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# A HYBRID APPROACH BASED ON PCA AND LBP FOR FACIAL EXPRESSION ANALYSIS

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## ABSTRACT

Facial expressions are essential to recognize human emotions. This paper focuses on facial expression analysis based on hybrid approach using principal component analysis (PCA) and local binary patterns (LBP). In this paper, the data set contains six various face expressions that include a set of emotional expressions like anger, disgust, fear, happiness, neutral and surprise. It covers five elements like face detection; face part detection; localization of points; feature extraction and classification. The first step is executed by famous Viola-Jones algorithm. Active Shape Model technique is applied for locating feature point in certain area of the face. The feature extraction is performed using PCA and LBP technique. Finally the classification step is performed by multi-class support vector machine (SVM) classifier. PCA technique converts whole facial expression image into global gray scale features as well as reduces the data size. LBP technique is used to extract the texture of the specified region which is in the form of gray scale image. The recognition rate for PCA with multi-class SVM is found to be 67 % and accuracy is 42% whereas the recognition rate of 75% and accuracy of 75% are achieved after the inclusion of LBP. Hence, the proposed hybrid approach gives better recognition rate and accuracy in terms of recognizing facial emotions.

**Keywords:** emotion, principal component analysis, local binary pattern, support vector machine classifier.

## INTRODUCTION

Face is considered as an essential feature for identification of human being. It is not difficult for a human being to identify different faces but it is not an easy task for the system to identify faces [1]. Facial expression analysis helps computer to read real-time expressions and emotions of people. In many applications like surveillance, security, face and facial expression identification play an important role and many researches have been conducted. In this paper, this application detects six facial expression like anger, happiness, disgust, neutral, fear, and surprise. In order to recognize facial expressions good computing and multi-dimensional feature detection techniques have to be used.

Face detection and recognition application is widely used in image processing functions as well as this functionality is used in electronic devices like television, laptop, mobile phones and video games. Intelligent presence sensor feature is added to newly manufactured television which has built-in camera that helps in detecting position, motion, faces and even age in the television. The enhanced feature turns on and off automatically in order to save energy and television life, if there is no audience [2]. The facial image feature is extracted using two methods i.e. geometric feature and appearance feature. Deviation in the face such as space between eyes, nose length, shape, location can be identified by geometric features. The appearance feature identifies wrinkles, furrows in the face image which creates variation in appearance [11]. The specific region of the whole image is extracted from the facial image using appearance feature. The binary code that is generated using LBP is described in the pattern of local texture by making intensity value to normal form. LBP image is used to extract mouth region and for each pixel of the image LBP histogram is drawn. In LBP feature vector, PCA is applied in order to reduce the vector size .To express and highlight similarities in data and to determine the factor PCA is used. In this paper, we focus on eye, nose and mouth region of the face.

## Data set

In the observation, we have assumed a familiar Indian face data list. Indian face shows facial images. The nine facial emotions among the six fundamental facial emotions are fear, happiness, disgust, anger; surprise respectively and along with one neutral also Figure-1.

