. A display is depicted by the kind of parts it contains and by its shape. For example, a system may be addressed as an assortment of shape (M×N) that contains numbers, e.g., floating point or complex numbers. Not in the least like systems, can NumPy bunches have any dimensionality. Moreover, they may contain distinctive sorts of segments (or even mixes of parts, for instance, Booleans or dates. Underneath the hood, a NumPy show is really just a beneficial technique for depicting no less than one bits of PC memory, so that the numbers addressed may be easily controlled.

### **Computer Vision**

Consider a  $n \times 3$  cluster of three dimensional focuses and a  $3 \times 3$  camera grid:

```
Points = np.random.random((100000, 3))
```

```
camera = np.array([[500., 0., 320.], [ 0., 500., 240.], [ 0., 0., 1.]])
```

Regularly, we need to change the 3D arranges into their 2D pixel areas on the picture, as seen by the camera. This operation includes taking the network speck result of each point with the camera lattice, and after that partitioning the subsequent vector by its third segment. With NumPy, it is composed as:

```
# Perform the matrix product on the coordinates
```

```
vecs = camera. dot (points).T
```

```
# Divide resulting coordinates by their z-value
```

```
pixel_coords = vecs/vecs[:, 2, np.newaxis]
```

The spot work executes the lattice item, rather than the component shrewd item. It can be connected to maybe a couple dimensional clusters. This code executes in 9 milliseconds—70x speedup over a Python for-circle form. Beside the enhanced NumPy dab item, we make utilization of NumPy's exhibit operations with component by-component division and the telecom apparatus. The code `new_vecs/new_vecs[:, 2, np.newaxis]` separates every section of `new_vecs` by its third segment (at the end of the day, each column is isolated by its third

component). The `np.newaxis` file is utilized to change `new_vecs[:, 2]` into a column-vector so that broadcasting may take place.

### **3.3.4 FACE RECOGNITION**

One of the least complex and best PCA approaches utilized as a part of face acknowledgment frameworks is the supposed eigenface approach. This approach changes faces into a little arrangement of basic attributes, eigenfaces, which are the fundamental parts of the underlying arrangement of learning pictures (preparing set). Acknowledgment is finished by anticipating another picture in the eigenface subspace, after which the individual is grouped by contrasting its position in eigenface space and the position of known people. The upside of this approach over other face acknowledgment frameworks is in its

Effortlessness, speed and harshness to little or progressive changes on the face. The issue is constrained to records that can be utilized to perceive the face. In particular, the pictures must be vertical frontal perspectives of human appearances

#### **PCA Approach to Face Recognition [5]**

Essential part investigation changes an arrangement of information gotten from perhaps related factors into an arrangement of estimations of uncorrelated factors called vital segments. The quantity of parts can be not exactly or equivalent to the quantity of unique factors. The primary important segment has the most astounding conceivable fluctuation, and each of the succeeding part has the most elevated conceivable difference under the limitation that it must be orthogonal to the past segment. We need to discover the foremost parts, for this situation eigenvectors of the covariance network of facial pictures. The main thing we have to do is to frame a preparation informational collection. 2D picture  $I_i$  can be spoken to as a 1D vector by connecting columns. Picture is changed into a vector of length  $N = mn$ .

$$\mathbf{I} = \begin{bmatrix} x_{11} & x_{12} & \dots & x_{1n} \\ x_{21} & x_{22} & \dots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \dots & x_{mn} \end{bmatrix}_{m \times n} \xrightarrow{\text{CONCATENATION}} \begin{bmatrix} x_{11} \\ \vdots \\ x_{1n} \\ \vdots \\ x_{2n} \\ \vdots \\ x_{mn} \end{bmatrix}_{1 \times N} = \mathbf{x}.$$

Let  $M$  such vectors  $x_i$  ( $i = 1, 2, \dots, M$ ) of length  $N$  form a framework of learning pictures,  $\mathbf{X}$ . To guarantee that the primary central part portrays the heading of most extreme fluctuation, it is important to focus the framework. To begin with we decide the vector of mean qualities  $\Psi$ , and afterward subtract that vector from each picture vector.

