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Facial Expression Recognition using Local Gabor Binary Pattern(LGBP) and Principle Component Analysis (PCA)

Shalu Gupta & Sonit Singh

***Abstract*—Facial Expression Recognition is one of the active research area in the field of Human Machine Interaction (HMI) because of its several applications such as human emotion analysis, stress level and lie detection. In this paper, an algorithm for facial expression recognition has been proposed which integrate the Local Binary Patterns (LBP), Gabor filter and Principal Component Analysis (PCA). The proposed technique has been applied on JAFFE database. The comparative analysis on the basis of average recognition rate has been performed for each individual and integrated approach. The results shows highest recognition rate while combining LGBP and PCA, which is 87.5. The results indicate that when we integrate LBP, Gabor filter and PCA, then it provides high recognition rate.**

Keywords—Facial expression analysis (FER), Principal Component Analysis (PCA), Local Gabor Binary Patterns (LGBP), Gabor filter. (key words)

I. Introduction

In recent years, FER becomes an interesting area for research. These research areas can be medical science, robotics and automation. The application of FER is increasing day by day. FER covers the different regions such as HMI (human machine interaction), computer vision design. In the robotic field robots such as industrial robots, designing and manufacturing robots, protection robots can interact with their user with the help of expressions. Maximum part of human's life is covered by communication [1]. An expression lies in the category of non verbal communication. These changes in the different muscles of the face transmit the emotional message to the observer. These expressions follow the epidermis path in the brain. There are two methods to recognize the expressions

Shalu Gupta
Discipline of ECE
Lovely Profession University, India

Sonit Singh
Discipline of ECE
Lovely Profession University, India

These methods are depending upon the type of the features which is extracted from the image. First, includes appearance based features of the data. Linear discriminate analyses (LDA) [2], Scale Invariant Feature Transform (SIFT) Independent Component Analysis (ICA), Principle Component Analysis (PCA) are the methods which extract the appearance based features. Second method includes geometric based features. Active Shape Model and Active Appearance [3] Method are the methods which extract geometric based features. Geometric [4] features and Appearance based features both have their own advantages and limitations. In geometric based features, there is loss of spatial information. Another problem in geometric based features is high degree of ensemble rate

II. Overview Of FER

The key steps for FER are collection of standard Database, pre – processing, Feature extraction & Classification.

A. *Database*

Database is the collection of images on which the algorithm has to be applied. For comparative analysis there is need of standard database. There are different sources for database that are available publicly on the net such as Cohn – Kanade database, MMI database, Japanese Female Facial Expression (JAFFE) database, Belfast naturalistic database..
In this paper, the proposed algorithm has been applied on JAFFE database. This database is available publicly. There are seven basic expressions (disgust (DI), neutral (NA), happiness (HA), fear (FE), anger (AN), sad (SA), surprise (SU)) presented in the JAFFE database. The JAFFE database has total 213 images of seven different expressions. In JAFFE database, only the female expressions are present.

B. *Pre-processing*

There is need of pre-processing to enhance the quality of the images. The accuracy of any algorithm is highly dependent on the quality of the images. At the time of image capturing various unwanted effect like noise, illumination change, shadowing effect may degrade the image quality. So pre-processing can be used to overcome these undesired effects. It performs the removal of unwanted information and provides local information of an image. When there is irrelevant redundant information, noisy and unreliable data present in the image then data pre-processing is essential step. We obtain the images of uniform shape and size. Figure 1 shows the disgust

expression of original and localized image respectively of JAFFE database.

(a) (b)

Figure 1. Pre-processing of face image, (a). Original image, (b). Localized image.

C. *Feature Extraction*

Feature extraction can be defined as the relevant information which has shows some unique properties of the data. After feature extraction, redundant data has to be discarded. The dimension reduction of feature vectors taken place because, only non redundant data is present in data set. The choice of the feature set is the very important and critical part in the case of any classification and recognition problem. The very basic constrains related to image classification consist of scale, pose, translation and variations in illumination level. The feature vector which is extracted from particular image should be invariant to these types of constrains in order to achieve better accuracy in classification and recognition. Appearance based features are very popular, in facial expression classification and face recognition because of its great discriminative power as compared to texture features. When LBP is used as feature extraction method then it gives excellent light invariance results and low computational complexity [13].PCA can be a good option for dimension reduction of feature vector..