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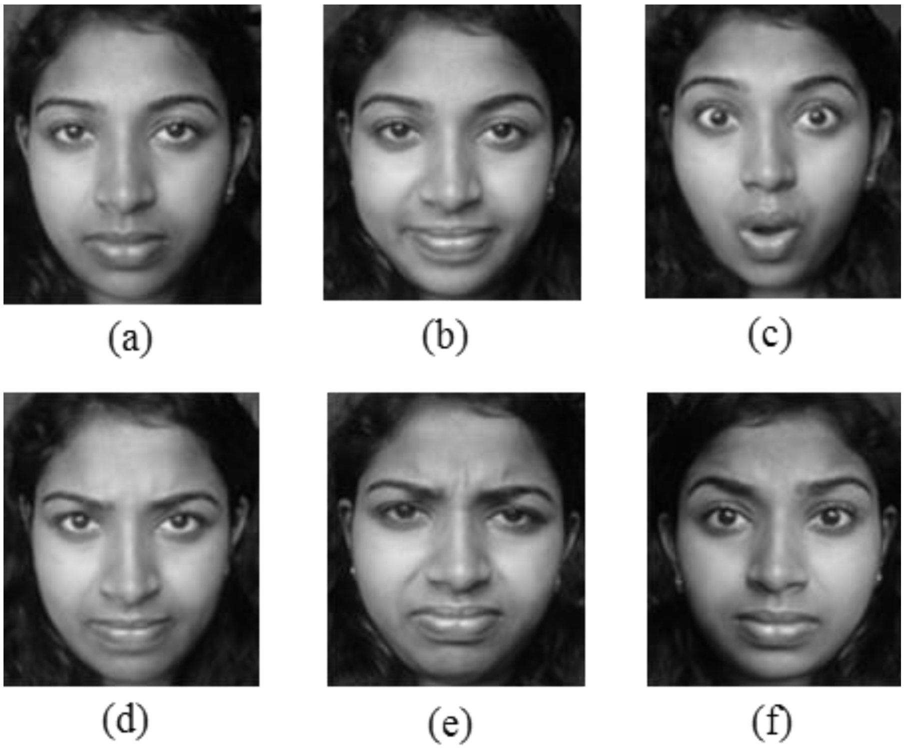

**Figure-1.** Six basic emotions of human: (a) Neutral, (b) Happiness, (c) Surprise, (d) Anger, (e) Disgust and (f) Fear.

**Block diagram**

The real time facial emotion identification system processes the image which is taken by camera and categorizes the kind of expression that the facial emotion displays. The facial emotion categorizer, the practicing procedure in the frame work is described in the following sections.

Here in this process the chiefly eradicated facial emotion characters are linked with facial emotions to particular expression types [3, 13]. Holding face image by the usage of cameras, then utilize the categorizer in the practicing process for the identification of the facial emotion linked with the particular expression; this happens in an actual time identification method. The categorization results are then output in actual time. The proposed block diagram is depicted in Figure-2.

**Viola-Jones object detection**

Viola-Jones object detection is used to detect object in the real time. It was proposed by Paul Viola and Michael Jones. Viola-Jones algorithm is executed in Open CV as cvHaar Detect Object (). It helps us to locate the face region with accuracy and efficiency in the form of image. Viola-Jones algorithm consists of 4 stages:

***Haar like feature selection:*** The similarity property of human face is matched by Haar features in this stage. Some of the properties that are common to human face are:

a) Eye region is darker than the upper cheek
b) Nose bridge is brighter than eye

**Creating integral image:** Integral image is obtained in this stage. The integral image location is detected by adding the pixel which helps us to compute the rectangular part of the face in a constant time.

**Adaboost training:** Adaboost is used for face detection. Adaboost compute the strong classifiers by combining all weak classifiers along with its weight.

**Cascade classifier:** In this stage, all the features are combined together. In this several classifiers are applied to a region of interest until it is rejected. It helps us to identify the non-face and face regions and helps us to achieve better detection rate [12].

