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A Standalone Vision Device to Recognize Facial Landmarks and Smile in Real Time Using Raspberry Pi and Sensor

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Abstract*: In current scenario of technological advancement, human-machine association is becoming sought after and machine needs to comprehend human emotions and feelings. The productivity of an exercise can be improved to a considerable extent, if a machine can distinguish human feelings by understanding the human conduct. Feelings can comprehend by content, vocal, verbal and outward appearances. The major deciding factor in the identification of human emotions is Facial expression. Working with facial images and emotion is real time is a big task. It is also found that confined amount of work has been done in this field. In this paper, we propose a technique for facial landmark detection and feature extraction which is the most crucial prerequisite for emotion recognition system by capturing the facial images in real time. The proposed system is divided into three tightly coupled stages of face detection, landmark detection and feature extraction. This is done by HOG and Linear SVM-based face detector using dlib and OpenCV. The curiosity of our proposed strategy lies in the execution stage. Raspberry Pi III, B+ and a normal exactness of 99.9% is accomplished at ongoing. This paper can be proved as the basis of real time emotion recognition in majority of applications.

Keywords: Raspberry Pi, Face Detection, HOG, SVM.

I. INTRODUCTION

In current Scenario Human Computer is high in demand and the requirement of machines to understand human emotions is of utmost priority. It can fill in as an indispensable estimation apparatus for behavioral science; with can be helpful in the development of smart and intelligent software's those can be used for robots. Feelings or Emotions is a psychological state related with the apprehensive system expedited by synthetic changes differently connected with considerations, conduct reactions, and a level of delight or disappointment. Emotions play a vital role in our day to day activities and tasks like basic leadership, learning, consideration, inspiration, adapting, observation, arranging, cognizance, thinking and some more, which prompts feeling acknowledgment a major research field. Emotion recognition should be possible by vocal content, or outward appearance. Albert Mehrabian in 1968 Indicated that in human association 7% of Correspondence is done by verbal prompts, 38% is done by vocal signs and real segment 55% is carried out by outward appearances. So the major component of Facial Emotion recognition is facial expression interpretation and analysis. A lot of study has already been done in the area of facial emotion recognition with 2D images. But the real challenging area is real time emotion detection even with low quality images. The greater part of the work [2]-[4] depends on facial front view pictures of the appearances. More efforts should be done on other that front view pictures with various enlightenment circumstances as progressively these worldwide conditions are not uniform. A system has been proposed in this paper that can recognize real time smile using landmarks of human faces. The product framework created utilizing our proposed technique is conveyed on Raspberry Pi III B+ Model as it tends to be utilized with robots as the measure of Raspberry Pi III is little, light weighted and less power supply is required for it. Accordingly it tends to be mounted over any robot in all respects effectively and can be utilized for some applications, for example, observation security, checking senior resident or kids at home, observing basic patients in ICU, for consumer loyalty and some more.

II.REVIEW OF LITERATURE

Facial emotion recognition is a vast field of research and the main reason behind that is multiformity in applications. Particularly in real world applications like home security, suspicious activity detection and recognition, marketing and monitoring, tendency analysis, group perception analysis etc. However, huge number of challenges is still being faced because of inherent problems that are mainly data insufficiency, computational challenges, real time implementation and response time. A novel, cheap and efficient framework has been proposed that will detect the suspicious activities based on facial expression recognition. The framework is mainly based on Raspberry Pi. SVM classifier has been used to classify the seven basic emotions.. So predictive picture behind the scene can be used to detect any belligerent situation in advance and help to avoid the occurrence of such situation. The datasets used for testing the system are: Cohen Kande (CK+), MMI, and JAFEE.