$$\Psi = \frac{1}{M} \sum_{i=1}^M x_i,$$

$$\phi_i = x_i - \Psi.$$

Averaged vectors are arranged to form a new training matrix (size  $N \times M$ );

$$\mathbf{A} = (\phi_1, \phi_2, \dots, \phi_M).$$

The next step is to calculate the covariance matrix  $\mathbf{C}$ , and find its eigenvectors  $e_i$  and eigenvalues  $\lambda_i$ :

$$\mathbf{C} = \frac{1}{M} \sum_{n=1}^M \phi_n \phi_n^T = \mathbf{A} \mathbf{A}^T,$$

$$\mathbf{C} e_i = \lambda_i e_i.$$

Covariance network  $\mathbf{C}$  has measurements  $N \times N$ . From that we get  $N$  eigenvalues and eigenvectors. For a picture size of  $128 \times 128$ , we would need to compute the network of measurements  $16.384 \times 16.384$  and find 16.384 eigenvectors. It is not exceptionally successful

since we needn't bother with a large portion of these vectors. Rank of covariance framework is restricted by the quantity of pictures in learning set — on the off chance that we have  $M$  pictures, we will have  $M-1$  eigenvectors relating too non-zero eigenvalues. One of the hypotheses in direct polynomial math expresses that the eigenvectors  $e_i$  and eigenvalues  $\lambda_i$  can be acquired by discovering eigenvectors and eigenvalues of grid  $C = A^T A$  (measurements  $M \times M$ ) [3]. On the off chance that  $v_i$  and  $\mu_i$  are eigenvectors and eigenvalues of lattice  $A^T A$ , then:

$$A^T A v_i = \mu_i v_i$$

Multiplying both sides of this equation with  $A$  form the left, we get:

$$\begin{aligned} A A^T A v_i &= A \mu_i v_i, \\ A A^T (A v_i) &= \mu_i (A v_i), \\ C(A v_i) &= \mu_i (A v_i). \end{aligned}$$

Differentiating these conditions, we can reason that the essential  $M-1$  eigenvectors  $e_i$  and eigenvalues  $\lambda_i$  of system  $C$  are given by  $A v_i$  and  $\mu_i$ , independently. Eigenvector related with the most essential eigenvalue reflects the most raised change, and the one related with the slightest eigenvalue, the smallest distinction. Eigenvalues decrease exponentially so that around 90% of the total contrast is contained in the underlying 5% to 10% eigenvectors. In this way, the vectors should be sorted by eigenvalues so that the foremost vector looks at to the most dumbfounding eigenvalue. These vectors are then institutionalized. They shape the new system  $E$  so that each vector  $e_i$  is a segment vector. The estimations of this grid are  $N \times D$ , where  $D$  addresses the desired number of eigenvectors. It is used for projection of data system  $A_n$  and calculation of yivectors of matrix.

$$Y = (y_1, \dots, y_M):$$

$$Y = E^T A.$$

Every unique picture can be reproduced by adding mean picture  $\Psi$  to the weighted summation of all vectors  $e_i$ . The last stride is the acknowledgment of appearances. Picture of

the individual we need to find in preparing set is changed into a vector P, decreased by the mean esteem  $\Psi$  and anticipated with a network of eigenvectors (eigenfaces):

$$\omega = E^T (P - \Psi)$$

Arrangement is finished by deciding the separation,  $\epsilon_i$ , amongst  $\omega$  and each vector  $y_i$  of network Y. The most well-known is the Euclidean separation, however other measures might be utilized. This paper introduces the outcomes for the Euclidean and Manhattan separate. On the off chance that A and B are two vectors of length D, the distance between them is resolved as takes after:

1. Manhattan distance:

$$d(A, B) = \sum_{i=1}^D |a_i - b_i|;$$

2. Euclidean distance:

$$d(A, B) = \sqrt{\sum_{i=1}^D (a_i - b_i)^2} = \|A - B\|.$$

If the base partition between test confront and get ready appearances is higher than an edge  $\theta$ , the test face is thought to be dark, else it is known and has a place with the individual argmin. The program requires a base separation between the test picture and pictures from the readiness base. Notwithstanding the likelihood that the individual is not in the database, the face would be seen. It is accordingly important to set a breaking point that will empower us to choose if a man is in the database. There is no condition for choosing the edge. The most widely recognized way is to first process the base partition of each photo from the preparation base from substitute pictures and place that division in a vector rast. Threshold is taken as 0.8 times of the best estimation of vector rast.