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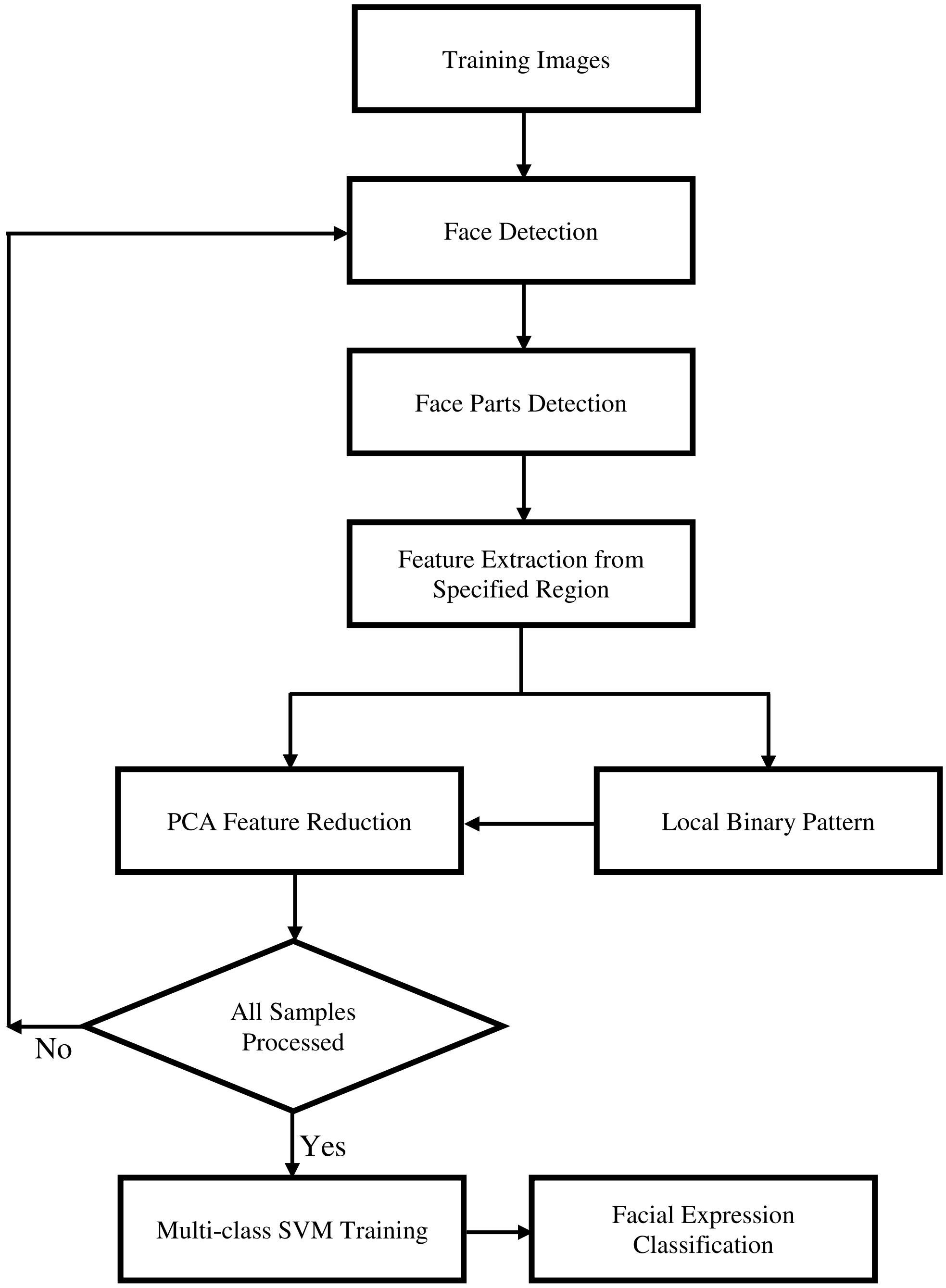


**Figure-2.** Block diagram for proposed methodology to classify the facial expressions.

**A. Viola-Jones upper body detection**

Viola-Jones algorithm is used to detect upper body region like head and shoulder. It encodes head and shoulder region using Haar features. This model is very efficient to find the region effectively even if the pose changes like head rotation. The upper body classification involves identification of detector object and its properties, identification of upper body regions.

**B. Viola-Jones face detection**

Face detection technique was started in early 1970's.The technique can be classified into two groups. The feature based approach and image based approach. Linear subspace method and neural network statistical approach are used in image based approach to detect face whereas feature based is further classified into low level analysis, i.e., feature analysis and active shape model.

A special classifier named Viola-John face detection algorithm is used to detect face in real time. To detect fast and accurate results, 3 ingredients such as integrated image which helps in feature selection and cascade which helps to allocate computational resource efficiently.