D. *Classification*

Classification is used for identifying the category in which observation belongs. Classifier can be act separator, which classifies the images into their respective categories. The supervised learning is used to train the algorithm. In this paper PCA with Euclidian distance is used as classifier. PCA maps data from a high dimensional space to a lower dimensional sub-space. Here each expression is considered as a class. The distance of testing image from each of class is being calculated.

E. *Results*

There are several ways to shown the results such as Region of Convergence (ROC), Confusion Matrix, and True False Recognition (TFR) rate. Confusion matrix shows the actual and predicted images. In confusion matrix if actual and predicted images falls under the same class that means the recognition is correct.

III. Related Work

For facial expression classification and recognition Facial Action Coding System (FACS), a good synchronies example for understanding and determination of human facial expressions, based on this approach a number of systems were independently developed for FER. Turk and Pentland elaborate the Principal Component Analysis (PCA) to compute the feature vectors called the Eigen values. Abboud and Davoine [6] proposed a two dimensional mean squared algorithm for expression classification. Lyons et al.[7] employed a fast approach to classified the facial images in automatic way based on marked converged [8] graph matching and two dimensional Gabor wavelet representation. Yacoob et al. [9] used a system which is based on artificial intelligence and neural networks. In these networks the complexity of facial expressions classification was sub divided into different layers of network decomposition. Along with these systems some new and appropriate approaches are applied in the expression recognition such as Artificial Neural Networks(ANN), Support Vector Machines(SVM), Histogram Orient Gradient(HOG),Wavelet Packet Analysis, Hidden Markov Model (HMM) and Optical Flow. Although enormous and wonderful efforts have been derived by many researchers and great achievements were obtained in Automatic FER, recognition of facial expression with a high accuracy is achieved.

In Automatic FER, Feature extraction and dimension reduction and classification are important steps. The main motive of feature extraction and dimension reduction is to receive more compact and precise representations and descriptions of the data with tolerable deduction of information or accurate rate of classification. Accuracy rate of any recognition and classification depends upon directly on the level and quality of the feature which is extracted.

Along with above approaches, principle component analysis (PCA), Independent component analysis (ICA) and linear discriminant analysis (LDA) are commonly used [9] in large geographical area. But these approaches didn't have any concern with local texture information of facial images which is very important information for Automatic FER. Generally there are two popular appearance based approaches to extract facial features: Gabor filter [10] magnitude and LBP. Gabor filter magnitude features are commonly used to describe the local properties of the facial image, in order to achieved recognition rate is high, but its computation complexities is increased [11]. Compared to Gabor feature, LBP is brilliant option because of its low computation complexity and local texture description ability. But the combination of both these approaches may give good results.

IV. Proposed Technique

In this paper a new approach for FER using LGBP and PCA has been propoosed. The methodology which is proposed here emphases on the convergence of linear space properties like local feature and static features.

A. *Principal Component Analysis (PCA)*

In the initial step, we resize the images of JAFFE database. In this work we use resolution of 128 x 128 for every image,

as the original resolution of each image in database is 256 x 256. When we applied PCA to database we get feature set. The main function which can be performed by PCA is derived non redundant data, compression of data extraction of features, or prediction etc. It is very important if there is need of dimensions reduction.
Few steps for PCA is given below:-

- Suppose there are L training facial images of size N X M. Calculate the mean of images which is represented by v-mean.

$$\sum_{i=1}^{I} Vi \quad (1)$$

- Subtracts the mean of the individual face image to the corresponding image.

$$\Psi_i = V_i - (\text{v-mean}) \quad (2)$$

- Now calculate the co variance matrix for each class.

$$\text{Cov} = 1/I \; S*S^T \quad (3)$$

Here S = [$\Psi_{1.....}$ Ψ_I] and T represents the transpose of the vector.

- Step 4:- Compute Eigen values and Eigen vectors for each expression.

$$G_i = 1/ D_i^{1/2} \; S* u_i \quad (4)$$

Here G represents the Eigen vectors and D represents the Eigen values. Where [$D_1 > D_2 > D_i$].

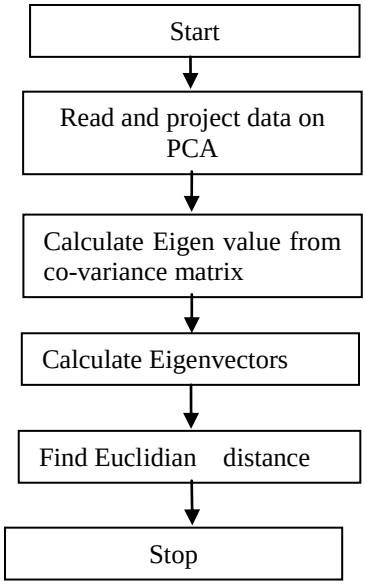

Figure 2. Flow chart of FER using PCA

- The Euclidian distance D between the samples of training and testing has been calculated.

$$D = [(x_1y_1-x_2y_2)^2] ^{1/2} \quad (5)$$

In the above equation x_1y_1 and x_2y_2 are the co-ordinates or the position of the different samples.