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A superior method has been presented that will help in the enhancement of law enforcement services [1]. Presently, as per statistics of last 15 years, the main reason behind the increase in the patients that are treated in-home and the count is very high in countries like Europe, USA and Japan. Such situations need some help to handle the critical situations (e.g. handling the panic attacks, depression and accidental situations). Although embedded computing has enabled the formation of Health Smart Homes (HSH) but still very minute literature has been found in the context of use of camera and image processing with IoT in HSH. Large number of images has been widely used to handle the issues related to safety, security and surveillance, particularly to assist elderly and sick people as a part of in home care system. The article mainly discusses that how these images can be helpful for caregivers and nurses when implemented with the help of IoT technologies. A prototype has been proposed that will work on multiple computing platforms with demonstrative and feasibility approach [2].With the advancement of technology and availability of Nano devices it becomes easy for law enforcement agencies to identify and detect the suspects or finding the lost and missing person. A system based on Raspberry-Pi and cloud technology based approach has been proposed that can equip the law enforcement agents with portable and secure device that can recognize the faces in real time. Support vector machine (SVM) has been proposed for classification. Raspberry Pi, because of its limited memory and storage space has not been used for processing [3].Whenever pattern recognition has been discussed in context of Facial recognition the major challenge encountered is variation in environment such as illumination, facial expression or pose. Huge number of recognition methods has already been suggested but none of them provided the excellent accuracy. To handle such issues the most recent method is based on Swarm intelligence that is basically based on the combination of classifiers.[4].The major challenge in facial emotion recognition is to extract the dynamic variability from captured videos. So to resolve this issue a part-based hierarchical bidirectional recurrent neural network (PHRNN) has been proposed, that is very effective to extract "temporal features" on the basis of landmark points from continuous frames. Furthermore to extract "spatial features" from recorded frames, a multi signal neural network (MSCNN) is also proposed. A PHRNN and MSCNN based deep evolution spatial –temporal network has been proposed to boost the facial expression based recognition. The implementation results on three different databases (Oulu-CASIA, MMI and CK+) with a reduced error rate by 25.8%, 24.4% and 45.5% have been achieved [5]. A new and improved method is presented that will mainly extract out the useful information by the reduction of facial feature vectors called (IPCA).In order to minimize the reconstruction error least-square method has been used in (LRC) Linear regression classification algorithm to achieve better result than the state-of –the art algorithm [6].Facial expression analysis has huge range of applications in current scenario. A latest review has been presented to conquer the real time challenges and techniques that has been used in different phases of facial emotion recognition system in real time [7].A new method for the detection of action units has been proposed that will mainly detect eight facial landmarks in 3D facial videos. The classifier that has been trained using the extracted features is Support Vector Machine to detect the action units. A better system in-term of performance and information about facial expression has been proposed [8].A merger based approach has been proposed to recognize multiple facial action units (AU) and estimation of intensity. This technique will combine the multi-task based features and their intensity with Bayesian network based action units that will finally perform the multiple action unit recognition and AU intensity estimation [9].A video based facial emotion recognition system has been proposed that will automatically select the face which is closest to the neutral expression. Results of the proposed system proved that the proposed method is efficient when it comes to spontaneous facial expressions and pose variation challenges [10]. A method that will represent the bridge work carried out in the field of vision, physiology and neuropsychology has been proposed. A Strategy Length & Internal Practicability (SLIP) based model has been proposed for thinking about categorization specifically about the time course of categorization [11].A novel object recognition system has been proposed that will select the points of interest by using Derivative Kadir-Brady (DKB) detector with SVM as a classifier[12].A fusion based technique using LBP,SIFT and SURF has been proposed that can be helpful in the fusion of visible and infrared features for the recognition of the face [13]. A novel technique based on the geometrical modelling of facial regions based feature extraction has been proposed. In order to reduce the error based on the landmark based approach a new reference points based approach is used that will detect the upper and lower action units Results were very promising as compared to the results of single threaded CPU [14].In order to handle the most serious and complex problem in today's scenario, A method to recognize speech emotion as high arousal and low arousal to understand the emotions of human being has been proposed. Perceptual linear prediction (PLP), linear prediction coefficients (LPC), Mel frequency cepstral coefficient (MFCC) and linear prediction cepstral coefficient (LPCC) features are used for emotion recognition using multilayer perception (MLP).For testing and training purpose one hundred and seventy-five and twenty-five utterances have been used [15].For better recognition of human facial expressions a pseudo-Voigt kernel-based Extreme Learning Machine (PVK-ELM) has been proposed. To prove the efficiency of the proposed method Static Facial Expressions in the Wild (SFEW), Oulu-Chinese Academy of Science, Institute of Automation (Oulu-CASIA), Japanese Female Facial Expression (JAFFE), Multimedia Understanding Group (MUG) and Cohn Kanade (CK+) dataset has been used [16]. A data mining model for facial expression recognition has been proposed and called as MPMFFT (Multiple Pattern Multiple Feature based Feature Transformation) integrated model that will convert the important facial information into corresponding 22 aggressive features. A SVM and KNN method has been used for final compilation [17].In order to analyze the stress level in patients; Magnetic resonance imaging (MRI) image processing based approach has been proposed that will be segmented using fuzzy logic [18]. An Adaptive Image Steganalysis (AIS) algorithm has been proposed to replace the adaptive steganography methods.