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**C. Viola-Jones eye detection algorithm**

As eyes are darker than other parts of the face, it is detected based on certain hypothesis. It satisfies anthropological characteristics based on certain constrain, that are possessed by human eyes. It considers the fact that the center part of eye region is darker and discards detection of the eyebrow part. Histogram analysis is done for selecting the eye region. It possessed two peaks, where one peak is found in eyebrows. It is done by aligning the two major axes of eyes, so that eye region is found in same line and the final constrain is set [4]. A new algorithm is used to determine iris geometrical information in order to detect the eyes from whole image. It also helps in identifying symmetry between both eyes.

**D. Viola-Jones nose detection algorithm**

The nose is identified with three characters as follows: (i) similarities: The Euclidean distance is used to measure the left and right side of nose; (ii) Dark white dark property: Due to light reflection the below part of the nose can be divided into dark and light nostrils region. The middle sub region of nose tip is high than two nostril region; (iii) Difference in upper and lower part: It is difficult to measure the degree of the properties when the face is in rotation, so the difference between the upper and lower part is measured using variance. Due to this certain region among the highest region is identified by spreading the light on the nose tip, so as the other part is dull when compared to nose tip region. As nose tip is brighter it is shown as binary image in black color. Dark pixel is marked in the binary image. Therefore this algorithm connects the entire black pixel to locate the whole image of the nose. The lower tip is taken as the nose tip after identifying the whole image. Nose width is calculated by the distance of the nose edges that is found in the binary image of the nose tip [5].

**E. Viola-Jones mouth detection algorithm**

In this algorithm, Haar feature is used to detect mouth detail. Weak classifiers are used to detect and extract some features of mouth region. This algorithm helps to divide the image of the face based on location of eyes, nose and mouth and can detect the mouth region exactly. This algorithm is one of the efficient methods to detect the public mouth. This algorithm uses color segmentation and geometry to locate and extract components like skin, lips etc. Figure 3 shows the detected regions from the original image.

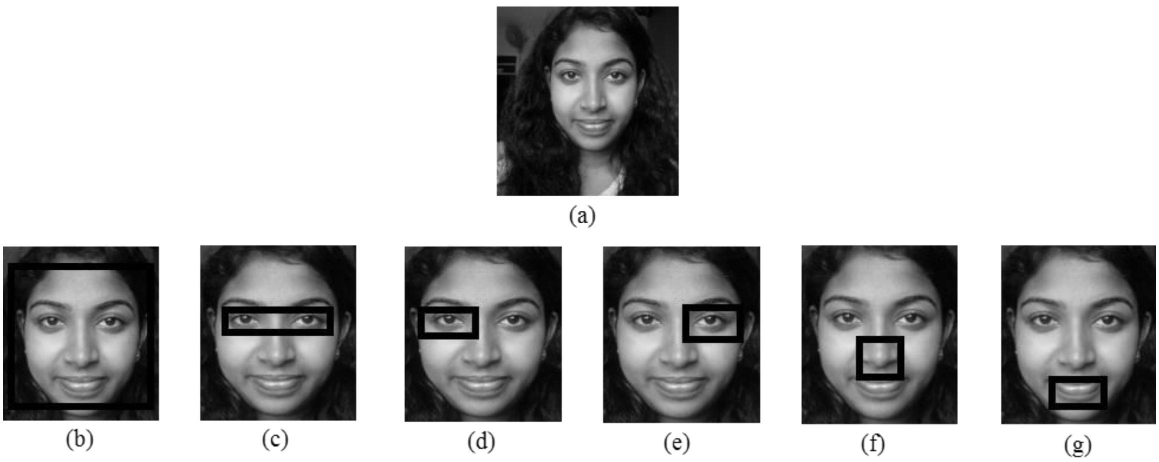


**Figure-3.** (a) Original image, (b) Face detection, (c) Eye detection, (d) Right eye detection, (e) Left eye detection, (f) Nose detection, (g) Mouth detection.