### **Local Binary Patterns for Face Recognition [6]**

The LBP executive is one of the best performing surface descriptors and it has been by and large used as a piece of various applications. It has wound up being exceedingly



discriminative and its key favorable circumstances, to be specific, its invariance to monotonic dim level changes and computational efficiency, make it sensible for asking for picture investigation assignments. For a book reference of LBP-related research, see [http://www.ee.oulu.fi/ask about/imag/surface/](http://www.ee.oulu.fi/ask_about/imag/surface/). Using LBP for face depiction is influenced by the way that faces can be seen as a union of littler scale plans which are all around portrayed by such manager. The LBP chairman was at first planned for surface depiction. The executive delegates a name to every pixel of a photo by thresholding the 3 x 3-neighborhood of each pixel with the middle pixel regard and considering the result as a matched number. By then,

The histogram of the marks can be utilized as a surface descriptor. See Fig. 6 for a representation of the essential LBP operator. To have the capacity to manage surfaces at various scales, the LBP operator was later stretched out to utilize neighbourhoods of various sizes. Characterizing the nearby neighbourhoods an arrangement of inspecting points evenly separated on a hover focused at the pixel to be marked allows any span and number of testing focuses. Bilinear interpolations utilized when a testing point does not fall in the focal point of a pixel. In the accompanying, the documentation  $\delta P; R_p$  will be utilized for pixel

Neighborhoods which infers  $P$  testing centers around a float of range of  $R$ . See Fig. 7 for an instance of round neighborhoods. Another expansion to the main overseer is the meaning of purported uniform cases. An area twofold case is called uniform if the combined case contains at most two bitwise moves from 0 to 1 or the other route around when the bit configuration is viewed as circuitous. For example, the cases 00000000 (0 transitions), 01110000 (2 moves) and 11001111 (2 moves) are uniform while the examples 11001001 (4 moves) and 01010011 (6 moves) are most certainly not. In the calculation of the LBP histogram, uniform examples are utilized so that the histogram has separate canister for each uniform example and all no uniform patterns are doled out to a solitary container. Ojala et al. seen that in their experiments with surface pictures, uniform examples represent abut under 90 percent of all examples when utilizing the neighbourhood and for around 70 percent in the neighbourhood. We have found that 90.6 percent of the examples in the neighbourhood and 85.2 percent of the examples in the neighbourhood are uniform if there should arise an occurrence of pre-handled FERET facial images. We utilize the accompanying

documentation for the LBP chairman:  $LBP_{u2P;R}$ . The subscript addresses using the executive in a  $\delta P;R P$  neighbourhood. Superscript  $u2$  stays for using simply uniform cases.

