Project Report On

Real-Time Emotion Detection using Quad-Pi

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Under the guidance of

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Declaration

We hereby declare that the Project Work Report entitled "**Real-Time Emotion Detection using Quad-Pi**" which is being submitted to **National Institute of Technology Karnataka, Surathkal** in accordance with the completion of the minor project for the degree of **Bachelor of Technology** in **Information Technology** is a bonafide report of the work carried out by us.

Register No.	Name of Student
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Place: NITK, Surathkal

Date: March 21, 2018

Department of Information Technology

National Institute of Technology Karnataka, Surathkal

Certificate

This is to certify that this is a bonafide record of the project entitled "**Real-Time Emotion Detection using Quad-Pi**" presented by the students whose names are given below during VI semester 2018 in partial fulfilment of the requirements of the degree of Bachelor of Technology in Computer Science and Engineering.

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Finally, we thank God Almighty for his blessings without which the completion of this project work would not have been possible.

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March 21, 2018
National Institute of Technology Karnataka

Abstract

In present day technology human-machine interaction is growing in demand and machine needs to understand human gestures and emotions. If a machine can identify human emotions, it can understand human behavior better, thus improving the *task efficiency*. Emotions can understand by text, vocal, verbal and facial expressions (speech can also be used). Facial expressions play big role in judging emotions of a person. It is found that limited work is done in field of real time emotion recognition using facial images. In the base paper [1], they proposed a method for real time emotion recognition from facial image. The proposed method used three steps face detection using Haar cascade, features extraction using Active shape Model(ASM) and Adaboost classifier for classification of five emotions anger, disgust, happiness, neutral and surprise. Implementation of emotion recognition at real time on Raspberry Pi II is achieved at real time. This process is *parallelized* using Quad-Pi (four Raspberry Pi).

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Chapter 1

Introduction

In present day technology human-machine interaction is growing in demand and machine needs to understand human gestures and emotions. If machine can identify human emotion, it can understand human behavior better, thus improving the task efficiency. It can serve as a vital measurement tool for behavioral science, socially intelligent software can be developed which can be used for robots. Emotions are the strong feelings which are governed by the surroundings and play a great role in daily task like decision making, learning, attention, motivation, coping, perception, planning, cognition, reasoning and many more, which leads to emotion recognition a big research field. Emotion recognition can be done by text, vocal, verbal and facial expression. Facial expression analysis is one of the most important components for emotion recognition. Facial emotion recognition from 2D images is well studied field but lack of real-time method that estimates features even low quality images. Most of the work are based on frontal view images of the faces.

The method proposed is a real-time emotion recognition system that recognizes basic emotions like anger, disgust, happiness, surprise and neutral using CMU MultiPIE database consisting 2D images with different illumination and poses. The software system developed using our proposed method is deployed on Raspberry Pi II as it can be used with robots as the size of Raspberry Pi II is very small, lightweight and very less power supply is needed for it. As a result it can be mounted over any robot very easily and can be used for many applications such as surveillance security, monitoring senior citizen or children at home, monitoring critical patients in ICU, for customer satisfaction and many more.

1.1 Motivation

If machines can identify human emotions, it can understand human behaviour better which improves task efficiency. Emotions greatly affect decision making, learning, attention, motivation, coping, planning, cognition, reasoning etc. Facial emotion detection from 2D images is well studied field but lack of real-time method to estimate features gives the necessity to develop a method for the same Parallelization of the real-time process, which might lead to higher speeds keeping accuracy at it peak.

Chapter 2

Literature Review

2.1 Background and Recent Work

2.1.1 Real-Time Emotion Detection using RPi2

Authors:	Suja, P. et al. [1]
Methodology:	Using Raspberry Pi II, CMU MultiPIE database to detect emotions in real-time
Advantages:	Real-time, speed and accuracy
Limitations:	Only facial expressions are used (Speech was considered under 'future work')

2.1.2 Image Processing on RPi in Matlab

Authors:	Horak, K. et al. [2]
Methodology:	Using Raspberry Pi II, Simulink in Matlab to process images with many filters including 'Sobel filter' etc.
Advantages:	Speed, real-time, edge, corner, line detection
Limitations:	Increased FPS due to transfer from RPi2 to Simulink