**Localization of feature points**

Active shape model consist of two processes they are model construction and searching. It helps to locate features in faces. For each face image we have to mark key feature point in the training set. In different image the feature point has same index. The key points in the face image is marked and connected and represented as shape vector shown in Figure-4.

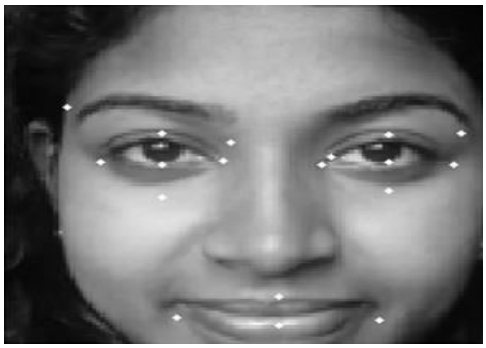

**Figure-4.** Localization of feature points from the detected face.

The shape vector is assigned with rotation, curling and translation so that face size, position and orientation can be recognized. The alignment is measured by computing the feature point square distance. The principal component analysis is done for the assigned shape vector. The local structure is analyzed in a simple way to find the exact key point position. The pixel profile is calculated by determining the local structure which is aligned with the normal path along with the key points of contour. The points (xi, yi) are given, the profile length 2m+1 is calculated by sampling m pixels on both sides in addition to normal vector of contour [6]. The first order derivative is computed by the points on the local structure of this profile. Table-1 shows the geometric facial features from specific regions. The width and length of these features can be found out by using Euclidean distance formula.

**Table-1.** Geometric facial features extracted from different types of emotions.

| Emotion | Happiness | Surprise | Anger | Disgust | Fear | Neutral |
|---|---|---|---|---|---|---|
| Left Eye Length (mm) | 28.89 | 23.14 | 33.98 | 22.85 | 30.29 | 26.88 |
| Left Eye Width (mm) | 21.61 | 20.75 | 31.22 | 15.69 | 20.79 | 20.88 |
| Right Eye Length (mm) | 31.22 | 24.36 | 33.98 | 22.85 | 30.29 | 29.55 |
| Right Eye Width (mm) | 19.53 | 20.13 | 31.22 | 15.14 | 20.79 | 20.42 |
| Mouth Length (mm) | 48.01 | 29.42 | 43.74 | 54.02 | 45.41 | 47.00 |
| Mouth Width (mm) | 24.83 | 27.58 | 24.06 | 28.90 | 20.69 | 24.98 |

**Principal Component Analysis (PCA)**

PCA is a method in which from the large set of variables available in the data set some important variables are extracted. High dimensional data set is used to extract low dimensional set which has some set of features with the intention to capture information exactly. PCA method is essential when dealing with three or high dimensional data. Covariance matrix is performed symmetrical which implies standardized data must contain numeric matrix [7]. PCA represents least means square condition of the original data which helps in finding best projection direction. For example, the face image consist of classes in the training set, say, i (i=1,2,…, C) with face image M, say,$\varepsilon_{i1}$,$\varepsilon_{12}$,….$\varepsilon_{iM}$. Two dimensional intensity of size m x n array is calculated for the training set of each image. If N = C x m training set images can be determined by x =[ $\varepsilon_{i1}$ , $\varepsilon_{12}$ ,….$\varepsilon_{ij}$], where i= 1,2,…, C and j= 1,2,…M. The training set is subtracted from mean to get standard training set $\bar{\varepsilon}$as shown in Equation (1).

$$X = [\varepsilon_{i1}-\bar{\varepsilon},\varepsilon_{12}-\bar{\varepsilon},...,\varepsilon_{ij}-\bar{\varepsilon}];\ \text{where } \bar{\varepsilon} = \frac{1}{N}\sum_{i=1}^{C}\sum_{j=1}^{M}\varepsilon_{ij} \quad (1)$$

