ROBUST DECISION MAKING SYSTEM BASED ON FACIAL EMOTIONAL EXPRESSIONS

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Abstract

Human emotions impact is high on decision making systems. In order to avoid inconsistent effect on decision making for proper judgment emotions are recognized and according to emotions decisions are made. The difficulty of emotion recognition stems from the faces appears to be roughly alike and the difference between them is quit subtle. Frontal face images form a very dense cluster in image space which makes it virtually impossible for traditional image processing techniques. In this paper an Eigen vector based system has been presented to automatic recognize the basic emotional expressions and precisely measures. This method acquires the image and crop five significant portions mouth, nose, left eye, right eye and both eyes of image and applied eigenvector based method on each part of the database images and query image and similarities were obtained and put it in the tables to recognize the emotions. This method has given batter accuracy rate for noisy and low contrasted images with rotation variant.

Keywords: Eigen-faces, cropping, PCA, covariance, LBP and HRI

1. INTRODUCTION

A natural way of interaction between man and machine can be obtained by detection and classification of facial expressions. Making face recognition more reliable under uncontrolled lighting conditions is one of the most important challenges for practical facial emotional recognition systems [1]. This problem tackle by combining the strengths of robust illumination normalization, local texture based face representations, and distance transform based matching, and multiple feature fusion. The local binary patterns (LBP) with entropy technique and different approaches proposed in the literature to represent and to recognize faces but it is having limitations like, not suitable for shadow images and low contrasted images [2]. To overcome those problems 2D principles of component analysis (2D-PCA) is presented to extract the facial features of an image [1, 3].This method fails to retain important and significant features. Many different face emotion-recognition approaches have been developed in the last few years [4–7], ranging from classical Eigen space-based
methods Eigen faces [8], to sophisticated systems based on thermal's information, high-resolution images, or 3D models
[7, 9, 10]. However, the recognition of faces in unconstrained environments has not been completely solved [11]. In addition,
sometime demanding applications, such as searching faces in no annotated or partially annotated databases and HRI (Human-Robot Interaction), impose extra requirements of real-time operation, just one image per person and fully on-line operation which are difficult to achieve. Accordingly, frontal face images form a very dense cluster in the image space which makes it virtually not possible for traditional pattern recognition techniques to accurately discriminate among them with a high degree of success [12]. The sources of variation in the facial appearance can be categorized into two groups: intrinsic factors and extrinsic ones [13]. A) Intrinsic factors and are independent of the observer and are due purely to the physical nature of the face. These factors can be further divided into two classes: intrapersonal and interpersonal [14]. Intrapersonal factors are accountable for varying the facial exterior of the same person, some illustrations being age, facial expression and facial paraphernalia. Interpersonal factors, however, are responsible for the differences in the facial appearance of different people, some examples being ethnicity and gender. B) Extrinsic factors cause the appearance of the face to alter via the interaction of light with the observer and the face. These factors include illumination, pose, scale and imaging parameters like resolution, focus, imaging, noise etc. Evaluations of state-of-the-art recognition techniques conducted during the past several years, such as the FERET evaluations [14], FFRVT 2002[15] and the FAT 2004 [16], have confirmed that age variations, illumination variations and pose variations are three major problems plaguing current face recognition systems [17]. More sophisticated feature extraction techniques involve deformable templates ([18], [19], [20]), Hough transform methods [21], and Graf's filtering and morphological operations [22]. However, all of these techniques rely heavily on heuristics such as restricting the search subspace with geometrical constraints [23]. Furthermore, a certain tolerance must be given to the models since they can never perfectly fit the structures in the image. Holistic approaches attempt to identify faces using global representations. However global features are not suitable

for detection of emotions of uneven illuminated and rotation variant Images. Local features are suitable for face emotions expressions. PCA is more powerful tool for recognition of the face emotions.

2. PRINCIPLE COMPONENT ANALYSIS (PCA)

The basic idea of PCA is to identify the most meaningful basis to re express the data set. The goal of PCA is to extract relevant information from face data sets consisting of a large number of interrelated variables. PCA defines a new orthogonal coordinate system that optimally describes variance in a single dataset. However PCA has certain limitation like 1) PCA is high sensitive to images with uncontrolled illumination conditions. 2) difficult to detect the impact of intentional feeling on facial expressions 3) tedious to work at places of low lighting conditions and 4)less effective if facial expressions vary e.g. Even a big smile can render the system less effective [1]. To overcome these limitations new method is proposed based on eigenvector.