2.1.3 Real-Time Face Recognition using RPi2

Authors:	Viji, A. et al. [3]
Methodology:	Using Raspberry Pi II, Haar cascade classifier, PCA feature extraction, Adaboost classification to detect faces in real-time
Advantages:	Speed, real-time, accuracy
Limitations:	Considers only PCA feature extraction

2.1.4 Robust Real-Time Face Detection

Authors:	Viola, P. et al. [4]
Methodology:	Using Haar feature selection, creating an internal image, Adaboost training, Cascading classifiers to detect faces in real-time
Advantages:	Minimal computation time and high detection accuracy
Limitations:	Real-time conditions (illuminations, non-uniform conditions) were ignored

2.2 Outcomes of Literature Review

Current state-of-art implementations consider facial expressions to be the primary source of emotion detection. Various methods for feature extraction have been used in the past like ASM, PCA which employ geometric-based feature detection. Processing on Raspberry Pi can give speeds upto 100ms and Viola-Jones feature detection gives about 95% accuracy. Current state-of-art implementations do not consider parallelization of the process.

2.3 Problem Statement

Capturing the image (real-time) using a camera (webcam, for experimental purposes). Face detection (and cropping if necessary) using Viola-Jones detection algorithm. Image processing and feature extraction using Active Shape Model (ASM) or using PCA algorithm. Classification using Adaboost classifier. The recognized emotion is displayed

on the monitor. Finally, parallel model (master-slave) deployment using Quad-Pi (four RPi3).

2.4 Research Objectives

The main objective is to develop emotion recognition from facial images to Simulate and experiment in near real-time environment, Programming the Raspberry Pi III, Deals with Image Processing (cropping and face extraction), Feature extraction from grayscale face image extraction, and Classify using Adaptive Boosting classifier trained with CMU MultiPIE database, Finally, use Quad-Pi (four RPi3) to implement master-slave parallel processing model to the deployed application.

Chapter 3

Methodology

3.1 System Architecture

The following components form the system architecture:

- Raspberry Pi III (Model B)
- Raspbian Stretch OS
- Ubuntu 16.04 OS
- Ethernet Crossover Cable
- SD Card
- Adapter for Raspberry Pi III

3.2 Methodology

3.2.1 Input

For real-time simulations, input is taken from webcam (further development would be to use a mobile robot) to dynamically recognize emotions, serves as input to Raspberry Pi III.

3.2.2 RPi3 Processing

Pre-Processing for Facial Feature Extraction is the beginning processing unit for RPi3 processing. Viola-Jones [4] face detection technique is used to detect the facial image. Viola-Jones used Haar wavelet concept to develop integral image to detect face. Haar features consider the different intensity of values of adjacent rectangular region as different area of face has different value of intensity from other region. After detection, facial image is saved for further processing and non-face area is removed.

3.2.3 Image Processing

Image is cropped according to required size and converted in gray image. This cropped image is used as input to *Sobel filter* for smoothing to remove the noise.

3.2.4 Feature Extraction

Feature extraction is based on geometric approach for which Active Shape Model (ASM) is used. ASM automatic fiducial point location algorithm is applied first to a facial expression image, and then Euclidean distances between center gravity coordinate and the annotated fiducial points coordinates of the face image are calculated. Extract geometric deformation difference features between a person's neutral expression and the other basic expressions. Compare with shape model to extract feature points of input facial image.

3.2.5 Classification

This is done by adaptive boosting classifier (AdaBoost). AdaBoost is a powerful learning concept that provides a solution to supervised classification learning task. It combines the performance of many weak classifiers to produce a powerful committee. AdaBoost is a flexible classifier which can be combined with any learning algorithm. It is very simple and easy to perform in which only one parameter i.e., number of iteration is varied to get good accuracy.

3.2.6 Quad-Pi Parallelization

Using master slave the Quad-Pi parallelization perform its operation, Master starts the slave computation, and the slave computation returns the result to the master. No

significant dependencies among the slave computations is there. In sense of this research work, *Sobel filter* can be parallelized. In case of multiple people in an image, multiple emotions detection is needed where speeds and task division matter [6].

