International Journal of Computer Trends and Technology (IJCTT) – volume 17 Number 4 Nov 2014

A Literature Survey on Facial Expression Recognition techniques using Appearance based features

Jaimini Suthar[#1], Narendra Limbad[*2],

[12] *Department of Computer Engineering, Gujarat Technological University, Gujarat, India*

***Abstract*— Ability of recognizing facial expression is important part of behavioural science, which helps to ease the communication. This ability can serve in many contexts. Hence, facial expression is an important research area over the last two decades. In this paper, we have surveyed various feature extraction methods, which is the success key to Facial Expression Recognition (FER). Facial Expression Recognition has light volume because the facial image, facial occlusion, faces colour / shape etc is not an easy to deal with. In this paper, we have presented few appearance based techniques like Gabor Filter, Principal Component Analysis (PCA), Local binary patterns (LBP), Linear Discriminant Analysis (LDA), with different classifiers like a Support Vector Machine (SVM), Artificial Neural Network (ANN), and fuzzy logic, which are used to recognize human expression in various conditions on different databases.**

Keywords- Facial Expression Recognition (FER), Feature Extraction, Gabor Filter, Principle Component Analysis (PCA), Linear Discriminant Analysis

I. INTRODUCTION

A human face has significant and unique characteristics, which play most dominant role in recognizing the expression of human faces. Facial Expression Recognition (FER) defined as a change that happens in response to human internal emotional states. It is used in different application of Human Computer Interaction (HCI) like face image processing, facial video surveillance system, and facial animation in the area of Computer Vision, Digital Image Processing and Artificial Intelligence. Automatic recognition of human expression is challenging task and has gained much attention during recent years. In FER, the stage of feature extraction plays a major role. In literature [1], Mehrabian et al. have shown that facial expression contributes 55% to the total communication. While vocal and verbal contributes 38% and 7% respectively.

Ekman and Frisen have identified six basic universally accepted expression in their research discussed in [2]. These basic six expressions are happy, angry, disgust, sad, fear and surprise.

The purpose of the research is to develop an automated and interactive computer vision system for the recognition of human facial expressions. Due to recent advances in image processing, it opens up the wide possibility of interaction with the machine and provides the different techniques for the automatic detection of face from image and classification of emotional and conversational facial signals. Space-time analysis for understanding the facial expressions in the previous work, however suffer the following shortcomings:

- Most of these technologies are not in real-time to respond to the facial expression of the user. Facial movement patterns are trained offline from the training image dataset, since it limits its reliability for applications large variations between and contains a large number of possible Face action unit combinations [2].
- In FER, for feature extraction, different techniques are available which depends on geometric and appearance based features. However, these techniques having performance variant according to the input images, rate of recognition of each expression and timely manner.
- At the step of Classification of expression, classifiers do not generalize well for each expression and adapt the specific properties of database [3].
- Possession of a large amount of data, images is usually makes it difficult to analyze human expressions. Raw data of FER are defined in a magnified image of facial expressions and facial expressions that can be used for higher-dimensional image space analysis. Therefore, this analysis is critical for dimension reduction [4].
- Human's gesture is a dynamic process.

In this paper, we focus on various feature extraction methods using appearance based features for recognizing human facial expression. There are different approaches have been developed for extracting features from face images are Gabor Filter, Principal Component Analysis (PCA), Linear Discriminate Analysis (LDA), Local Binary Pattern (LBP), with different classifier Support Vector Machine, Artificial Neural Network (ANN), and fuzzy logic [3-13].

II. TECHNIQUES AND METHODS

FER proceed in mainly three steps [6]:

1. Preprocessing
2. Feature Extraction
3. Classification

Preprocessing:

The first step of image preprocessing is detection of face in the image. Because of variability of illumination, scale, orientation and pose, face detection is challenging task. Among available techniques for detection of faces, edge detection is common. Edge detection is done by convolving proper filter which applies positive weight on one edge and negative weight on another. There are different edge detection filters: Canny, Laplacian, Prewitt, Sobel and Kirsch [5], where Canny edge detection used to extract the facial components

such as an eye, nose, eyebrows and mouth with manually setting of threshold [7].

The input facial images have different format and size. Therefore the input image is processed and converted into appropriate to feature extraction method. General ways adopted for this are [6]

- By converting the RBG image into a grayscale image.
- Resize the image if size is too large.

Feature Extraction:

After the localization of the face and facial components of the input image, the next step is to extract representative features. Extracting a features affected with expression, is a crucial step from all steps of FER [5]. These feature parameters are further divided into two parts: Geometric based and Appearance/Texture based [6]. As shown in Figure1 different techniques for Appearance based features.