This method uses an intelligently selected block of images. Afterwards a selected set of features have been extracted from the selected images. As an outcome a feature vector is generated this improves the accuracy. Results have proven the improved performance over conventional Steganalysis approach [19].A gaze-contingency method has been proposed to test the effect of facial expressions in an emotion discrimination and oddball detection experiment.N170 i.e eye-sensitive ERP component has been used to detect the sensitivity that mainly do not vary across facial expressions. The scalp topography has also been used to analyze and reveal different distributions of these two emotion effects. The role of eyes and mouth in neutral processing and for happy expression the role of mouth has been suggested as a result [20].A method of 3-dimensional facial features integration with spatio-temporal descriptor has been proposed. A multi-class support vector machine based classifier is used to recognize facial expressions.

The datasets used for the experimentation are MMI and CK+. The results provided a promising and superior performance [21].A novel convolutional neural network approach has been proposed in order to provide the solution of recognition problem when it comes to multi-view dynamic facial action unit detection. A holistic, modular and efficient approach has been proposed and applied on FERA 2017 challenge that results a 14% improvement on F1-metric [22]. A research has been carried out in order to understand the depression and its analysis. A two year cross sectional study of 59 older patients with minor or major depression has been done. The results proven to be promising and shows that depressed patients have lower sensitivity to identify happiness as compared to non-depressed ones when measured based on facial stimuli. [23].