B. *Local Binary Pattern (LBP)*

LBP is defined as an ordered set of binary comparisons of pixel intensities between the central pixel and its neighbor pixels. LBP gives the local information of face space, or micro partition information. It requires less time to perform their operation as compared to other high orientation scale. It computes their operation in one scale and reached to raw data which is required for further operation. LBP gives great result if input has low resolution [12]. The LBP has been calculated the local factor of an image with the help of non parametric descriptors.
For a given pixel position (x_p y_p), LBP is defined as :-

$$\sum_{n=0}^{7} s(in - ip)\, 2n \quad (6)$$

Where *i*p is intensity value of centre pixel i.e. (x_p y_p), and *i*n is intensity value of surrounding pixels of 8 neighborhood.

If (*i*n – *i*p) > 0 then *S*(*i*n – *i*p) = 1
Else *S*(*i*n – *i*p) = 0

An example of LBP operator using 3 x 3 window is given below

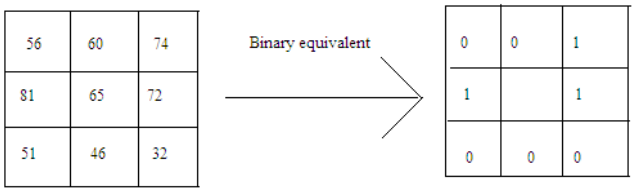

Figure 3. An example of LBP operator

It's decimal equivalent is 25.

Algorithm for FER using LBP and PCA is given below

- Detect and resize the each face image into N X M resolutions.
- Pre process the face image in order to remove the noise.
- Sub divided the face image into different blocks of 3 x 3 window and apply LBP operator as defined in equation 6.

- Same LBP operator has been applied on the entire image.
- Concatenate all the values of each block to obtain the feature set.
- Compute the mean of the feature vector of individual class as defined in equation 1.
- Subtracts the mean of the individual face image to the corresponding image.
- Calculate the co variance matrix for each class as defined in equation 3.
- Compute Eigen values and Eigen vectors for each expression as defined in equation 4.
- Place only L Eigen vectors which is correspond to L largest Eigen values.
- Finally compute the error using Euclidian distance, as defined in equation 5.

C. *Gabor filter*

When there is need of edge detection, Gabor filter can be used for this purpose. In order to achieve the Gabor filtered image, first of all Gabor filter has to be designed. Now convolution of face image and Gabor filter has taken place. In this system we use 40 Gabor filter. The Gabor filter has derived from the following equation.

$$G_K(z)= kv^2/c^2\ e(-k^2z^2/2c^2)\ (e^{ikz} - e^{-c2/2}) \quad (6)$$

In the above equation z(x,y) is the co-ordinate or spatial location of each pixel in Gabor filter. $G_K(z)$ is the Gabor kernel. It has two main parameters such as scale [13] and orientation. In the above equation kv = (Π/2, Π/4, Π/8, Π/16, Π/32). Where k= (0,1,2,3,4,5,6,7). This constitutes 40 magnitudes Gabor filter. The last term $e(c^2/2)$ is used for compensate the effect of d.c value [14]. After this input image and convolution of Gabor kernel is obtained. Suppose input image is represented by f(z) and the Gabor convolved [15] image characterization is represented by $O_K(z)$. So

$$O_K(z)=f(z)*G_k(z) \quad (7)$$

By changing the values of orientation and frequency at different level we can obtains multi resolution and orientation analysis. Above description is suitable for two dimensional Gabor filter.

D. *LGBP*

Here we apply LBP operator on the 40 Gabor magnitude image. The combination of LBP and Gabor i.e. LGBP gives 40 LGBP maps per input face image. The combined effect of LBP and Gabor creates multi resolution and multi orientation link [16] in between the pixels, which improves the description of the features. LGBP proves a good choice in case illumination changes [17] and the environment where there is chance of misalignment always occurred.
LGBP+PCA is used for dimension reduction. PCA has been applied on the featured image after LGBP

- In training stage, we extract the features of the facial images using LBP operator and Gabor filter. After this PCA has been applied to reduce the dimensions of vector. After applying PCA we have only those components [18] which are in Eigen directions.

