

# **A Principal Component Analysis based Recognition of Facial Expression**

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**ABSTRACT:** In daily interactions, humans convey their emotions through facial expression and other means. There are several facial expressions that reflect distinctive psychological activities such as happiness, surprise or anger. This work focuses on the extraction and selection of salient features for behaviour of facial expression identification. The proposed approach is evaluated on the Japanese Female Facial Expression (JAFPE) database with seven types of facial expressions such as anger, disgust, fear, happiness, neutral, sadness and surprise. The features will be extracted by using principal component analysis (PCA) is applied over this to reduce the feature vector length and the resulting data of the facial expression recognition with good accuracy to identify the human behavioural expression. Thus facial expression analysis deals with visually recognizing and analysing different facial motions and facial feature changes.

**KEYWORDS:** Facial expression, Human behaviour analysis, Principal component analysis (PCA)

## **I. INTRODUCTION**

Human behavior analysis is an important area devoted to detecting, tracking, and understanding people's physical behaviors [1]. The present invention pertains to the detection of physiological response characteristics representative of one or more altered human states, e.g., anxiety, alertness, fear, depression using face image. The image can be acquired by means of Video camera in which it provides detection, segmentation and unique feature extraction and similarity measurements for human physiological biometrics recognition [3].

Facial expression recognition (FER) is a rapidly growing and ever green research field in the area of computer vision, artificial intelligent and automation [4]. There are many applications which use facial expression to evaluate human nature, feelings. Recognizing human facial expression is not a simple task because of some circumstances due to illumination, facial occlusions, face color /shape etc [5].

Emotions can be organized hierarchically, with the non-basic emotions falling under one or more of the basic emotions. Emotions can be recognized from speech, facial expressions and other nonverbal behaviors. Information from different modalities can be used to reduce ambiguity, or to complete information. Moreover, studies from psychology show the need to consider the integration of different behavior modalities in the human-human interaction, behavior, emotions etc.

## **II. RELATED WORK**

In facial recognition technique, a self-organizing map (SOM) is used to classify the intensity values of the gray scale pixels and obtained with a recognition rate of 81.36% [1]. Haar feature extraction and Adaboost classifier is used to detect both face and facial expression and gives more accurate resultant features [2]. The Active appearance model (AAM) and Gabor wavelet transformation recognizes the person even under various expressions and the resulting system gives 60 % to 70 % of recognition [3]. A non-negative matrix factorization (NMF) and local non-negative matrix factorization (LNMF) are used to detect the seven facial expressions using principal component analysis (PCA)

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 1, Januray 2016

and achieved a higher classification accuracy of 81.42% [4]. An optical flow technique algorithm with PCA are used to detect the facial motion and as a result it has greater accuracy with consistency [5].

Facial expressions are processed with specified investment flow-through trust (SIFT) flow technique that yields the best generalization performance with a recognition rate of 86.69% has been taken for the accurate detection [6]. Using Eigen values approach and Raster Scan algorithm technique it produces an efficient and accurate method for human face identification and segmentation in gray scale images [7]. The six basic emotional categories using facial action coding system (FACS) coders are validated by developing a fuzzy expert system for face action tracking and face action emotional classification will increase the quality of the system by allowing the involved face actions according to the accuracy of the performed facial feature tracking [7].

### III. METHODOLOGY

Facial expression analysis deals with visually recognizing and analyzing different facial motions and facial feature changes. The facial expression recognition system consists of four steps (Figure 1). First is face detection phase that detects the face from a still image or video. Second is normalization phase that removes the noise and normalize the face against brightness and pixel position. In third phase features are extracted and irrelevant features are eliminated. In the final step basic expressions are classified into six basic emotions like anger, fear, disgust, sadness, happiness and surprise.

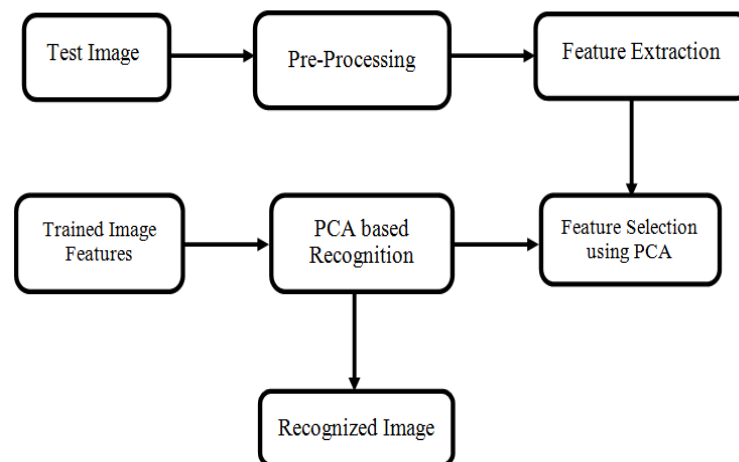


Fig.1 Facial expression classification modes

A facial expression recognition technique is detected using PCA. The performance will be analyzed based on elapsed time recognition and the accuracy. Once the image is being processed the statistical feature extraction is done in which we evaluate certain statistical metrics. After evaluating statistical features, spatial features are being evaluated for which we follow the template matching algorithm using correlation technique. Once the template is being matched the facial points are evaluated which help in calculating the spatial features such as opening and width of eyes, mouth and height of eyebrows etc.

