Facial Expression Recognition Using Principal Component Analysis

Ajit P. Gosavi, S. R. Khot

***Abstract*— Expression detection is useful as a non-invasive method of lie detection and behaviour prediction. However, these facial expressions may be difficult to detect to the untrained eye. In this paper we implements facial expression recognition techniques using Principal Component analysis (PCA). Experiments are performed using standard database like Japanese Female Facial Expression (JAFFE) database. The universally accepted six principal emotions to be recognized are: Angry, Happy, Sad, Disgust, Fear and Surprise along with neutral. Euclidean distance based matching Classifier is used.**

***Index Terms*— Facial Expression Detection, Feature Extraction Japanese Female Facial Expression (JAFFE) database, Principal Component Analysis (PCA),**

I. INTRODUCTION

Expression is the most important mode of non-verbal communication between people. Recently, the facial expression recognition technology attracts more and more attention with people's growing interesting in expression information. Facial expression carries crucial information about the mental, emotional and even physical states of the conversation. Facial expression recognition has practical significance; it has very broad application prospects, such as user-friendly interface between man and machine, humanistic design of goods, and emotional robot etc. With facial expression recognition systems, the computer will be able to assess the human expressions depending on their effective state in the same way that human's senses do [3]. The intelligent computers will be able to understand, interpret and respond to human intentions, emotions and moods [3].

The facial expression recognition system applied in different areas of life such as security and surveillance, they can predict the offender or criminal's behavior by analyzing the images of their faces that are captured by the control-camcorder. Furthermore, the facial expression recognition system has been used in communication to make the answer machine more interactive with people. The answer machine has become more intelligent by analyzing the client's voice and dealing with the responses according to their emotions.

Manuscript received August 30, 2013.

Ajit P. Gosavi, Electronics and Telecommunication Department, S.S.P.M. college of Engineering, Kankavali, India.

Prof.S.R.Khot, Information Technology department, D.Y. Patil college of Engineering and Technology, Kasaba Bawada, Kolhapur, India.

Moreover, it is powerful in signed language recognition system that deals with the deaf and dumb people. The facial expression recognition system has a considerable impact on the game and entertainment field besides its use to increase the efficiency of robots for specific military tasks, medical robots, and manufacturing servicing [7]. Generally, the intelligent computer with facial expression recognition system has been used to improve our daily lives.

II. RELATED WORK

A. *Previous Approaches to Facial Expression Recognition*

Bartlett explores and compares techniques for automatically recognizing facial actions in sequences of images. These techniques include analysis of facial motion through estimation of optical flow; holistic spatial analysis, such as independent component analysis, local feature analysis, and linear discriminant analysis; and methods based on the outputs of local filters, such as Gabor wavelet representations and local principal components [1].

Lien describes a system that recognizes various action units based on dense flow, feature point tracking and edge extraction. The system includes three modules to extract feature information: dense-flow extraction using a wavelet motion model, facial feature tracking, and edge and line extraction [5].

The system that used color information, Rajapaskse et al., (2004) proposes the use of non-negative matrix normalization (NMF) with color cannel encoding [4]. This process is performed by representing the (RGB) color channel as a three indexed data vector separately: red, green and blue channel for each image. Then the color using non-negative matrix (NMF), a decoding method, is applied. This technique makes better use of the color image because of the excessive iterative matrix and the decoding operation that involves inverting the matrix; the inherent processing cost was so big [4].

Author Yang, J. and Zhang; suggested a new technique two-dimensional Principal Component Analysis (2DPCA) for image representation. As opposed to Principal component analysis, two-dimensional principal component analysis is based on 2D image matrices rather than 1D vector. In two-dimensional Principal Component Analysis, Principal Component Analysis must be applied [3].

B. *Approach Taken for Facial Expression Recognition*

The work presented here provides a novel solution to the facial expression recognition problem, describing a facial recognition system that can be used in application of Human computer interface. There are three main

components to this system: a Feature Extraction, Principal Component Analysis and Euclidean Distance Classifier. To classify the images final facial expression recognition system uses Euclidean Distance Classifier.

The system developed is able to find and recognize the facial expressions of JAFFE database. It recognizes expression of the seven basic emotions, namely happy, disgust, neutral, anger, sad, surprise and fear.