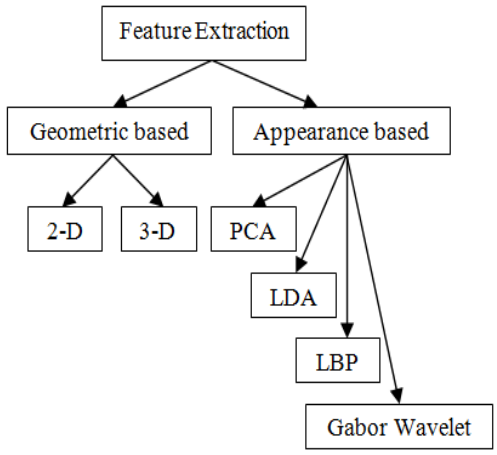

Figure 1: Techniques for feature extraction

Priya Sisodia et. al [6] have used gabor filter bank for detecting an appearance based features. Image was first converted to gray scale and then face was detected and resized. Few of the most representative features are selected through feature selection method and SVM was used for classification.

Rosdiyana Samad et. al [3] developed the algorithm to identify minimum number of Gabor wavelet parameters for natural FER. They convert image into gray scale and resize before applying a Gabor filter after that Gabor features are down sampled and dimensions of feature vector were reduced using PCA. Classification using SVM claims 81.7% recognition rate for FEEDTUM database.

Gabor filter, named after Dennis Gabor, is a linear filter used for detection of edge. Orientation and frequency representations of Gabor filters are similar to those of the human ocular system, and they have been found to be specially reserve for discrimination and texture representation. In the spatial domain, Gaussian kernel function for a 2D Gabor filter which is modulated by a sinusoidal plane wave. Gabor Wavelet is essential filter, which is used to extract local features from image with applying different scale and orientation. Gabor function is defined as [8]:

$$\varphi(x, y, \omega, \theta) = \frac{1}{2\pi\sigma^2} e^{-\left(\frac{x'^2+y'^2}{2\sigma^2}\right)} e^{i\omega x'}$$

Where (x, y) represents the pixel position, ω for center accuracy of filter plane, θ shows the orientation of Gabor filter, σ is standard deviation in x and y direction and x' and y' from following equation

$$x' = x\cos\theta + x\sin\theta \; y' = -y\sin\theta + y\cos\theta$$

This Gabor function has a Gabor filter in all orientations and then it convolute with the images as shown in figure 2.

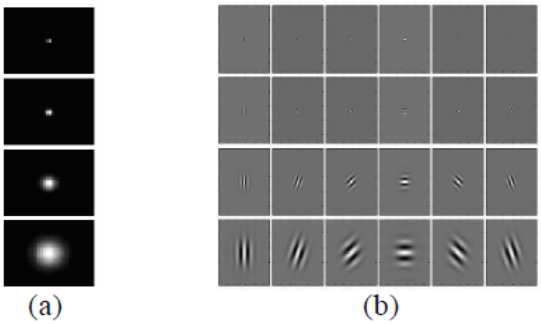

Figure 2: Gabor kernel having (a) Four scales and (b) six orientations [8]

Samad Rosdiyana et. al [5] have presented use of edge-based feature extraction with Gabor Features. Image was filter by Gabor and convolute with multiple edge detector. They were use multiple edge detector because each edge detection problem of manual selection of threshold value. The features are reduced in dimension by PCA and classify by SVM, which resulted 91.7% recognition rate for FEEDTUM database among all subject dependent recognition.

Abdulrahman et. al propose a method which is implemented using Gabor wavelet transform with PCA and LBP [8]. This hybrid approach gives 90% average recognition rate for JAFFE database.

Le Hoang Thai et. al present novel approach for Canny-edge detection, PCA and ANN (Artificial Neural Network) [7]. They detect the local region of the face such as an eyebrow, eye and mouth then reduce the dimension using PCA. ANN applied for classification on JAFFE database which have 85.7% recognition rate.

Meher et. al [4] proposes a PCA for Face Recognition and FER. For PCA classification is matters for performance. In this paper, result of recognition rate is 81.36% for CSU dataset and 85.5% for ATT dataset.

Sobia M. Carmel et. al [9] investigated FER using PCA based interface for wheel chair. In this paper, for preprocessing color space transform, skin region detection, noise removal and morphological operation apply on facial images. Then based on PCA, Eigen vectors and Eigen faces

are calculated and classify expression using Euclidean Distance. This approach resulted 96.667% recognition rate for the 60 Eigen faces for JAFFE database.