Chapter 4

Work Done

4.1 Experimental Framework

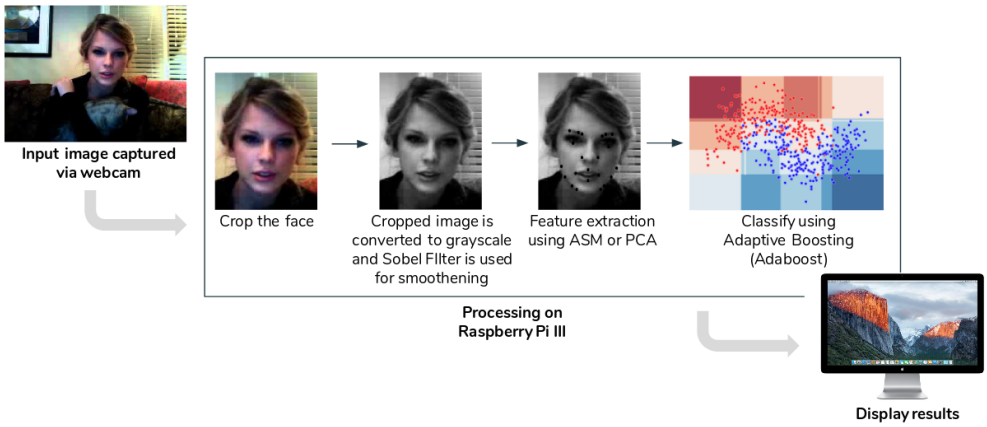

Figure 4.1: Flow of control from Input to Output to detect 'Emotions' (real-time)

4.2 Work Done (Mid-March 2018)

4.2.1 Capturing Input via Webcam (Linux)

```
pygame.camera.init()
cam = pygame.camera.Camera("/dev/video0", (640, 640))
cam.start()
image = cam.get_image()
```

```
pygame.image.save(image, localpath)

try:
    conn = sftp.Connection(host='10.42.0.178', username='pi',
    password='raspberry')
    conn.put(localpath, remotepath)
    conn.close()
except Exception, e:
    print str(e)
```

4.2.2 Preprocessing the Image (RPi): Facial Region Extraction

```
def convertToRGB(image):
    return cv2.cvtColor(image, cv2.COLOR_BGR2RGB)

image = cv2.imread(filename)
grayImage = cv2.cvtColor(image, cv2.COLOR_BGR2GRAY)
plt.imshow(grayImage, cmap = "gray")

haarFaceCascade = cv2.CascadeClassifier('training/
   haarcascade_frontalface_alt.xml')

faces = haarFaceCascade.detectMultiScale(grayImage,
   scaleFactor = 1.1, minNeighbors = 5)
print "Number of faces found: %s" %(len(faces))

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

def violaJones(filename, trainingFile, scaleFactor = 1.2):
    image = cv2.imread(image_directory + filename)
```

```
    grayImage = cv2.cvtColor(image, cv2.COLOR_BGR2GRAY)

    haarFaceCascade = cv2.CascadeClassifier(
training_directory + trainingFile)
    faces = haarFaceCascade.detectMultiScale(grayImage,
scaleFactor = scaleFactor, minNeighbors = 5)
    print "Number of faces found: %s" %(len(faces))

    deleteAllFiles(faces_directory)
    for (x, y, w, h) in faces:
        cv2.rectangle(image,(x, y),(x+w, y+h),(0, 255, 0),2)
        sub_face = image[y : y + h, x : x + w]

        faceFile=faces_directory + "face_" + str(y) + ".jpg"
        cv2.imwrite(faceFile, sub_face)
    image = convertToRGB(image)
    return image
```

4.2.3 Preprocessing the Image (RPi): Sobel Filter

```
image = cv2.imread(filename, cv2.IMREAD_GRAYSCALE)
laplacian = cv2.Laplacian(image, cv2.CV_64F)
sobelX = cv2.Sobel(image, cv2.CV_64F, 1, 0, ksize=5)
sobelY = cv2.Sobel(image, cv2.CV_64F, 0, 1, ksize=5)

def sobelYFilter(directory):
    deleteAllFiles(sobel_directory)
    filelist = [f for f in os.listdir(directory)]
    for f in filelist:
        filename = faces_directory + f

        image = cv2.imread(filename, cv2.IMREAD_GRAYSCALE)
        sobelY = cv2.Sobel(image, cv2.CV_64F, 0, 1, ksize=5)
```

```
14
15          sobelFile = sobel_directory + f
16          cv2.imwrite(sobelFile, sobelY)
17          plt.imshow(sobelY)
```