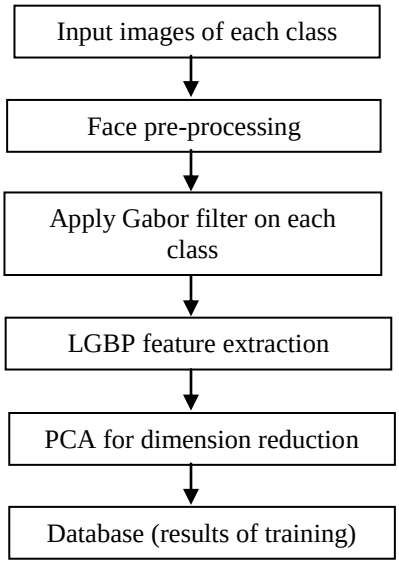

Figure 4. Flow chart of training phase

- In testing phase, we classify the face images into their respective categories. As the features are calculated in the training phase, similarly features are obtained in the testing phase. Now the projection [19] of each feature in direction of Eigen range for each class of emotion is performed.

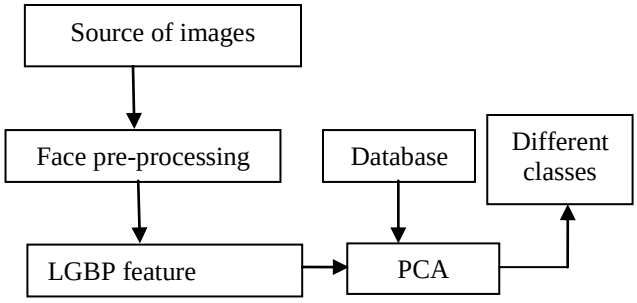

Figure 5. Flow chart of testing phase

Now the distance testing image from each of class is being calculated. The expression which has minimum distance [20] with training image is assigned to that particular class.

V. Experimental Results and Discussion

Facial images for different expressions were taken for each class. For each class 63 training images were taken. 9 images of each 7 expressions. In the testing phase 56 images of different expressions were taken place, where for every expression 8 images were taken placed.

A. .FER using PCA

When small number of training images are provided even though recognition rate is good because reduced dimension is given by PCA. Steps which is used in recognition using PCA is defined in section (A) of part IV.

Table I: Confusion matrix for FER based on PCA features

	P.E % →						
A.E ↓	HA	AN	SA	SU	FE	DI	NE
HA	**75.0**	0.00	0.00	12.5	0.00	12.5	0.00
AN	0.00	**62.5**	25.0	00.0	0.00	0.00	12.5
SA	0.00	0.00	**87.5**	0.00	12.5	0.00	0.00
SU	12.5	12.5	0.00	**62.5**	0.00	12.5	0.00
FE	0.00	12.5	25.0	0.00	**50.0**	0.00	12.5
DI	12.5	0.00	0.00	12.5	12.5	**62.5**	0.00
NE	0.00	12.5	12.5	0.00	0.00	0.00	**75.0**

Table I is showing the confusion matrix for FER based on PCA features. In this confusion matrix P.E stands for predicted expressions percentage and A.E stands for actual expressions. From the above confusion matrix we can conclude that FER is very poor in the case of fear and approximate good in the case of sad. In case of PCA overall recognition rate is 71.4 %

B. FER using LBP and PCA

LBP gives the local information of face space, and output after LBP operator is in high dimension space.

Table II: Confusion matrix for FER based on LBP and PCA features

	P.E % →						
A.E ↓	HA	AN	SA	SU	FE	DI	NA
HA	**87.5**	0.00	0.00	12.5	0.00	0.00	0.00
AN	0.00	**62.5**	12.5	0.00	12.5	0.00	12.5
SA	12.5	0.00	**75.0**	0.00	0.00	12.5	0.00
SU	0.00	12.5	0.00	**75.0**	0.00	0.00	12.5
FE	0.00	12.5	25.0	0.00	**62.5**	0.00	0.00
DI	0.00	0.00	0.00	12.5	0.00	**87.5**	0.00
NE	0.00	0.00	12.5	0.00	0.00	0.00	**87.5**

So in order to reduced the dimension space PCA has been applied on LBP feature vector. The steps which are used in recognition using LBP + PCA is defined in section (B) of part IV.