3. EIGENVECTOR BASED SYSTEM

The eigenvector based system is proposed in order to find the six basic facial expressions .This system consist of five steps such as preprocessing, face detection, Cropping, Feature Extraction, matching and Classification. This method is better for recognition of face, processing and finally find the emotional expressions of the face. Here, first the image is acquired and after that improves the quality of the Image by normalizing image and removing noise. Secondly the feature of the face are to be extracted such as the eye pair, left eye, right eye, mouth, nose. Next the Eigen values are calculated for those features. This step is repeated for every feature of every expression. The Euclidean Distance is calculated for those Eigen values, and the expression with the minimum Euclidean distance is considered as the output expression. The six basic expressions such as anger, fear, sad, happy, surprise, disgust are to be considered. The overall design of system has been given in fig.1.

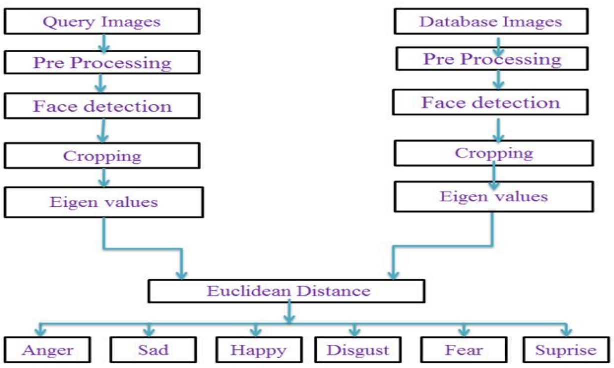


Fig.1

3.1. Preprocessing: It improves the quality of the image by normalization and removing the noise in the Image. The Adaptive Median Filtering is applied widely as an advanced method compared with standard median filtering. The Adaptive Median Filter performs spatial processing to determine which pixels in an image have been affected by noise. The Adaptive Median Filter classifies pixels as noise by comparing each pixel in the image to its surrounding neighbor pixels. The size of the neighborhood is adjustable, as well as the threshold for the comparison. A pixel that is different from a majority of its neighbors, as well as being not structurally aligned with those pixels to which it is similar, is labeled as noise. These noise pixels are then replaced by the median pixel value of the pixels in the neighborhood that have passed the noise. This method removes noise and reduces distortion, like excessive thinning or thickening of object boundaries.

3.2. Face Detection: The face detection process used to detect the location of face in the image because of variability in the scale, location, orientation. Face detection from a single image is challenging task. Face detection is a computer technology that determines the locations and sizes of human faces in digital images. It detects face and ignores anything else, such as buildings, trees and bodies. Face detection can be regarded as a more general case of face localization the task is to find the locations and sizes of a known number of faces. In face detection, face is processed and matched bitwise with the underlying face image in the database. In this paper face is derected using Viola-Jones Algorithm which is more powerful to extract face features even in low contrast.

Fig.2

3.3. Cropping: Image cropping separate the features like lips, mouth, left eye, right eye, both eyes and nose from the detected face image. Eyes, nose and lips take different shapes for different expressions and significant information is carried by them. Significant information is carried by them.

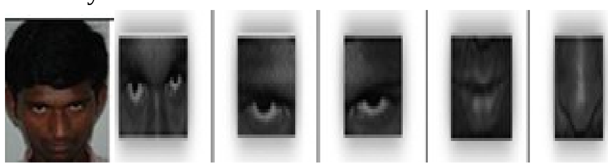


Fig.3

3.4. Eigen spaces: The Eigenvectors and Eigenvalues are dependent on the concept of orthogonal linear transformation. An Eigenvector is basically a non-zero vector. The dominant Eigenvector of a matrix is the one corresponding to the largest Eigenvalue of that matrix. In this work, the universal expressions are set into six classes as the training images. Eigenvectors and Eigenvalues of six different individual segments of the image is computed and stored. For a single class, after the selection of a particular feature, a matrix is obtained which is stored as, say X of dimension M x N. Similarly for the rest of the features.

$$X=\begin{bmatrix}1 & 1 & 1\\1 & 9 & 1\\1 & 1 & 1\end{bmatrix}_{3x3}$$

Calculating the mean of the matrix

$$\mu X = 1/N \sum_{n=1}^{N} X[m,n] \quad (1)$$

μx=round (17/9) =2

The mean centered feature image vectors is obtained by subtracting the mean from the feature image. This image vectors are depicted as matrix only.