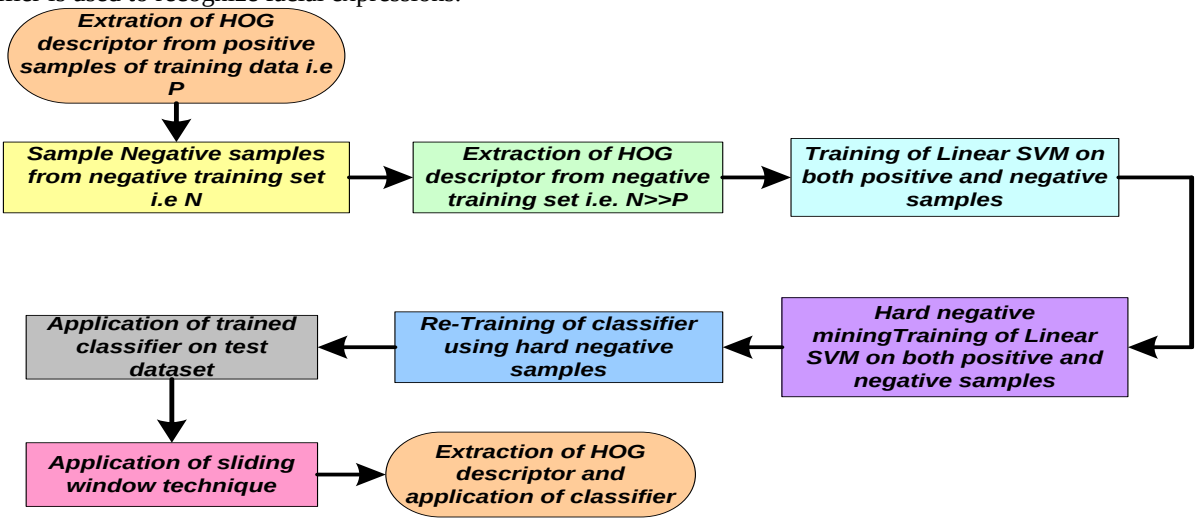


Fig 1. Process flow of training an object detector using HOG

III. ANALYSIS AND DEVELOPMENT

Real time emotion recognition system can be explained in broadly three different stages i.e shown in figure 2.The hardware used for emotion detection in real time is shown in figure 7.The detail description of real time facial emotion recognition system using Raspberry Pi III B+ Model is explained as follows.

Step 1: Capture the real time images through Pi-Cam.

Step 2: After capturing the image, the next important step is to get the facial part from the image. This can be carried out by two different methods.

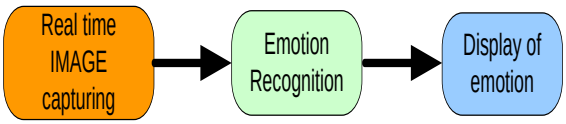


Fig 2.Real time emotion recognition system

Method 1-a): In order to identify the facial images the most well-known Viola-Jones [6] algorithm has been used. Viola Jones used Haar wavelet for face detection. Haar highlights consider the diverse force of estimations of neighboring rectangular locale as various region of face has distinctive estimation of power from other district. Moreover After location, facial picture is put something aside for more processing and area apart from face zone is expelled. The flow chart of method 1 is shown in figure 3.

b): Initial processing known as pre-processing is one of the major steps to remove the unwanted data from the captured images. In pre-processing the images are cropped as per the required size and converted in gray image. In order to remove the noise Sobel filter is used for smoothing and removing the noise.

c): Active Shape Model and HOG is used for Face alignment and feature extraction. ASM programmed fiducial point area calculation is connected first to an outward appearance picture, and afterward Euclidean separations between focus gravity arrange and the clarified fiducial focuses directions of the face picture are determined. So as to extricate the separate deformable geometric data, the framework removes the geometric twisting distinction includes between an individual's unbiased articulation and the other fundamental articulations.

In ASM info face shape is iteratively distorted to get the shape model. After examination with shape model
element purpose of information facial picture is separated. Euclidean separation is utilized to quantify remove between two points with x and y facilitates for a 2 dimensional picture.

$$D = \sqrt{(x_u - x_v)^2 + (y_u - y_v)^2} \quad \ldots\ldots\ldots (1)$$

Where u, v =1, 2, 3, 4, 5, 6…26
And x, y are the co-ordinates of extracted point in 2 dimensional image. The facial highlights esteems are spared and utilized for examination between the various articulations as various articulations have various qualities for ten facial highlights.
d): Recognition or Classification is done by versatile classifier known as AdaBoost. AdaBoost is strong classifier that gives an answer for directed grouping recognition. It consolidates the presentation of numerous frail classifiers to create an amazing board as appeared in condition (2) [12].
Method 2-a).Facial landmark is another important step in the recognition of facial emotions. Facial landmarks are actually the subset of the framework that will help to predict the shape. The major target of using facial landmarks is to locate the structure of face by using a face prediction framework as shown in figure 3. Landmark detection is further divided into two different steps.
Step I. Locate the face in the image
Step II. Locate the major facial structures on the facial region of interest