### Face Description with LBP

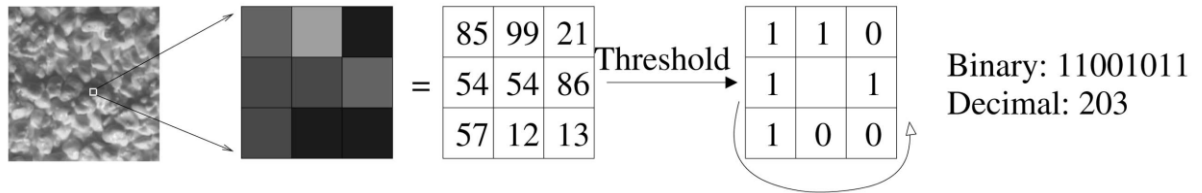


Figure 21 - The basic LBP operator

In this work, the LBP technique introduced in the past segment issued for face depiction. The system comprises of utilizing the texture descriptor to manufacture a few nearby depictions of the face and combining them into a worldwide portrayal. Rather than taking a stab at an all encompassing portrayal, this approach was moved by two reasons: the area incorporate based or cross breed approaches to manage confront acknowledgment have been getting interest recently, which is justifiable given the requirements of the far reaching depictions. These nearby incorporate based and cream methodologies give off an impression of being more vigorous against assortments in position or edification than complete strategies. Another clarification behind picking the close-by segment based approach is that endeavoring to make a widely inclusive depiction of a face using surface strategies is not sensible since surface descriptors tend to normal over the photo run. This is an appealing property for common surfaces, since surface depiction should as a rule be invariant to understanding or even upset of the surface and, particularly, for minimal dull surfaces, the little scale connections decide the nearness of the surface and, in this way, the largescale relations don't contain profitable information. For appearances, be that as it may, the condition is particular: holding the information about spatial relations is vital. This reasoning prompts the crucial procedure of this work. The facial picture is secluded into close-by areas and surface descriptors are removed from each zone self-rulingly. The descriptors are then connected to shape an overall delineation of the face. See Fig. 7 for a case of a facial picture parceled into rectangular

areas.

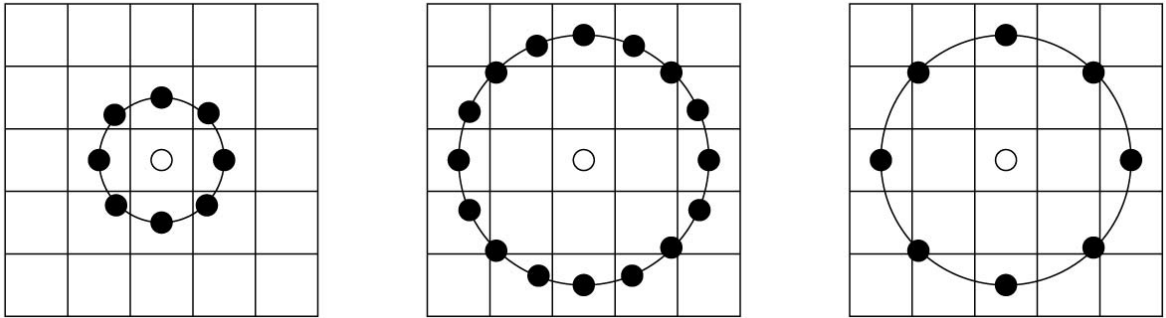


Figure 22 - The circular (8, 1), (16, 2), and (8, 2) neighbourhoods. The pixel values are bilinear interpolated whenever the sampling point is not in the centre of a pixel.

this approach was moved by two reasons: the area incorporate based or cross breed approaches to manage confront acknowledgment have been getting interest recently, which is justifiable given the requirements of the far reaching depictions. These nearby incorporate based and cream methodologies give off an impression of being more vigorous against assortments in position or edification than complete strategies. Another clarification behind picking the close-by segment based approach is that endeavoring to make a widely inclusive depiction of a face using surface strategies is not sensible since surface descriptors tend to normal over the photo run. This is an appealing property for common surfaces, since surface depiction should as a rule be invariant to understanding or even upset of the surface and, particularly, for minimal dull surfaces, the little scale connections decide the nearness of the surface and, in this way, the largescale relations don't contain profitable information. For appearances, be that as it may, the condition is particular: holding the information about spatial relations is vital. This reasoning prompts the crucial procedure of this work. The facial picture is secluded into close-by areas and surface descriptors are removed from each zone self-rulingly. The descriptors are then connected to shape an overall delineation of the face. See Fig. 7 for a case of a facial picture parceled into rectangular areas.

$$\chi_w^2(\mathbf{x}, \boldsymbol{\xi}) = \sum_{j,i} w_j \frac{(x_{i,j} - \xi_{i,j})^2}{x_{i,j} + \xi_{i,j}},$$

in which  $\mathbf{x}$  and  $\mathbf{m}$  are the normalized enhanced histograms to be compared, indices  $i$  and  $j$  refer to  $i$ th bin in histogram corresponding to the  $j$ th local region and  $w_j$  is the weight for

region

j.