Table II is showing the confusion matrix for FER based on LBP + PCA features. From the above confusion matrix we can conclude that FER is good in the case of happy and disgust. Using LBP + PCA results are improved in case of fear and surprise as compared to PCA alone. In case of LBP + PCA overall recognition rate is 77.2 %

C. FER using LGBP and PCA

LGBP inherit the properties of Local binary operator alone with Gabor filter. 40 Gabor magnitude images of 5 orientations and 8 frequencies are processed by LBP operator. Along with this the problem of high dimension space is over come by PCA. The sequence of operation is defined in section (C) of part IV.

Table III: Confusion matrix for FER based on the LGBP and PCA features

	P.E % →						
A.E ↓	HA	AN	SA	SU	FE	DI	NE
HA	**87.5**	0.00	12.5	0.00	0.00	0.00	0.00
AN	0.00	**87.5**	0.00	0.00	0.00	12.5	0.00
SA	12.5	0.00	**75.0**	12.5	0.00	0.00	0.00
SU	0.00	0.00	0.00	**87.5**	0.00	0.00	12.5
FE	0.00	0.00	0.00	0.00	**100**	0.00	0.00
DI	0.00	12.5	0.00	0.00	0.00	**87.5**	0.00
NE	0.00	0.00	0.00	12.5	0.00	0.00	**87.5**

Table III is showing the confusion matrix for FER based on LGBP and PCA features. From the above confusion matrix we can conclude that FER is quite excellence in case of fear and gives well results in the cases of anger, surprise and disgust happy. In the case of LGBP and PCA overall recognition rate is 87.5 %.

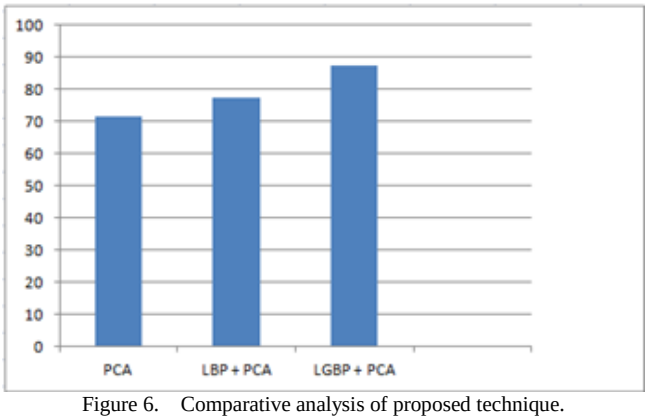

Figure 6. Comparative analysis of proposed technique.

On comparing the above three confusion matrix the recognition rate is improved when the integration of individual approach i.e. LGBP and PCA has been applied. The computational cost is reduced due to PCA and recognition rate is increased by using LGBP.

The Comparative analysis of PCA, LBP+PCA, LGBP+PCA is shown in figure 6 with the help of bar graph. In this bar graph horizontal axis shows the proposed technique and vertical axis represents the average recognition rate.

This bar graph shows that recognition is improved in the case of LGBP+PCA. The overall recognition rate is 71.4 % in case of PCA. The classification rate will improve up to 77.2% when we move towards LBP + PCA. Finally our proposed algorithm i.e. LGBP+PCA gives fine recognition rate up to 87.5%, which is more than the PCA and LBP + PCA.

VI. Conclusion and Future Work

In this paper, FER has been done by applying Gabor filter and LBP along with PCA. The methodology which is proposed here utilizes the properties of three approaches like local feature from LBP, edges from Gabor filter and dimension reduction by using PCA. Gabor is basically a band pass filter and insensitive to rotation, LBP feature is not sensitive to any change in illumination and rotation and PCA can reduce the dimensions of given feature vector. The effective impact of the proposed approach has been illustrated through experimental results and analysis. When we integrate the individual approach i.e. Gabor filter, LBP and PCA then algorithm will give good results. In future work there is way to shift towards 3-dimensional facial expression recognition. Multiple cameras can be used in image capturing to extent the recognition rate. Further there is an option to deal with paralyses facial expressions recognition, which may provide a helpful direction in the case of medical science and neurology, also there, is need to reduce the training time along with performance accuracy.

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About Author (s):

Shalu Gupta has been working towards her M.Tech in Digital Image Processing from Lovely Professional University, Phagwara, Punjab, India. Her research interests includes digital image processing, face recognition, facial expression recognition & human machine interface.

Sonit Singh has been working as an Assistant Professor in the Department of ECE, Lovely Professional University, Phagwara, Punjab, India. His research interests include pattern recognition, machine learning, digital image processing, machine vision, soft computing and computational neuroscience.