4.3 Results and Discussion

4.3.1 Capturing on Linux

Figure 4.2: Capturing through webcam in real-time (different illuminations and non-uniform conditions) with low resolution

4.3.2 Viola-Jones on RPi3

The facial image is detected by using Viola-Jones face detection technique. The integral image is developed by using Haar wavelet concept to detect the face. It consider the different intensity of values of adjacent rectangular regions. The different areas of face have different intensity. Face is detected and pointed by using rectangular box (then cropped). Refer figures 4.3, 4.4, 4.5 and 4.6.

4.3.3 Image Processing on RPi3

In image preprocessing, image is cropped according to required size and converted in gray image. This cropped image is used as input to Sobel filter for smoothing to remove the noise. Refer figures 4.7, 4.8.

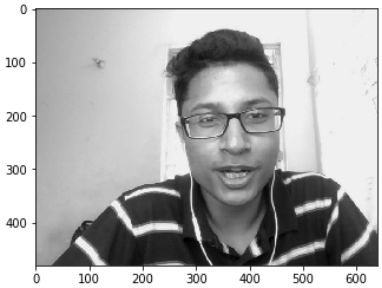

Figure 4.3: Converting the input image (from Linux) into grayscale

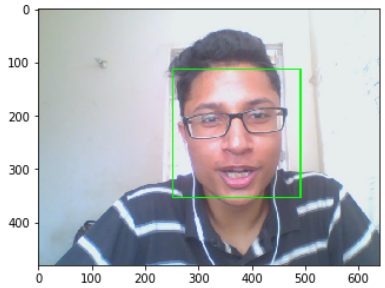

Figure 4.4: Face Detection using Haar-Cascade Classifier (of figure 4.3)

4.4 Individual Contributions

- Tushaar Gangarapu (15IT117) – RPi3 Configuration, Capturing real-time input and directing it to RPi3 for pre-processing and emotion detection.
- Bharath A. Kinnal (15IT114) – Use the image obtained and run Haar-Cascade classifier to obtain 'facial' region of the image.
- Jyoti Prakash Sahoo (15IT213) – Use the facial image and run 'Sobel Filter' along *Y-axis* and remove noise.

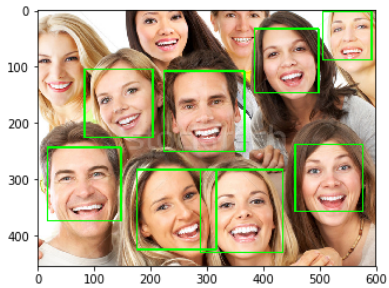

Figure 4.5: Capturing multiple faces using Viola-Jones Algorithm (Haar-Cascade)

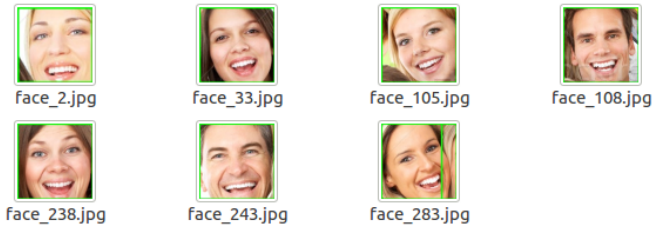

Figure 4.6: Crop the facial part and discard the rest of the image (of figure 4.5)

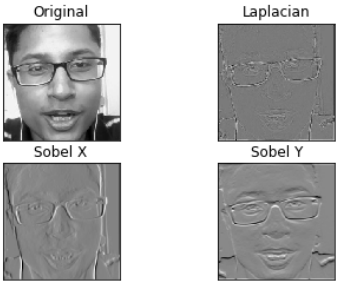

Figure 4.7: Crop the facial part and discard the rest of the image (of figure 4.4)

Figure 4.8: Crop the facial part and discard the rest of the image (of figure 4.6)

Chapter 5

Conclusion and Future Work

Input image is captured through webcam (real-time). Viola-Jones [4] face detection technique is used to detect the facial image. Viola-Jones used Haar wavelet concept to develop integral image to detect face. Haar features consider the different intensity of values of adjacent rectangular region as different area of face has different value of intensity from other region (*haarcascade_frontalface_default.xml* for training). After detection, facial image is saved for further processing and non-face area is removed. In image preprocessing, image is cropped according to required size and converted in gray image. This cropped image is used as input to Sobel filter for smoothing to remove the noise.