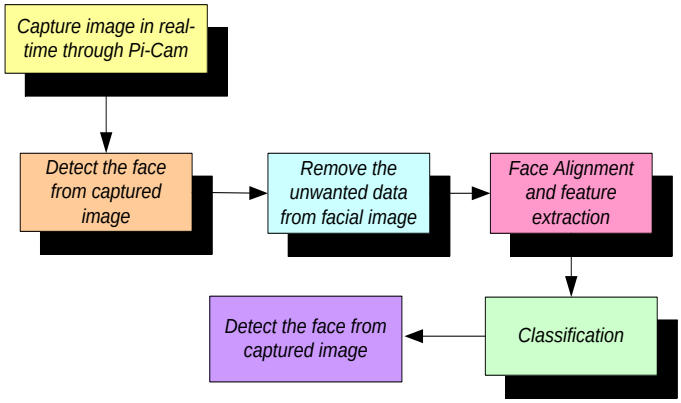
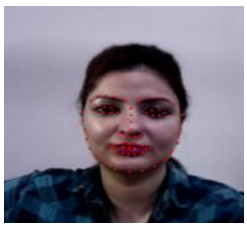


Fig 3.Block of diagram of real time emotion recognition system

There are different ways to achieve face detection in which either inbuilt Haar cascade or HOG + Linear SVM object detector can be used. Huge number of methods is available for the detection of landmarks but majority of them are used to locate the Mouth, Left and Right Eyebrows, Left and Right Eye, Jaw and Nose Region. All the above features are available in dlib library of OpenCV. Figure 8 shows the extraction of all the regions in facial images. Figure 1 shows the flow chart of object detection using HOG.
b).Training is next most important step. Training of machine learning algorithm is done by SVM in order to proceed towards facial emotion recognition. After completion of training the pre trained facial landmark detector is used to locate all the 68 landmarks on the structure of face. Figure 4 shows the real time landmark detection using OpenCV, Python and dlib.



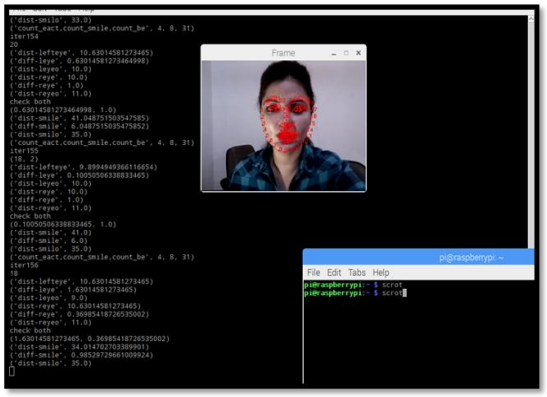


Fig 4. Real time facial landmarks detection using OpenCV, Python and dlib

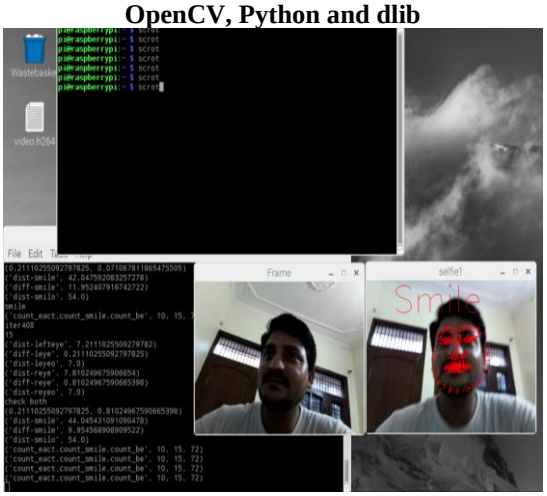


Fig 5. Real time smile detection via 68 facial landmarks Using Python and dlib

IV. METHODOLGY

The detailed methodology for detection of smile on our system is explained in following steps. The flow chart of the system is shown in figure 6.
a).Landmarks on our system has been located using dlib library on Raspberry Pi-III B+ Model.
b).Initially import required Python packages.
c).After the import of required packages we have to parse the command line arguments.
d).Incarnation of dlib's HOG-based face detector and prediction of facial landmarks.
e).Pre-processing of loaded input images.
f).Detection of faces in the input images