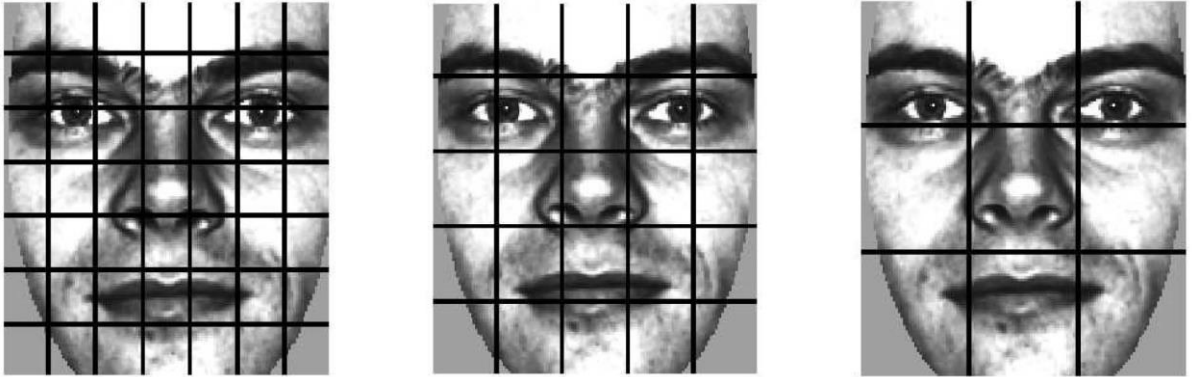


Figure 23 -A facial image divided into 7 x 7, 5 x 5, and 3 x 3 rectangular regions.

## **CHAPTER 4**

### **PERFORMANCE ANALYSIS**

#### **4.1 PERFORMANCE COMPARISON BETWEEN IDENTICALLY TRAINED CASCADES WITH THREE DIFFERENT BOOSTING ALGORITHMS**

All examinations were execution on the entire CMU Frontal Face Test Set of 130 greyscale pictures with 510 frontal countenances [11]. A hit was pronounced if and just if the Euclidian separation between the focal point of a distinguished and genuine face was under 30% of the width of the real face also as the width (i.e., size) of the recognized face was inside  $\pm 50\%$  of the real face width. Each recognized face, which was not a hit, was considered a false alert. Hit rates are accounted for in percent, while the false cautions are determined by their supreme numbers keeping in mind the end goal to make the outcomes practically identical with related work on the CMU Frontal Face Test set. But generally noted 5000 positive frontal face designs and 3000 negative examples separated by stage 0 to n-1 were utilized to prepare phase of the course classifier. The 5000 positive frontal face examples were gotten from 1000 unique face designs by arbitrary pivot about  $\pm 10$  degree, irregular scaling about  $\pm 10\%$ , irregular reflecting and irregular moving up to  $\pm 1$  pixel. Each stage was prepared to dismiss about portion of the negative examples, while effectively tolerating 99.9% of the face designs. A completely prepared course comprised of 20 phases. Amid recognition, a sliding window was moved pixel by pixel over the photo at each scale. Beginning with the first scale, the elements were developed by 10% and 20%, individually (i.e., speaking to a rescale variable of 1.1 and 1.2, separately) until surpassing the span of the photo in no less than one measurement. Regularly various appearances are recognizing at close by area and scale at a genuine face area. Hence, various adjacent discovery results were consolidated. Recipient Operating Curves (Rocs) were developed by changing the required number of identified countenances per genuine face before converging into a solitary location result. Amid experimentation just a single parameter was changed at once. The best method of a parameter found in an examination was utilized for the resulting tests.