5.1 Proposed Work Plan of the project

Table 5.1: Work Plan through the Course Time and Objectives

Milestones	February 2018	Mid-March 2018	End-March 2018	April 2018
Research and Feasibility study	✓	✓	✓	✓
RPi3 configuration with real-time input capturing and pre-processing		✓	✓	✓
Real-time emotion detection (RPi3)			✓	✓
Master-Slave model (Quad-Pi)				✓

References

[1] Suja, P., & Tripathi, S. (2016, February). Real-time emotion recognition from facial images using Raspberry Pi II. In Signal Processing and Integrated Networks (SPIN), 2016 3rd International Conference on (pp. 666-670). IEEE.

[2] Horak, K., & Zalud, L. (2015). Image Processing on Raspberry Pi in Matlab. Advances in intelligent systems and computing, 4.

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[4] Viola, P., & Jones, M. J. (2004). Robust real-time face detection. International journal of computer vision, 57(2), 137-154.

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[6] Redmon, J., Divvala, S., Girshick, R., & Farhadi, A. (2016). You only look once: Unified, real-time object detection. In Proceedings of the IEEE conference on computer vision and pattern recognition (pp. 779-788).

2016 3rd International Conference on Signal Processing and Integrated Networks (SPIN)

Real-Time Emotion Recognition from Facial Images using Raspberry Pi II

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Abstract— In present day technology human-machine interaction is growing in demand and machine needs to understand human gestures and emotions. If a machine can identify human emotions, it can understand human behavior better, thus improving the task efficiency. Emotions can understand by text, vocal, verbal and facial expressions. Facial expressions play big role in judging emotions of a person. It is found that limited work is done in field of real time emotion recognition using facial images. In this paper, we propose a method for real time emotion recognition from facial image. In the proposed method we use three steps face detection using Haar cascade, features extraction using Active shape Model(ASM), (26 facial points extracted) and Adaboost classifier for classification of five emotions anger, disgust, happiness, neutral and surprise. The novelty of our proposed method lies in the implementation of emotion recognition at real time on Raspberry Pi II and an average accuracy of 94% is achieved at real time. The Raspberry Pi II when mounted on a mobile robot can recognize emotions dynamically in real time under social/service environments where emotion recognition plays a major role.

Keywords—CMU Multi-PIE database; feature extraction; Active Shape Model; Adaboost; Raspberry Pi II;

I. INTRODUCTION

In present day technology human-machine interaction is growing in demand and machine needs to understand human gestures and emotions. If machine can identify human emotion, it can understand human behavior better, thus improving the task efficiency. It can serve as a vital measurement tool for behavioral science and socially intelligent software can be developed which can be used for robots. Emotions are the strong feelings which are govern by the surroundings and play a great role in daily task like decision making, learning, attention, motivation, coping, perception, planning, cognition, reasoning and many more, which leads to emotion recognition a big research field. Emotion recognition can be done by text, vocal, verbal and facial expression. In 1968, Albert Mehrabian [1] pointed out that in human to human interaction 7% of communication is contributed by verbal cues, 38% is contributed by vocal cues and major portion 55% is contributed by facial expressions. So, facial expression analysis is one of the most important components for emotion recognition. Facial emotion recognition from 2D images is well studied field but lack of real-time method that estimates features even low quality images. Most of the work [2]-[4] are based on frontal view images of the faces. More work need to be done on non-frontal images with different illumination conditions as in real time these global conditions are not uniform.