#### A. Pre-Processing

In order to evaluate statistical feature we need to perform pre-processing. In the initial stage, image is input in order to obtain the region of interest (ROI). The ROI of the face is obtained by simply cropping the area which does not contribute much information in recognizing the facial expressions. Data required for experimentation is collected from

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Japanese Female Facial Expression (JAFFE) database for training and testing. Sixty Japanese subjects have rated each image on six emotion adjectives.

### B. Feature Extraction

In order to recognize facial expressions from frontal images, a set of key parameters that best describe the particular set of facial expression needs to be extracted from the image such that the parameters can be used to discriminate between expressions. The real-valued parameters have a definite value depending upon the distance measured (Figure 2). This definite value was measured in number of pixels.

The binary measures gave either a present (1) or an absent (0) value. In all, eight real valued measures and seven binary measures were obtained. A number of parameters, both real-valued and binary, were extracted and analysed to decide their effectiveness in identifying a certain facial expression. The features which did not provide any effective information of the facial expression portrayed in the image were eliminated and were not used in the final study.

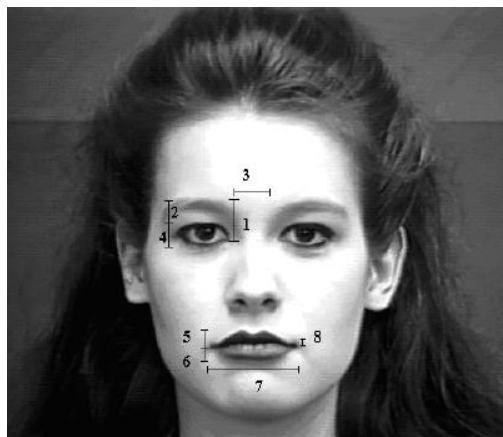


Fig.2 Real-valued measures from a sample neutral expression image.

The following real-valued parameter is used in the study.

1. *Eyebrow raise distance* – The distance between the junction point of the upper and the lower eyelid and the lower central tip of the eyebrow.
2. *Upper eyelid to eyebrow distance* – The distance between the upper eyelid and eyebrow surface.
3. *Inter-eyebrow distance* – The distance between the lower central tips of both the eyebrows.
4. *Upper eyelid – lower eyelid distance* – The distance between the upper eyelid and lower eyelid.
5. *Top lip thickness* – The measure of the thickness of the top lip.
6. *Lower lip thickness* – The measure of the thickness of the lower lip.
7. *Mouth width* – The distance between the tips of the lip corner.
8. *Mouth opening* – The distance between the lower surface of top lip and upper surface of lower lip.

The real-valued parameters were the distances (in number of pixels) measured between specified facial features. In case of parameters involving features which were symmetrically present on both sides of the face, an average of both the measurements was obtained. Real-valued measures were obtained for expressions including the neutral image.

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### C. Training Phase

In this study, supervised learning is used to train the facial database using PCA. The training samples are taken from the JAFFE database. This work has considered 213 training samples for all expressions. After getting the samples, supervised learning is used to train the network. It is trained three times and shown good response in reduction of error signal.

### D. Testing Phase

Face area is segmented using morphological image processing operations like dilation, erosion reconstruction, complementation, regional max and clear border (to get ROI). This proposed system is tested with JAFFE database. It is taken totally 10 sample images for all of the facial expressions.

Bounding box location of feature segments obtained in the above step are used to calculate the height and width of left eyebrow, height and width of left eye, height and width of right eyebrow, height and width of right eye, height and width of nose and height and width of mouth. Distance between center of left eye and eyebrow, right eye and eyebrow and mouth and nose is also calculated.

### E. Principle Component Analysis (PCA)

Principle component analysis (PCA) is used for recognition which takes the sample image and encodes it in the same way and compares it with the set of encoded images. There can be many Eigen vectors for a covariance matrix but very few of them are principle one's. Each Eigen vector can be used for finding different amount of variations among the face image. The goal of PCA is to reduce the dimensionality of the data while retaining as much as possible of the variation present in the original dataset. PCA allows us to compute a linear transformation that maps data from high dimensional space to low dimensional sub-space.

## IV. SIMULATION RESULTS

From the extracted features the expression of the image is recognized accurately with the help of classifiers is shown in Figure 3.