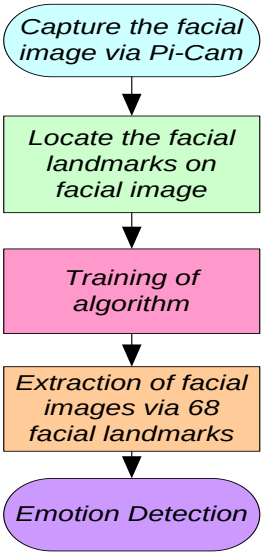


Fig 6. Flow chart of emotion detection via OpenCV

V. RESULT AND DISCUSSION

The results of the extraction of facial features are shown in figure.8.The results of smile detection using the facial landmarks are shown in figure 5.Real time emotion detection with accuracy is always a challenging task and the landmarks detected via proposed method can be the bases for detection of facial emotions in real time with high accuracy. In order to proceed with the emotion detection in real time we tested our system in real time to the smile and capture the image immediately as selfie after smile is being detected. Prediction of smile is final stage that was desired and achieved successfully.

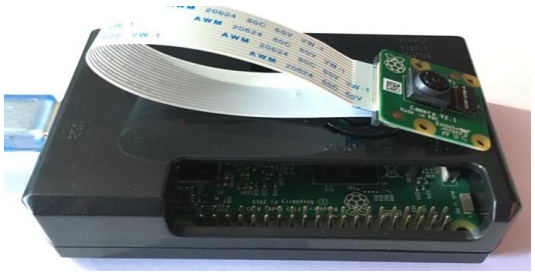
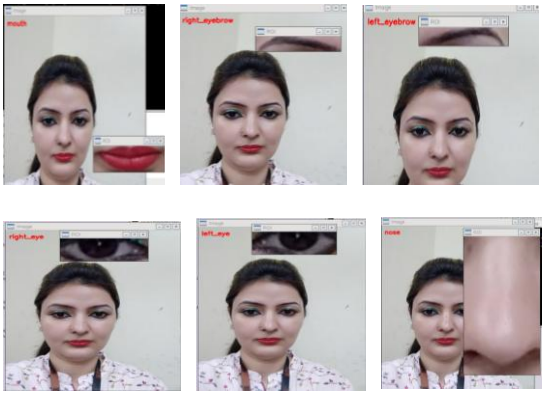


Fig.7 Hardware setup for real time smile detection



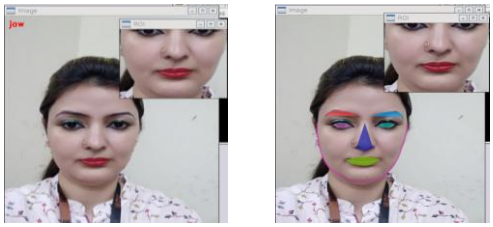


Fig.8 Extraction of facial regions from facial images

VI. CONCLUSION

In this paper, a fast and reliable method for the detection of landmark has been proposed. Moreover using these landmarks a system that can detect smile in real time has been designed. Such systems can act as promising system for the detection of facial emotions of human beings in real time. Such systems can contribute upto greater extent in society where real time identification is required. Such devices can be used in real time with an ease because of the compact size of Raspberry pi and light weight. Other important features can also be added in future to make this system more efficient like text and speech. In future work, we will use this setup to recognize emotions in real time and that can be done using different algorithm so that the accuracy of the system can be achieved.

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Dr. Rajesh Singh is currently associated with Lovely Professional University as Professor with more than fifteen years of experience in academics. He has been awarded as gold medalist in M.Tech and Hons. in his B.E. His area of expertise includes embedded systems, robotics, wireless sensor networks and Internet of Things. He has organized and conducted a number of workshops, summer internships and expert lectures for students as well as faculty. He has been honored as keynote speakers and session chair to international/national conferences, faculty development programs and workshops. He has twenty three patents in his account. He has published around hundred research papers in referred journals/conferences.