In this paper, we propose a real-time emotion recognition system that recognizes basic emotions like anger, disgust, happiness, surprise and neutral using CMU MultiPIE database [5] consisting 2D images with different illumination and poses. The software system developed using our proposed method is deployed on Raspberry Pi II as it can be used with robots as the size of Raspberry Pi II is very small, light weighted and very less power supply is needed for it. As a result it can be mounted over any robot very easily and can be used for many applications such as surveillance security, monitoring senior citizen or children at home, monitoring critical patients in ICU, for customer satisfaction and many more. Circuit board of Raspberry Pi is shown in Fig. 1

This paper is organized as follows: Section II outlines background work, section III discusses the proposed method, results and analysis are reported in section IV. Conclusion and future work are given in the last section.

II. RELATED WORK

Many research works on emotion recognition and analysis have been carried out for a decade due to applications in the field of human-machine interaction. For real time emotion recognition system, a few approaches have been proposed. First step in process of emotion recognition is face detection in given image. In 2004, Viola and Jones [6] proposed an algorithm for face detection which has four stages Haar feature

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Fig 1: Circuit Board of Raspberry Pi II

selection, creating an integral image, Adaboost training and Cascading classifiers. After face detection depending on facial feature extraction three types of approaches which geometric approaches, appearance based approach and hybrid approach combination of geometric and appearance can be used. In 2013, Rohit [7] used Local binary pattern (LBP) method to extract features, which is an appearance based approach depends on pixel values of facial image. In 2014, Myunghoon [8] used Active shape model (ASM) to extract 77 facial points. Active Shape Model is popular geometric based approach in which detected image is iteratively deformed to fit shape model and extract facial points after comparison with shape model. In 2014, Kamlesh [9] used combination of Active Appearance Model (AAM) and Local Binary Pattern (LBP) as an example of hybrid approach, extracted 68 facial points, in which AAM is geometric based approach and LBP is appearance based approach. After extraction of features, different classifiers are used for the classification of emotions. Least mean square method [2], Support Vector Machine (SVM) [3, 7, 8], Neural Networks (NN) [9], Hidden Markov Model [4] and Adaboost [3] are different types of classifiers used for classification. In classification process first training has to be done to train the software later testing is done using test subject. For training many database are available which are Cohn-Kanade, FEEDTUM, JAFFE and CMU MultiPIE. Later the software developed can be deployed on system development kit [9] or on mobile phones [3] for further use.

III. PROPOSED METHOD

In the proposed method, the objective is to develop real-time emotion recognition from facial images to recognize basic emotions like anger, disgust, happiness, surprise and neutral. We have used CMU MultiPIE database, which is a collection of images from 337 subjects with a variety of different facial expressions including neutral, happiness, surprise, disgust and anger. The subjects include 235 males and 102 females with different level of illuminations and poses. Viola-jones face detection method for face detection, Active shape Model (ASM) for extracting facial points and AdaBoost classifier have been used for developing the emotion recognition software.

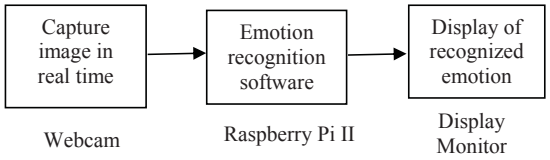

Fig 2: Real Time Emotion Recognition System

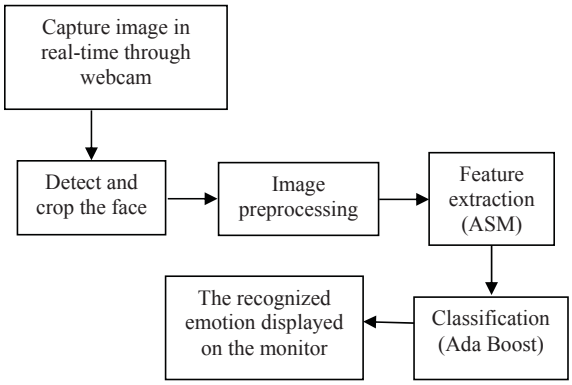

Fig 3: Block Diagram of real- time emotion recognition system

Raspberry Pi II is a credit card sized computer which has system on a chip Broadcom BCM2835. It contains an ARM1176JZFS, with floating point, running at 900 MHz and a video core 4 GPU.