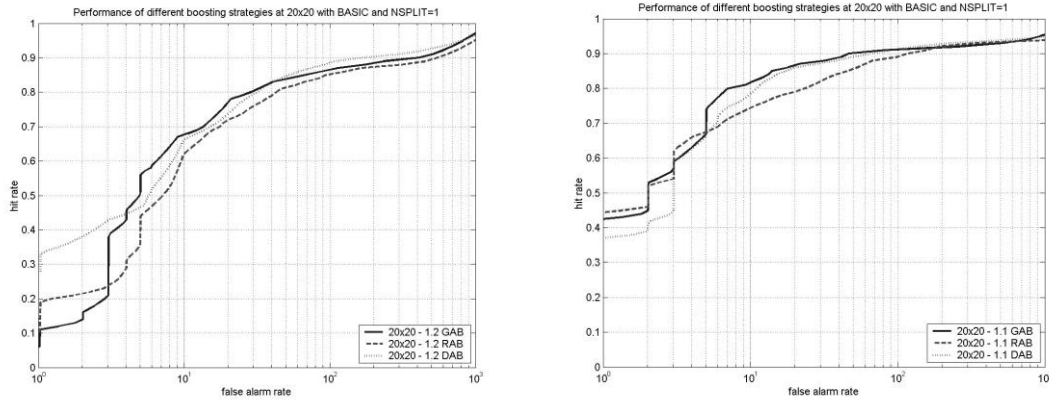


Figure 24 - Performance comparison between identically trained cascades with three different boosting algorithms. Only thebaic feature set and stumps as weak classifiers (nsplit=1) were used.

#### 4.2 ANALYSIS OF PHOTOS TAKEN BY CAMERA MODULE

Majority of the faces in the photos were detected but the photos with tilted faces or faces with an angle were not detected.

Also if the photo was rotated by 180 degrees, then also the program couldn't detect faces.

If the lighting was poor, then also the program couldn't detect face(s) in the photo.



Figure 25 – Face detected in average lighting

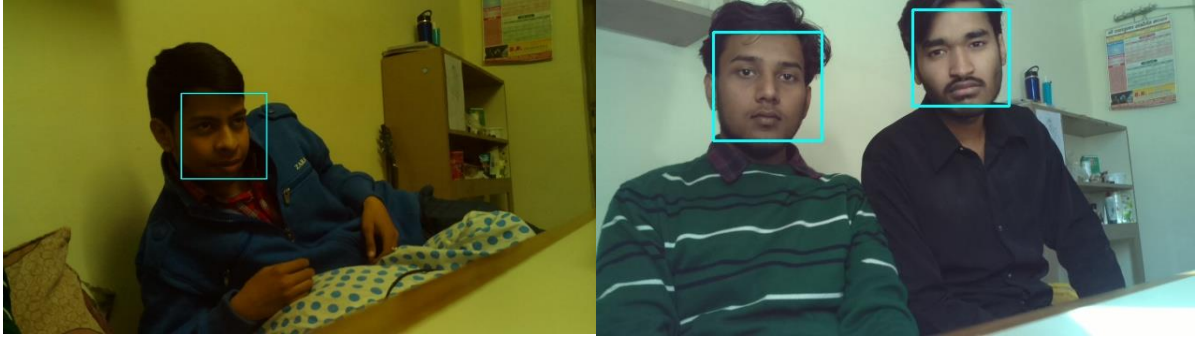


Figure 26 – Face detected in good lighting

## **CHAPTER 5**

### **CONCLUSION**

PCA based facial identification framework utilizes the Raspberry Pi 3 Model Development stage construct around a BCM2837 System-with respect to Chip wearing an ARM Cortex-A53 processor. Picture catch gadget utilized here is Pi Camera Module v2.

The recovery of pictures containing human countenances requires location of human faces in such pictures. We executed the Haar Cascade Classifiers technique that outputs the entire picture base on Haar Classifiers and distinguishes if a face is available in the picture. We took around 30 pictures from our Picamera and got around 83% of precision. The misses as a rule were because of revolution of picture or awful lighting. Our present execution is restricted to the location of frontal human appearances. A conceivable and intriguing augmentation is extend the format coordinating procedure to incorporate sided-see confronts too.