Poon Bruce et.al [10] have evaluated PCA based FER methods for distorted images. They are worked with the different database, like CMU and ORL database which is in same illuminating condition and calculate Eigen faces. In this paper, the comparison of recognition rate, which outcome with CMU database is 100% and ORL database is 90%.

Rahulamathavan Yogachandran et. al [11] developed FER with encrypted domain using LFDA (Local Fisher Discriminant Analysis). There is a challenge to work with encrypted domain even if there is not good recognition rate for unencrypted domain. This method is applied to JAFFE and MUG database which have a recognition rate respectively 94.37% and 95.24%.

Automatic FER from image sequence using LBP features are explained by Varsha Sarawagi et. al [12]. They make efforts for fully automated facial point detection for facial expression. There are good points were detected for lip, eyebrow, and both eyes. For classification SVM is used. It is an improvement over manual detection of points.

Wei-Lun Chao et. al proposes a optimize approach of expression specific local binary pattern features (Es-LBP) which is a modification of conventional LBP [13]. They were extract expression related features in training phase use SVM and k-NN as a classifier. This approach achieves better performance against state of art.

In [14], Vaibhavkumar et al has done the survey on FER using global features. In [15], authors have extended their work for recognizing facial expressions using Gabor filters. Mahesh et al have performed face recognition in low dimensional subspace using reconstructive and discriminative features in [16]. These features can be generalized for many pattern recognition applications. In [17], the authors have extended the application for the face recognition using various classification tools like correlation, artificial neural network and support vector machine using fisher discriminant analysis.

III. RESULT

The following table-1 list out the result derived from the respective techniques which are used FER. In the section, Gabor Filter, PCA, LBP, LDA with different classifiers like SVM, ANN, and fuzzy logic. There are many useful methods such as Gabor Filter and some of them are the combination of 2 or more methods for best performance provides 85+ % recognition rate in FER. Table-1 covered list of the most recent techniques use for appearance based features and their relevant information like Database, Recognition rate, Limitation and Future work in any.

TABLE I: Literature review on facial expression recognition

Sr. No	Methods / Database	Result/Conclusion	Limitation	Future Work
1.	Gabor Filter +SVM [6]	Gabor Filter outperformed then other existing techniques removes variability in lighting and other noise.	-	Selecting of best Gabor Features will reduce the space complexity of the system.
2.	Gabor Wavelet + PCA + Multi class SVM FEEDTUM database [3]	Average performance rate: 81.7%	Misclassification between Sad and Neutral expression	Implement in real time FER and testing different degrees.
3.	PCA ATT, CSU and MPI facial expression database [4]	ATT database: 85.5% CSU database: 81.3%	Classification are matters for recognition rate	-
4.	Multiple Edge detection on Gabor features+ PCA + SVM FEEDTUM database [5]	91.7% for 40 feature vectors	Work with frontal images	Further improvement of the robustness of the method and development of the real time facial expression system
5.	Gabor Wavelet + PCA + LBP JAFFE database [8]	90% average recognition rate	LBP operator is small which cannot capture dominant features	-
6.	PCA + FLDA (Fisher LDA) JAFFE, MUG database [9]	JAFFE: 94.37% MUG:95.24%	Facial images of different classes lead to poor classification	-

7.	Canny Edge detection+ PCA + ANN JAFFE database [7]	85.7%	It required the high calculating costs for the learning process	This approach uses ANN for classifying and the number of hidden nodes is identified by experience
8.	PCA+ Euclidean Distance JAFFE database [9]	96.667% for 60 Eigen faces	Specific distance for each class of expression was not calculated using Euclidean distance.	Need more work with preprocessing step for 100% recognition rate
9.	LBP for feature extraction From video frame [12]	94.7%	-	Video for some more scope for movement and video take in the real surrounding environment can be further updates for this Work.
10.	Local binary patter feature (LBP) +SVM [13]	91.9%	The necessity of the proposed unrelated features for facial expression recognition is verified to be important in facial recognition Framework	The proposed approach achieves the better performance against the state-of art Methods.

IV. Conclusions

This paper presents investigation and implementing of FER framework which improve the Performance of FER and reducing complexity. Section 2 describes the General FER module including Pre-processing, Feature Extraction and classification. From Literature reviewed papers, there are using two methods for feature extraction and different classifier for classification of expression. There is a hybrid approach of Edge detection, feature extraction and appropriate classifier used based on a database and features parameters of facial images. This hybrid approach having a good recognition rate compares to other methods of FER and performance is high due to segment the facial image into expression interested region such as an eye, eyebrows, and mouth, which have less size compared to whole image. For Feature extraction, Gabor wavelet features having an outstanding recognition rate. Therefore, we conclude that work with hybrid approach; Gabor Wavelet and facial component may increase performance of FER.