III. PROPOSED FACIAL EXPRESSION RECOGNITION SYSTEM

A. System Architecture

This section describes facial expression recognition system architecture. Our system is composed by four modules: Preprocessing, Principal Component analysis and expression classification using Euclidian classifier. Fig.1 represents the basic blocks of facial expression recognition system

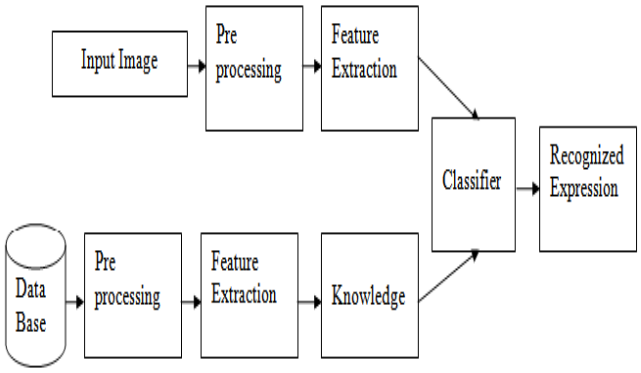

Fig. 1. Facial Expression Recognition System Architecture

B. Preprocessing

Pre-processing is the next stage after entering the data into the facial expression recognition system. The important data that is needed for most facial expression recognition methods is face position. In preprocessing module images are resized from 256 x 256 pixel value to 280 x 180 pixel values. The Sobel method has been used to identify the face edges.

C. Principal Component Analysis (PCA)

Principal component analysis or *karhunen-loeve transformation* is a standard technique used in the statistical pattern recognition and signal processing for data reduction. As the pattern often contains redundant information, mapping it to a feature vector can get rid of this redundancy and yet preserve most of the intrinsic information content of the pattern. These extracted features have great role in distinguishing input patterns. A face image in 2-dimension with size N × N can also be considered as one dimensional vector of dimension N^2.

Each of these vectors are of length N^2, this describes N × N image and is a linear combination of the original face images. As these vectors are the eigenvectors of the covariance matrix corresponding to the original face images, and because they are face-like in appearance, they are referred as “Eigen faces”. After estimation of the covariance matrix, significant eigenvectors of the covariance matrix are computed. The number of Eigen-vector depends on application and accuracy that the system needs and it is clear that if number of Eigen-vectors is large the accuracy of the method improved but computational complexity increased.

We can retain the maximum information by retaining the coordinate axes that have largest eigenvalues and delete those that have less information. This technique involves

- Gather x_i where i= 1 to p.
- Compute the mean m and subtract it to obtain x_i-m.
- Compute the covariance matrix
  $Cij = (x_i\text{-}m)(x_i\text{-}m)^T$.
- Determine Eigenvalues and Eigenvectors of covariance matrix C such that CV=AV where A=dig ($\lambda 1, \lambda 2 \ldots \lambda p.$), a diagonal matrix is defined by the eigenvalues of the matrix C and V = (V_1, V_2 .....V_p) be the associated eigenvectors.
- Sort the eigenvalues and corresponding eigenvectors such that $\lambda_1 \geq \lambda 2 \geq ,\ldots\ldots\ldots \geq \lambda_p$.
- Select the first $l \leq p$ eigenvectors and discard p-l eigenvectors to find the data in new directions.
- If the orthogonal matrix contains the eigenvectors of C, then C can be decomposed as $C= VAV^T$ where A is diagonal matrix of eigenvalues.

D. Facial Expression Classification

The proposed approach to the facial expression recognition involves following steps.

1) The train images are utilized to create a low dimensional face space. This is done by performing Principal Component Analysis in the training image set and taking the principal components with greater Eigen. In this process, projected versions of all the train images are also created.
2) The test images also projected on face space, all the test images are represented in terms of the selected principal components.
3) In order to determine the intensity of the particular expression its Euclidean distance from the mean of the projected neutral images is calculated.
4) The Euclidian distance of a projected test image from all the projected train images are calculated and the minimum value is chosen in order to find out the train image which is most similar to the test image.
5) The test image is assumed to fall in the same class that the closest train image belongs to.

IV. EXPERIMENTAL RESULTS AND DISCUSSION

A. Japanese Female Facial Expression Database

The database used for facial expression system is Japanese Female Facial Expression (JAFFE) Database contains 213 images of 7 facial expressions including neutral posed by 10 Japanese female models. Each image has been rated on 6 emotions adjectives by 60 Japanese subjects. For the implementation of facial expression recognition JAFFE database captured face data is used. In this implementation, all images are resized to a uniform dimension of 256 x 256. Figure 3 shows the database images considered for facial Expression recognition.

- 70 training images and 70 test images

The training set is consisted of 70 images (the set contains 10 persons and each person contains 7 images). On the other hand, the test set contains 70 images that are consisted of random choosing 10 images from every expression. The experiment is iterated 10 times. So, we can get the recognition rate of every expression and average recognition rate of all test samples. The average recognition rate of 70 JAFFE test samples with PCA is 67.14%. Fig. 4 reveals the comparison of the recognition rate for every expression with PCA methods about training set of 70 images and test set of 70 images. The recognition rate of the neutral, sad and anger with PCA Algorithm is higher than other expressions for 70 test images.