$$X^1 = |X - \mu x| \quad (2)$$

$$X^1 = \begin{bmatrix} 1-2 & 1-2 & 1-2 \\ 1-2 & 9-2 & 1-2 \\ 1-2 & 1-2 & 1-2 \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 \\ 1 & 7 & 1 \\ 1 & 1 & 1 \end{bmatrix}$$

Then the covariance matrix of each individual feature image is obtained by calculating the covariance of the matrix of each mean centered image vectors, and from each covariance matrix, the associated eigenvectors and Eigen values for the individually extracted features are computed.

six significant Eigenvectors are considered for further processing which are sorted in the decreasing order of the associated Eigen values of the covariance matrix E. With the available eigenvectors of expressions, separate subspaces for all the six universal expressions are created. With the available expression subspaces, the input image could be identified by incorporating a decision making system.fig4 shows the feature vector of the entire face Image.

$$\mathrm{Cov}(x,y) = \sum_{i=1}^{N} (X - \mu x)(Y - \mu y)/\mathrm{N-1} \quad (3)$$

$$\mathrm{Cov}(X) = \begin{bmatrix} 1 & 1 & 3 \\ 1 & 5 & 1 \\ 3 & 1 & 1 \end{bmatrix}$$

$$E = \begin{bmatrix} -1 & 1 & 1 \\ 0 & -1 & 2 \\ 1 & 1 & 1 \end{bmatrix} E^{-1} = 1/6 \begin{bmatrix} -3 & 0 & 3 \\ 2 & -2 & 2 \\ 1 & 2 & 1 \end{bmatrix}$$

$$E.\mathrm{Cov}(X).E^{-1} = D \quad (4)$$

$$E.\mathrm{Cov}(X).E^{-1} = \begin{bmatrix} -1 & 1 & 1 \\ 0 & -1 & 2 \\ 1 & 1 & 1 \end{bmatrix} . \begin{bmatrix} 1 & 1 & 3 \\ 1 & 5 & 1 \\ 3 & 1 & 1 \end{bmatrix} . 1/6 \begin{bmatrix} -3 & 0 & 3 \\ 2 & -2 & 2 \\ 1 & 2 & 1 \end{bmatrix}$$

$$D = \begin{bmatrix} -2 & 0 & 0 \\ 0 & 3 & 0 \\ 0 & 6 & 6 \end{bmatrix}$$

Fig.4

3.5. Classification: The classifier based on the Euclidean distance has been used which is obtained by calculating the distance between the image which are to be tested and the already available images used as the training images. Then the minimum distance is observed from the set of values. In testing, the Euclidean distance has been computed between the new testing image Eigenvector and the Eigen subspaces for each expression, and minimum Euclidean distance based classification is done to recognize the expression of the input image. The formula for the Euclidean distance is given by

$$ED = \sqrt{\sum (x1 - x2)^2} \quad (5)$$

Where x1 is one of the features values of Query image and x2 is the corresponding feature value of database image. The similarity is measured based on minimum distance between Query and Database Image of Euclidean distance.

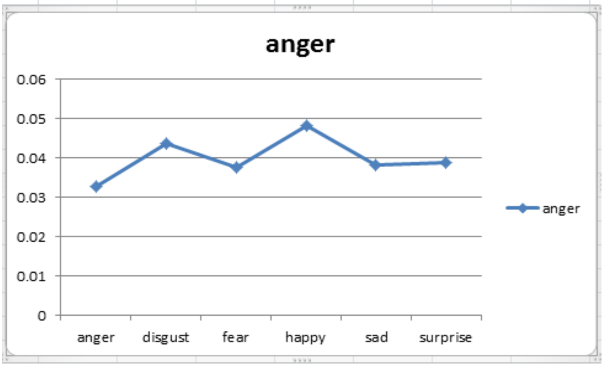
4. EXPERIMENTAL RESULTS

Eigenvector based system for facial emotion recognition has been presented in this paper. This method applied on standard databases like ORL face database, Sterling face databases and my own databases which have been developed for my DST projects and results have been produced in the form of tables and graphs. By comparing every feature of query image with of the database of a training image of every expressions and calculating minimum Euclidean distance. Below are the test cases of different facial expressions of query image. By considering the database and query image the output is derived.table1 show the training database with rotation variant, low contrast and noisy images. From the table2 to table7are shows the different emotions like anger, disgust, fear, happy, sad and surprise. The minimum values in the tables and graphs show the particular emotion. The performance and accuracy of the proposed method produced better results than traditional methods like LBP operator and Principle component analysis method.