The architecture of proposed system is shown in Fig. 2 and explained as follows: The input image in real time is captured through webcam and fed to emotion recognition software as input. Emotion recognition software is deployed in the Raspberry Pi II, which gives classified emotion as output. The recognized emotion is displayed in the monitor. The operations performed by the software deployed in the Raspberry Pi II is shown in Fig. 3.

The algorithm for real time implementation of emotion recognition using Raspberry Pi II is explained as follows

Step 1: Input image is captured through webcam.

Step 2: Viola-Jones [6] face detection technique is used to detect the facial image. Viola-Jones used Haar wavelet concept to develop integral image to detect face. Haar features consider the different intensity of values of adjacent rectangular region as different area of face has different value of intensity from other region. After detection, facial image is saved for further processing and non-face area is removed.

Step 3: In image preprocessing, image is cropped according to required size and converted in gray image. This cropped image

TABLE I. PAIRING OF EXTRACTED POINTS TO FIND FACIAL FEATURE

Facial feature	Paired extracted points
Eyes	1, 2, 3, 4, 5, 6, 7, 8
Forehead middle	11, 12,
Forehead + Chin	9, 10, 16, 17
Cheek1	13, 21
Cheek2	14, 23
Cheek3	20, 22
Cheek4	24, 19
Lip height	25, 26
Lip width	23, 24
jawline	15, 18

Fig 4: Cropped Images from CMU MULTIPIE database

Fig 5: Fiducial points extracted for CMU MULTIPIE database

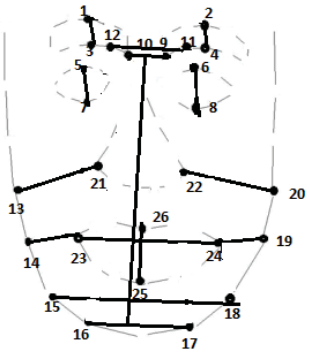

Fig 6: Fiducial points used in the proposed work

is used as input to Sobel filter for smoothing to remove the noise.

Step 4: Feature extraction is based on geometric approach for which Active Shape Model (ASM) is used. ASM automatic fiducial point location algorithm is applied first to a facial expression image, and then Euclidean distances between center gravity coordinate and the annotated fiducial points coordinates of the face image are calculated.

In order to extract the discriminate deformable geometric information, the system extracts the geometric deformation difference features between a person's neutral expression and the other basic expressions. In ASM input face shape is iteratively deformed to get the shape model. After comparison with shape model feature point of input facial image is extracted.

To train the model, frontal images of 5 emotions, 60 subjects from CMU MultiPIE database is used where sample images from the database are shown in Fig 4. Feature points are marked on these images as shown in Fig 5. These points are then normalized and formed as a feature vector. This operation is repeated for all the subjects and emotions, and the feature points forms a single feature vector which is given to the classifier for training.

During testing at real time, 26 facial points are extracted and Euclidean distances are calculated between points as shown in Fig 6. For example for right eye, the distance between centre of eyebrow and eye is calculated by using points 1, 3, 5 & 7. Similarly for other eye and other points Euclidean distance are calculated as shown in Table I using equation (1).

Euclidean distance is used to measure distance between two points with x and y coordinates for a 2D image.

$$D=\sqrt{(x_i-x_j)^2+(y_i-y_j)^2} \qquad (1)$$

where i, j = 1, 2, 3… 26

and x, y are the co-ordinates of extracted point in 2D image.

Ten facial features are formed after pairing 26 extracted facial points as shown in Table I. The facial features values are saved and used for comparison between the different expressions as different expressions have different values for ten facial features.

Step 5: Classification is done by adaptive boosting classifier (AdaBoost). AdaBoost is a powerful learning concept that provides a solution to supervised classification learning task. It combines the performance of many weak classifiers to produce a powerful committee as shown in equation (2) [12]. AdaBoost is a flexible classifier which can be combined with any learning algorithm. It is very simple and easy to perform in which only one parameter i.e., number of iteration is varied to get good accuracy.

$$F_t(x) = \sum_{t=1}^{T} f_t(x) \quad (2)$$

where f(x) is weak classifiers and F(x) is strong classifiers after number of iteration T.