Covariance matrix $X^TX$ is used to calculate Eigen values and Eigen vectors. P= [$p_1$,$p_2$,……$p_r$] are normalized Eigen vector of p which is also known as Eigen face which is corresponding to Eigen value r. Eigen face is projected in each training matrix, $\varepsilon_k$ whereas Eigen face feature is obtained by $Y_k$(Equation(2)).

$$Y_k= P^T\varepsilon_k \quad (2)$$

The original image vector dimension is reduced which can be considered as the original image of the PCA feature. Figure-5 shows the Eigen-face generation after keeping only 5, 10, 20 Eigen vectors.

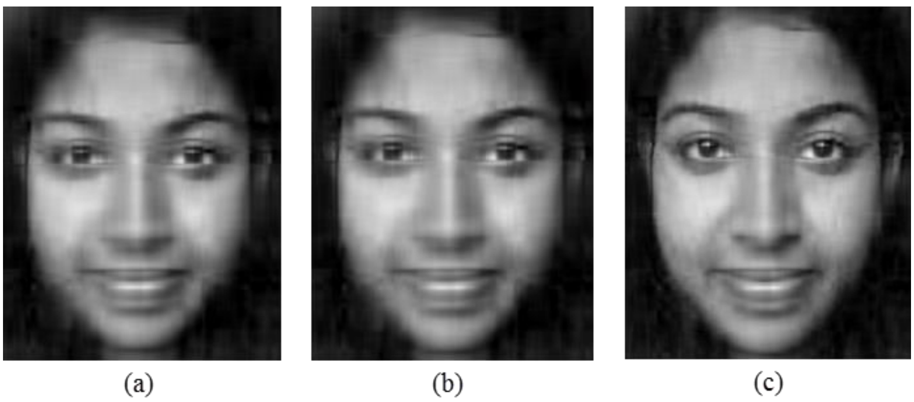


**Figure-5.** Example of Eigen-Face generation with full facial images: (a) $5^{th}$ Eigen-vector, (b) $10^{th}$ Eigen-vector and (c) $20^{th}$ Eigen-vector.

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**LOCAL BINARY PATTERNS (LBP)**

LBP is used in gray scale image to extract local information of the local texture. $g_c(x_c , y_c)$ is the face image local area in pixel. It consists of 8 points like $g_0$, $g_1$, …,$g_7$ with 3 x 3 window is the center of $g_c$. T= $t(g_c,g_0, …, g_7)$ is the local area texture and the 8 pixels within the window is implicated to binary processing using the threshold. The center pixel of similar gray value set in the window is taken as threshold shown in Equation (3)

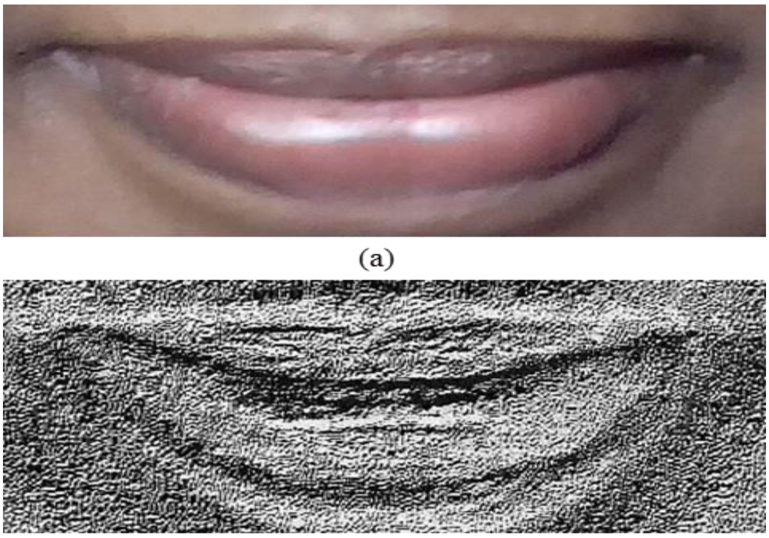
$$T_{LBP}= t[s(g_0-g_c),\ldots,s(g_7-g_c)] \quad (3)$$