Expressions	Eye pair	Left Eye	Right Eye	Mouth	Nose
Anger	3.5478e-04	6.8251e-04	6.4981e-04	6.8051e-04	7.5147e-04
Disgust	6.3861e-04	7.1262e-04	7.5466e-04	6.4701e-04	8.1034e-04
Fear	3.4985e-04	7.4360e-04	5.6535e-04	5.7980e-04	8.5182e-04
Happy	7.0509e-04	9.2579e-04	0.0011	6.9482e-04	6.1641e-04
Sad	4.2574e-04	5.0506e-04	6.2812e-04	6.4532e-04	5.8695e-04
Surprise	6.0399e-04	9.5604e-04	5.4922e-04	4.0732e-04	6.3094e-04

1. Table training Database

Anger	Anger	Disgust	Fear	Happy	Sad	Surprise
Eye Pair	2.8583e-04	5.6966e-04	2.8090e-04	6.3614e-04	3.5679e-04	5.3504e-04
Left Eye	3.2572e-04	3.5583e-04	3.8681e-04	5.6900e-04	1.4827e-04	2.0852e-04
Right Eye	1.5290e-04	2.5775e-04	6.8440e-05	6.0309e-04	1.3121e-04	5.2310e-05
Mouth	2.4015e-04	2.0665e-04	1.3944e-04	2.5446e-04	2.0496e-04	3.3040e-05
Nose	2.1591e-04	4.7478e-04	5.1626e-04	2.8085e-04	2.5139e-04	2.9538e-04
Minimum ED	0.0327	0.0436	0.0375	0.0480	0.0360	0.0386

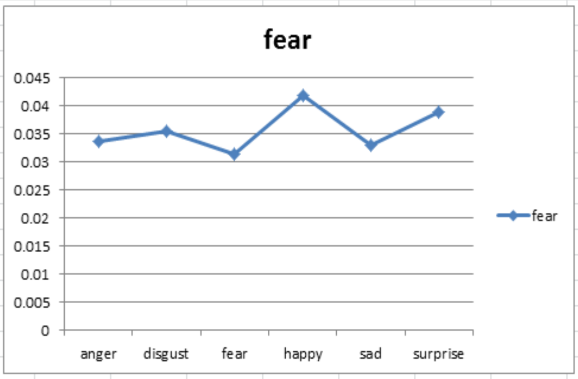


2. Table and graph for anger emotion

Disgust	Anger	Disgust	Fear	Happy	Sad	Surprise
Eye Pair	1.8380e-04	1.0003e-04	1.8873e-04	1.6651e-04	1.1284e-04	6.5410e-05
Left Eye	9.9900e-06	6.7650e-05	9.8630e-05	2.8082e-04	1.3991e-04	4.9670e-04
Right Eye	1.5290e-04	2.5775e-04	6.8440e-05	6.0309e-04	1.3121e-04	5.2310e-05
Mouth	1.4356e-04	1.1006e-04	4.2850e-05	1.5787e-04	1.0837e-04	1.2963e-04
Nose	3.4917e-04	4.0804e-04	4.4952e-04	2.1411e-04	1.8465e-04	2.2864e-04
Minimum ED	0.0290	**0.0207**	0.0291	0.0377	0.0260	0.0312

3.Table and Graph fordisgust emotion

Fear	Anger	Disgust	Fear	Happy	Sad	Surprise
Eye Pair	8.7730e-05	1.9610e-04	9.2660e-05	2.6258e-04	1.6770e-05	1.6148e-04
Left Eye	2.4000e-04	2.7011e-04	3.0109e-04	4.8328e-04	6.2550e-05	2.9424e-04
Right Eye	1.0230e-04	2.0715e-04	1.7840e-05	5.5249e-04	8.0610e-05	1.7100e-06
Mouth	1.7249e-04	1.3899e-04	7.1780e-05	1.8680e-04	1.3730e-04	1.0070e-04
Nose	3.9000e-04	4.4887e-04	4.9035e-04	2.5494e-04	2.2548e-04	2.6947e-04
Minimum ED	0.0335	0.0355	**0.0312**	0.0417	0.0329	0.0388