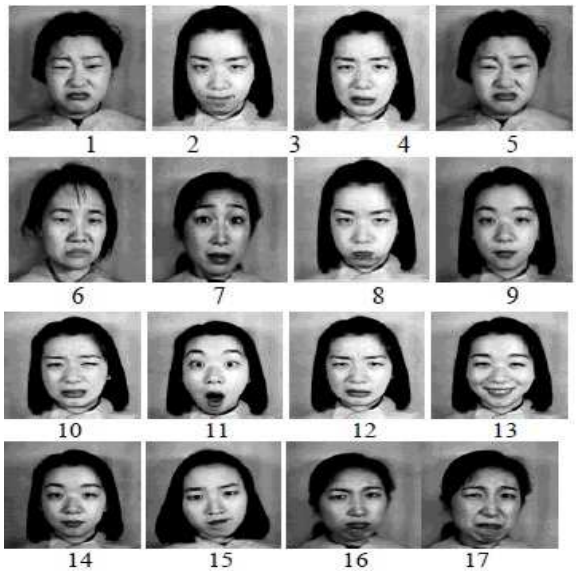

Fig.3.Images of JAFFE Database in various Facial Expressions

B. *Tools used for Evaluation*

The main useful statistical measurements that were utilized to evaluate the emotion recognition system are: Recognition Rate, Precision and Accuracy. These measures are useful in that they help judge the performance of the emotion recognition system. The recall rate measures and studies the relation between the correct classification rates of specific emotions and the wrong classification of this specific emotion whereas precision measures the relation between the correct classification rate of specific emotions and the wrong classification of other emotions that are classified as special emotions. Finally, the accurate rate measures the relation between the correct classification rate of specific and other emotions and the total number of testing images, i.e. the following convert of these relations into a symbolic equation.

$$Precision = \frac{truepositive}{truepositive + falsepositive}$$

$$Accuracy = \frac{truepositive + truenegative}{truepositive + truenegative + falsepositive + falsenegative}$$

Where *true positive* for specific data set of emotions (A) is the correct classification rate of emotion; while, *false positive* of (A) emotion is the wrong classification rate of other data set of emotions that are classified as (A) type whereas false *negative* is the wrong classification of emotion (A). Finally, *true negative* of emotion (A) is the correct classification for images whose label is not (A). Additionally, it is noticed that the summation of true *positive*, *false positive*, *false negative* and *true negative* is the total number of the testing images.

C. *Results Obtained Using Principal component Analysis*

The average recognition rate of 70 JAFFE test samples with PCA is 67.14%. Table II reveals the comparison of the recognition rate for every expression with PCA methods about training set of 70 images and test set of 70 images. The Accuracy rate of the Anger using PCA Algorithm is higher than other expressions for 70 test samples. The recognition rate of the sad, anger and neutral with PCA Algorithm is higher than other expressions for 70 test images. Table IV demonstrates the system results of the testing 70 “gray scale images” using PCA method.

TABLE I. Accuracy Rates of Various Facial Expressions

Facial Expression	Accuracy Rate using PCA (%)
Happy	88.81
Disgust	88.81
Neutral	92.31
Sad	81.12
Anger	94.41
Surprise	92.31
Fear	88.11

TABLE II. Recognition Rates of Various Facial Expressions

Facial Expression	Recognition Rate using PCA (%)
Happy	42.85
Disgust	68.42
Neutral	70
Sad	71.43
Anger	75
Surprise	50
Fear	63.63

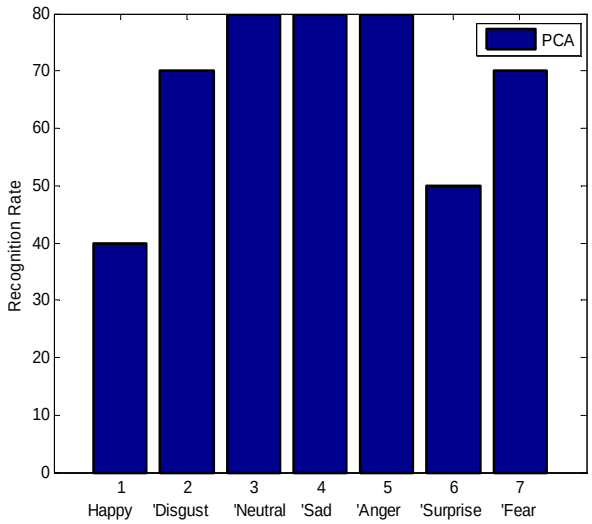

Fig.4 Bar Graph Showing Recognition Rates of Various Facial Expressions

TABLE III. Recognition Rate of Facial Expression Recognition System using JAFFE Database