Where $s(x)=\begin{cases}1, x > 0\\0, x \leq 0\end{cases}$

The center pixel Eigen value is the name given to clock wise direction of 8 binary numbers. Decimal number is calculated from the binary number by providing each symbol function with a formula. The local image texture feature with a special structure is described by LBP code using Equation (4)

$$T_{LBP}= (x_c, y_c)=\sum_{u=0}^{7} s(g_u-g_c)2^u \quad (4)$$

LBP operator is used to scan facial image expression. The original image, i.e., LBP coding image is obtained. The LBP image expression is described by the texture feature of the mouth image Figure-6.



(a)

(b)

**Figure-6.** Extracted local binary patterns (LBP) image from the detected mouth.

The image of LBP coding consists of edges, spot, point features and the original image information of micro mode etc. The LBP code can be formed by histogram which helps to describe facial image expression with local feature texture.

Chao *et al*. [10] proved to recognize the facial expression of the mouth area that is being extracted from feature is essential when compared with remaining parts of face. Compared to other area of the facial image expression the mouth area contributes more in recognizing the facial expression is proved by this experiment. Based on the observation the local texture feature is used to extract the mouth area and computed.

The gray scale feature is extracted from the facial expression image by using PCA where sensitivity is high in lighting environment. Facial image expression can be extracted from local feature texture using LBP [8, 9]. LBP is used to extract variations in the facial expressions and eliminates the complete information of the whole facial image expression. Therefore LBP and PCA algorithms are used effectively to extract the facial feature extraction. PCA is used to extract whole image by combining the global feature whereas LBP is used to extract the mouth area of the local feature, so multi-class SVM recognition rate can be improved.

**RESULT**

This paper primarily focuses on face and face parts identification and also localization of feature points on the facial image. Secondly, the full emotion of the overall feature is extracted using PCA and LBP; the mouth area with the local texture is detected separately. To identify and categorize expressions, multi-class SVM uses PCA and LBP features. The mean and Covariance of PCA is given to classifier and multi-class SVM classifier classifies the emotions and analyses the recognition rate and accuracy. In the next step, PCA along with LBP were given to the multi-class SVM classifier and then emotions like happy, surprise, fear, disgust, neutral, anger are classified. The recognition rate and accuracy are then quantified in Table-2. The recognition rate and accuracy for PCA with multi-class SVM are improved after the inclusion of LBP.

**Table-2.** Quantified recognition rate and accuracy from the existing (PCA + Multi-class SVM) and the proposed (PCA + LBP + Multi-class SVM) methods.

| Parameters | PCA + Multi-class SVM | PCA + LBP + Multi-class SVM |
|---|---|---|
| Recognition Rate | 67% | 75% |
| Accuracy | 42% | 71% |

## CONCLUSIONS

LBP technique is applied to the sample input image further divided into small region. LBP is derived and linked together as a single vector which represents face image. Orientation of the texture and face coarsen of the image is examined by LBP histogram. Fast processing can be done using LBP for feature vector. LBP operator is used to classify texture, recovery image and helps in doing facial image analysis. Due to its simple and direct calculation, rotation and light insensitivity, image detail capturing capability and extracting local region pattern is favorable. In stochastic process the elements of the image consist of variable random type. The scattered matrix of the Eigen vectors is defined as the basic vector by PCA. When the system is to store lot of face information, PCA technique helps the system to collect only the necessary information by using the mathematical representation. To eliminate co-linearities in the data and to identify linear regression PCA technique can be used effectively. It is analyzed that the proposed hybrid approach gives better recognition rate and accuracy when compared with PCA with multi-class SVM.

The residual problem can be solved by further researching and this study can be improved with algorithm to predict the emotions of an individual under different circumstances.

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