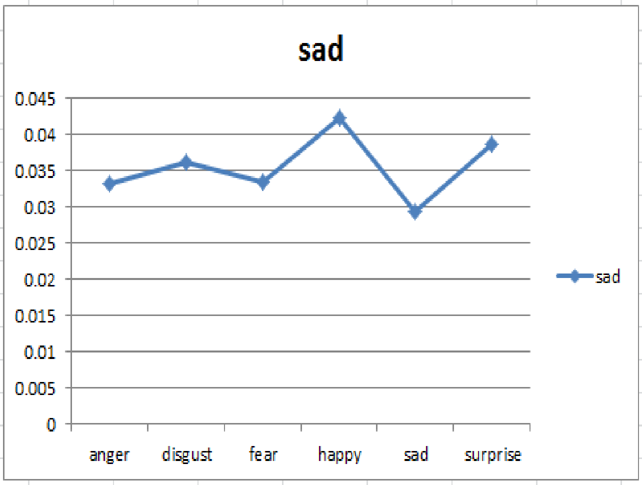


4. Table and graph fear emotion

Happy	Anger	Disgust	Fear	Happy	Sad	Surprise
Eye Pair	2.4223e-04	4.1600e-05	2.4716e-04	1.0808e-04	1.7127e-04	6.9800e-06
Left Eye	4.7570e-05	1.7460e-05	1.3520e-05	1.9571e-04	2.2502e-04	2.2596e-04
Right Eye	2.3630e-05	8.1220e-05	1.0809e-04	4.2656e-04	4.5320e-05	1.2422e-04
Mouth	1.0023e-04	6.6730e-05	4.8000e-07	1.1454e-04	6.5040e-05	1.7296e-04
Nose	4.0764e-04	4.6651e-04	5.0799e-04	2.7258e-04	2.4312e-04	2.8711e-04
Minimum ED	0.0287	0.0260	0.0296	**0.0234**	0.0274	0.0286

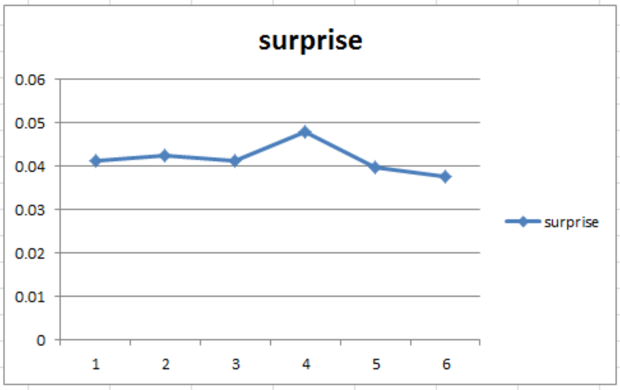
5. Table and graph for happy emotion

Sad	Anger	Disgust	Fear	Happy	Sad	Surprise
Eye Pair	1.3676e-04	1.4707e-04	1.4169e-04	2.1355e-04	6.5800e-05	1.1245e-04
Left Eye	7.8020e-05	1.0813e-04	1.3911e-04	3.2130e-04	9.9430e-05	9.5604e-04
Right Eye	1.8119e-04	2.8604e-04	9.6730e-005	6.3138e-04	1.5950e-04	8.0600e-05
Mouth	3.1411e-04	2.8061e-04	2.1340e-04	3.2842e-04	2.7892e-04	4.0920e-05
Nose	4.1591e-04	4.7478e-04	5.1626e-04	2.8085e-04	2.5139e-04	2.9538e-04
Minimum ED	0.0336	0.0360	0.0333	0.0421	**0.0292**	0.0385



6. Tableand Graph for sad emotion

Surprise	Anger	Disgust	Fear	Happy	Sad	Surprise
Eye Pair	1.7304e-04	1.1079e-04	1.7797e-04	1.7727e-04	1.0208e-04	7.6170e-05
Left Eye	6.8192e-04	7.1203e-04	7.4301e-04	9.2520e-04	5.0447e-04	9.5545e-04
Right Eye	8.7470e-05	1.9232e-04	3.0100e-06	5.3766e-04	6.5780e-05	1.3120e-05
Mouth	3.0797e-04	2.7447e-04	2.0726e-04	3.2228e-04	2.7278e-04	3.4780e-05
Nose	4.4724e-04	5.0611e-04	5.4759e-04	3.1218e-04	2.8272e-04	3.2671e-04
Minimum ED	0.0412	0.0424	0.0410	0.0477	0.0395	0.0375



7. Table and graph for surprise emotion

5. CONCLUSION

Facial Expression Recognition System has gained a lot of importance due to its applications. The objective of this paper is to introduce the recent advances in face expression recognition and the associated areas in a manner that should be understandable even by the new comers who are interested in this field but have no background knowledge on the same in real time images. The performance results show the efficiency of our suggested method used to recognize the six basic expressions. The recognition rate obtained for the proposed system is suitable for decision making system for emotional expression recognition.

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