Algorithm	**Recognition Rate (For 70 Test Image)**
Proposed PCA Method	67.14%

TABLE IV. System Performance Results For Testing 70 JAFFE mages using PCA Method

Target Recognition Rate	**Happy [10]**	**Disgust [10]**	**Neutral [10]**	**Sad [10]**	**Anger [10]**	**Surprise [10]**	**Fear [10]**	**Average**
Happy	04	00	00	00	00	01	00	
Disgust	00	07	00	00	01	01	02	
Neutral	01	00	08	01	00	00	00	
Sad	03	02	01	08	01	02	01	
Anger	00	00	00	00	08	00	00	
Surprise	00	00	00	01	00	05	00	
Fear	02	01	01	00	00	01	07	
Precision	80%	63.63%	80%	44.44%	100%	83.33%	58.33%	72.82%
Accuracy	90%	90%	94.29%	82.86%	97.14%	91.43%	95.71%	91.63%
Recognition Rate	40%	70%	80%	80%	80%	50%	70%	67.14%

V.CONCLUSION

We have implemented a facial expression recognition system using Principal component analysis method. This approach has been studied using JAFFE image database. The experiment results demonstrate that the accuracy of the JAFFE images using Principal component analysis is 91.63%. Similarly precision rate obtained is 72.82% in case of Principal component analysis method.

REFERENCES

[1] Bartlett, M. S., Donato, G., Ekman, P., Hager, J. C., Sejnowski, T.J., 1999,"Classifying Facial Actions", IEEE Trans. Pattern Analysis and Machine Intelligence, Vol. 21, No. 10, pp. 974-989.
[2] Yang, J., Zhang, D., 2004, "Two-dimensional pca: a new approach to appearance-based face representation and recognition", IEEE Trans. Pattern Anal. Mach. Intell.Vol.26, No. 1, pp. 131–137.
[3] Yi, J., R. Qiuqi et al. (2008),"Gabor-based Orthogonal Locality Sensitive Discriminant Analysis for face recognition'', Signal Processing, 2008. ICSP 2008. 9th International Conference on.
[4] Menaka Rajapakse, Jeffrey Tan, Jagath Rajapakse,"Color Channel Encoding With NMF for Face Recognition", International Conference on Image Processing; Proceedings; ICIP, pp 2007-2010 (October 2004).
[5] Cohn, J.F., Kanade, T., Lien, J.J., 1998,"Automated Facial Expression Recognition Based on FACS Action Units", Proc. Third EEE Int. Conf. Automatic Face and Gesture Recognition, pp. 390-395.
[6] M. Turk, A. and Pentland, "Eigen faces for face recognition ", Journal cognitive neuroscience, Vol. 3, No.1, 1991.
[7] Ching-Chih, T., C. You-Zhu et al. (2009),"Interactive emotion recognition using Support Vector Machine for human-robot interaction. Systems", Man and Cybernetics, 2009. SMC 2009. IEEE International Conference on.M. Turk, A. and Pentland, "Eigen faces for face recognition ", Journal cognitive neuroscience, Vol. 3, No.1, 1991.
[8] Pantic, M. and Rothkrantz, L., 2000, "Automatic analysis of facial expressions: The state of the art", IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol. 22, No. 12, pp.1424–1445.
[9] Jain, A.K., Duin R.P.W., Mao J., 2000,"Statistical Pattern Recognition: A Review", IEEE Trans. Pattern Analysis and Machine Intelligence, Vol. 22, No. 1, pp. 4-37.
[10] Pantic, M. and Rothkrantz, L., 2000, "Automatic analysis of facial expressions: The state of the art", IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol. 22, No. 12, pp.1424–1445.

Ajit P. Gosavi received the BE degree in Electronics and Telecommunication Engineering from the University of Mumbai, India, in 2004. He is currently pursuing a M.E. degree in Electronics and Telecommunication Engineering at Shivaji University. His research interests are in pattern recognition and image processing. He is a lifetime student member of the ISTE. He has published 01 International conference and 02 national conferences. From last 07 years he is on the Faculty of Electronics and Telecommunication department at SSPMCOE, Kankavali.

Prof.S.R.Khot received the BE degree in Electronics and Telecommunication engineering. He received the M.E. degree in Electronics and Telecommunication. His research interests are in computational vision and image processing. He is a professional member of the ISTE. He has published 06 International conference and 10 national conferences. From last 24 years he is on the Faculty of Information Technology Department at DYPCET, Kolhapur. Also he has attended 17 workshops.