This can be additionally advanced into a face acknowledgment framework by including a face database and setting up of new code. There can be numerous developments, for example, live stream as a security cam that recognizes at whatever point another face is identified and stores it into the database as per the client whether as well disposed or non-accommodating



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### Some Online Documentations:

- <http://docs.opencv.org/3.1.0/>
- <https://docs.scipy.org/doc/numpy-dev/dev/>
- <https://www.raspberrypi.org/documentation/>

## APPENDIX A

### PYTHON SOURCE CODES

#### Code Fragment for Face Detection On Image Files

```
#read image file
image_dir = sys.argv[1]
print "--- Locating image directory... ---"
img = cv2.imread(image_dir)
if img == np.array([]):
print "No such image in the directory!"
sys.exit()
print "Image loaded!"
#convert to grayscale
gray = cv2.cvtColor(img, cv2.COLOR_BGR2GRAY)
#load cascade files
print "--- Loading cascade files... ---"
fc3 =
cv2.CascadeClassifier('/usr/local/share/OpenCV/haarcascades/haarcascade_frontalface_a
lt2.xml')
fc4 =
cv2.CascadeClassifier('/usr/local/share/OpenCV/haarcascades/haarcascade_frontalface_a
lt.xml')
if not fc4:
print "Could not load cascade files!"
sys.exit()
print "Cascade files loaded!"
#start time
start_detect_time = time.time()
#start detecting faces
print "--- Detecting faces... ---"
```

```

face1 = fc4.detectMultiScale(gray, 1.1, 1, cv2.CASCADE_SCALE_IMAGE)
for (x,y,w,h) in face1:
roi_gray = gray[y:y+h+5, x:x+w+5]
50
roi_color = img[y:y+h+5, x:x+w+5]
#detect face again inside 1st layer detected face
face2 = fc3.detectMultiScale(roi_gray)
#draw rectangles around faces
for (x2, y2, w2, h2) in face2:
cv2.rectangle(roi_color,(x2,y2),(x2+w2,y2+h2),(0,255,0),2)
#end time
face_detect_time = time.time() - start_detect_time
print "Faces detected in %d seconds" % face_detect_time
cv2.imshow('img',img)
cv2.waitKey(0)
cv2.destroyAllWindows()

```

### **Code Fragment for Face Detection on Video Frames**

```

#set webcam and resolution
cap = cv2.VideoCapture(0)
cap.set(3,160)
cap.set(4,120)
#load classifier file
fc3 =
cv2.CascadeClassifier('/usr/local/share/OpenCV/haarcascades/haarcascade_frontalface_a
lt2.xml')
while(True):
#read frames from webcam
ret, frame = cap.read()
#convert to grayscale
gray = cv2.cvtColor(frame,cv2.COLOR_BGR2GRAY)
#detect face

```

```

faces = fc3.detectMultiScale(gray, 1.1, 5)
#draw rectangles on face
for (x, y, w, h) in faces:
cv2.rectangle(frame, (x,y), (x+w,y+h), (255,0,0), 2)
cv2.imshow('frame', frame)
#exit keys
if cv2.waitKey(1) & 0xFF == ord('q'):
break
cap.release()
cv2.destroyAllWindows()
51

```

### **Code Fragment to Test the FPS of Video Processing**

```

frm = 120;
#load cascade file
fc3 =
cv2.CascadeClassifier('/usr/local/share/OpenCV/haarcascades/haarcascade_frontalface_a
lt2.xml')
#start time
start = time.time()
#set resolution
video.set(3,160)
video.set(4,120)
for i in xrange(0, frm):
ret, frame = video.read()
gray = cv2.cvtColor(frame,cv2.COLOR_BGR2GRAY)
faces = fc3.detectMultiScale(gray, 1.1, 5)
for (x, y, w, h) in faces:
cv2.rectangle(frame, (x,y), (x+w,y+h), (255,0,0), 2)
cv2.imshow('frame', frame)
#end time
end = time.time()

```

```
#time elapsed
seconds = end - start
print "Time taken: {0} seconds".format(seconds)
#calculate fps
fps = frm / seconds;
print "Estimated FPS: {0}".format(fps);
#release video
video.release()
```