Step 6: Hardware implementation using Raspberry Pi II:

The software developed for real time implementation is tested and deployed in Raspberry Pi II in linux environment. The proposed system design using Raspberry Pi II with external webcam, keyboard and display monitor is shown in Fig. 7. Monitor and keyboard are connected to Raspberry Pi II as it does not have display and input unit. Laptop can also be used as remote desktop for display and keyboard for input by using Virtual Network Connection (VNC) and putty software. In real time, when a person look into the webcam, his/her image will be taken and given to Raspberry Pi II. Emotion recognition software that is already deployed will recognize emotions and displays the recognized emotion into the display monitor.

IV. RESULTS AND ANALYSIS

The results of the classification for 5 basic expressions for frontal poses are recorded. To determine the accuracy of our proposed system in real-time, we tested using 25 subjects who performed 5 expressions by looking into the webcam connected to Raspberry Pi II, as shown in Fig. 7.

Fig 7: Screenshot for Raspberry Pi II interfacing camera and laptop as display monitor

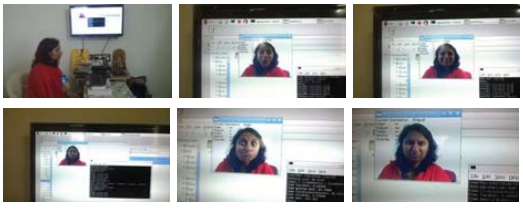

Fig 8: Screenshot of facial expression captured in real time with Raspberry Pi II.

Recognition accuracy of 94% is achieved with average processing time of 120ms on Linux platform by using Raspberry Pi II (ARM1176JZF, 900MHz) as shown in the confusion matrix in Table II.

TABLE II. CONFUSION MATRIX SHOWING ACCURACY OF PROPOSED METHOD

	Anger	Disgust	Happy	Neutral	Surprise
Anger	90%	10%			
Disgust		100%			
Happy			80%	10%	10%
Neutral				100%	
Surprise					100%
Recognition Accuracy	90%	100%	80%	100%	100%

TABLE III. COMPARISION OF RESULTS WITH EXISTING LITERATURE

[Author, year]	Technique used	Data set used	Accuracy	Number of points	Time taken
[Peng, 2010] [2]	Canny filter, AAM, Least square method	JAFFE	85%	24	-
[F. Abdat, 2011] [3]	Shi & Thomasi method, RBF SVM	Cohn-Kanade, FEEDTUM	95%	38	721 ms with PC Intel Pentium 3.4GHz
[Rohit, 2013] [7]	Local binary patterns, SVM, Ada Boost	JAFFE	86.67%	Texture based	227 ms (SVM), 1052 ms (Adaboost) with PC Intel i3 2.2 GHz
[Myungho, 2014] [8]	ASM, SVM classifier	Cohn-Kanade,	72%	77	421.6 ms
[Kamlesh, 2014] [9]	AAM, LBP, Neural Network classifier	Cohn-Kanade,	88%	68	--
Proposed Method	**ASM, Ada boost**	**CMU Multi PIE**	**94% with Raspberry Pi II**	**26**	**120ms with Raspberry Pi II (Linux, ARM1176JZF, 900MHz)**

The results are compared with literature in Table III. We have used only 26 feature points in a facial image and achieved better accuracy with less processing time when compared to other methods. Implementation of real time emotion recognition in Raspberry Pi II is a novel method and it is can be used in a variety of applications as it is very small, light weighted and very less power supply is needed. It can be mounted over small size of robot and used for many applications.

V. CONCLUSION

In this paper, we have proposed a method for emotion recognition in real time, based on geometric features using Raspberry Pi II. We have achieved an overall accuracy of 94 % with average processing time of 120ms on Linux platform by using Raspberry Pi II (ARM1176JZF, 900MHz). The Raspberry Pi II is a very small hardware kit with low weight which can be mounted on a mobile robot. If a portable small display screen is attached to the mobile robot, it can display the emotions of a person dynamically under surveillance / social environments like hospitals, old age home etc.,. Our proposed system is highly useful to the society for different applications where emotion recognition plays a major role.

In future work, different algorithm can be implemented to improve recognition accuracy. Robots can also be made to recognize emotion by neurological inspiration. Other modality like speech can be combined along with image for emotion recognition.

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