References

[1] Mehrabian A., "Communication without words", Psychology Today, Vol. 2, No. 4, 1968, pp. 53-56.

[2] Ekman, P and Friesen, W, "Facial Action Coding System: A Technique for the Measurement of Facial Movement", Consulting Psychologists Press, Palo Alto, 1978 pp. 10-11.

[3] Samad, Rosdiyana, and Hideyuki Sawada. "Extraction of the minimum number of Gabor wavelet parameters for the recognition of natural facial expressions." *Artificial Life and Robotics* 16, no. 1 (2011) Springer: pp. 21-31.

[4] Meher, Sukanya Sagarika, and Pallavi Maben. "Face recognition and facial expression identification using PCA." In *Advance Computing Conference, 2014 IEEE International*, pp. 1093-1098. IEEE, 2014.

[5] Samad, Rosdiyana, and Hideyuki Sawada. "Edge-based Facial Feature Extraction Using Gabor Wavelet and Convolution Filters." In *MVA*, pp. 430-433. 2011.

[6] Sisodia, Priya, Akhilesh Verma, and Sachin Kansal. "Human Facial Expression Recognition using Gabor Filter Bank with Minimum Number of Feature Vectors." International Journal of Applied Information Systems, Volume 5 – No. 9, July 2013 pp. 9-13.

[7] Thai, Le Hoang, Nguyen Do Thai Nguyen, and Tran Son Hai. "A facial expression classification system integrating canny, principal component analysis and artificial neural network." *arXiv preprint arXiv: 1111.4052* (2011).

[8] Abdulrahman, Muzammil, Tajuddeen R. Gwadabe, Fahad J. Abdu, and Alaa Eleyan. "Gabor wavelet transform based facial expression recognition using PCA and LBP." In *Signal Processing and Communications Applications Conference, 2014 22nd*, pp. 2265-2268. IEEE, 2014.

[9] Sobia, M. Carmel, V. Brindha, and A. Abudhahir. "Facial expression recognition using PCA based

interface for wheelchair." In *Electronics and Communication Systems, 2014 International Conference on*, pp. 1-6. IEEE, 2014.

[10] Poon Bruce, M. Ashraful Amin, and Hong Yan. "Performance evaluation and comparison of PCA based human face recognition methods for distorted images." *International Journal of Machine Learning and Cybernetics* 2, no. 4 (2011): 245-259.

[11] Rahulamathavan, Yogachandran, RC-W. Phan, Jonathon A. Chambers, and David J. Parish. "Facial expression recognition in the encrypted domain based on local fisher discriminant analysis." *Affective Computing, IEEE Transactions on* 4, no. 1 (2013): 83-92.

[12] Sarawagi, Varsha, and K. V. Arya. "Automatic facial expression recognition for image sequences." In *Contemporary Computing, 2013 Sixth International Conference on*, pp. 278-282. IEEE, 2013.

[13] Chao, Wei-Lun, Jun-Zuo Liu, Jian-Jiun Ding, and PO-Hung Wu. "Facial expression recognition using expression-specific local binary patterns and layer denoising mechanism." In Information, Communications and Signal Processing, 2013 9th International Conference on, pp. 1-5. IEEE, 2013.

[14] Vaibhavkumar J. Mistry, Mahesh M. Goyani, "A literature survey on Facial Expression Recognition using Global Features", International Journal of Engineering and Advanced Technology, Volume-2, Issue 4, pp. 653-657, , April 2013

[15] Vaibhavkumar J. Mistry, Mahesh M. Goyani, "Facial Expression Recognition using Gabor Filter by minimizing Feature Vector", International Journal of Computer Science and Management Research, Vol 2, Issue 5, pp. 2571-2575, , May 2013

[16] Mahesh Goyani, Gunvantsinh Gohil, Amit Chaudhari, "Robust Face Recognition in Low Dimensional Subspace Using Reconstructive and Discriminative Features", International Conference on Communication Systems and Network Technologies, IEEE Xplore, Pp. 355-359, Katra, Jammu, 03-05 May, 2011

[17] Mahesh Goyani, Akash Dhorajiya, Ronak Paun, "Performance Analysis of FDA Based Face Recognition Using Correlation, ANN and SVM", International Journal of Artificial Intelligence and Neural Networks, pp. 108-111, 2011