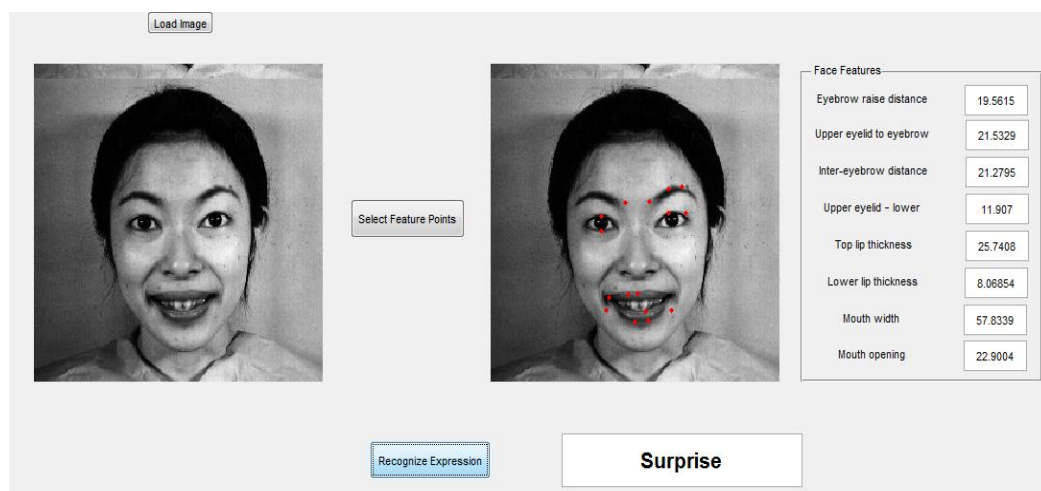


Fig.3 Recognition of facial expression

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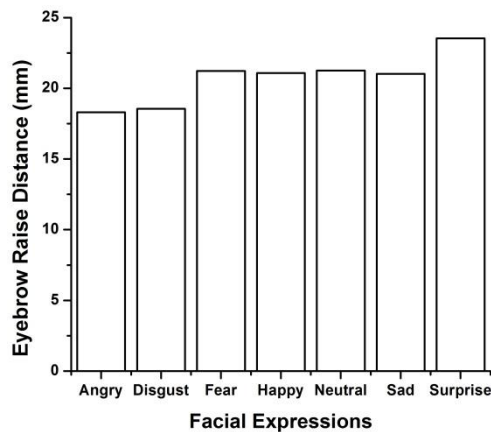
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The performance will be analyzed using PCA algorithm based on elapsed time recognition and it results in higher accuracy with minimum elapsed time is shown in Table 1.

Feature Parameters (in mm)	Happy	Sad	Surprise	Neutral	Fear	Angry	Disgust
Upper Eyelid Eyebrow Distance	17.51	20.15	26.23	18.54	22.12	14.55	17.62
Upper Eyelid Lower Eyelid Distance	10.49	6.70	15.03	11.06	11.15	10.65	8.62
Top Lip Thickness	28.73	17.07	25.76	20.18	18.78	17.06	22.11
Bottom Lip Thickness	28.62	21.17	32.64	20.86	23.67	20.11	15.89
Mouth Width	56.17	48	41.78	42.88	51.05	45.41	47.68
Mouth Opening	19.11	14.88	42.43	19.66	20.52	13.24	13.61
Elapsed Time	1.37	1.39	1.34	1.38	1.31	1.33	1.35

**Table.1** Extraction real-valued parameter

The performance of feature parameter extraction for facial expression vs. eyebrow raise distance is plotted in which the surprise expression has the maximum percentage is shown in Figure 4.



**Fig.4** Plot For Facial Expression Vs. Eyebrow Raise Distance

The performance of feature parameter extraction for facial expression vs. inter eyebrow distance is plotted in which the happy expression has the maximum percentage is shown in Figure 5.

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(An ISO 3297: 2007 Certified Organization)

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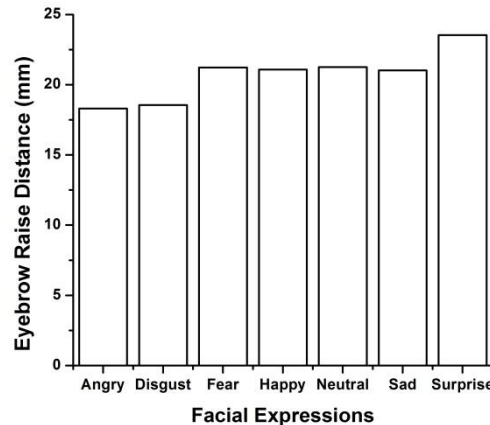


Fig.5 Plot For Facial Expression Vs. Inter Eyebrow Distance

## V. CONCLUSION

Facial expression recognition has attracted more and more attention due to its important applications in a wide range of areas. One key step in facial expression recognition is to extract the low dimensional discriminative features before the feature data are fed into classifier for classification. The main objective of this work is to design and implementation of face detection system. A face detection system is designed and implemented using adaptive boosting algorithm. It is implemented on Matlab and the eight real valued features were successfully extracted from 10 subjects (213 facial images) for seven different expressions (neutral, angry, disgust, fear, sad, happy and surprised). The extracted features from PCA reduced the feature vector length and resulted facial expression recognition with 100% accuracy to identify the human behavioural expression.

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