A literature survey on Facial Expression Recognition using Global Features

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Abstract— Facial Expression Recognition (FER) is a rapidly growing and ever green research field in the area of Computer Vision, Artificial Intelligent and Automation. There are many application which uses Facial Expression to evaluate human nature, feelings, judgment, opinion. Recognizing Human Facial Expression is not a simple task because of some circumstances due to illumination, facial occlusions, face color/shape etc. In these paper, we present some method/techniques such as Principal Component Analysis (PCA), Linear Discriminate Analysis (LDA), Gabor Filter/Energy, Line Edge Mapping (LEM), Neural Network, Independent Component Analysis (ICA) which will directly or/and indirectly used to recognize human expression in various condition.

Index Terms— Facial Expression, Expression Recognition, Gabor Filter, Gabor Energy, Principal Component Analysis, Neural Network, Eigenface.

I. INTRODUCTION

Highlight In the domain of Digital Image Processing, The Human Facial Expression Recognition is one the most active research area in the field of Human Computer Interaction (HCI), Smart Environments, Medical applications, Artificial intelligent based robotics and automated access control. Recognising facial expression is a complex task to complete and therefore several limitations are exists such as lightning condition, Age, similar expression type.

Ekman and Friesen [1] represent 6 basic face expressions (emotions), show in figure 1, which are Happy, Surprise, Disgust, Sad, Angry, Fear.

As per Meharabian [2], 55% communicative cues can be judge by facial expression; hence recognition of facial expressions became a major modality. For example, Smart Devices like computer/robots can sense/understand the human's intension from their expression then it will helpful to the system to assist them by giving suggestions or proposals as per their needs.

Automatic facial expression and facial AU (Action Unit) recognition have attracted much attention in the recent years due to its potential applications. In this paper, we introduced global feature techniques which are widely used to detect as well as identify the human facial expression from a digital images form given dataset if any.

Face Expression approach (As per Anastasios *et al.* [4]) can be divided into three major steps so that the face in an image is known for further processing, facial feature extraction which is the method used to represent the facial expressions and finally classification which is the step that classifies the features extracted in the appropriate expressions.

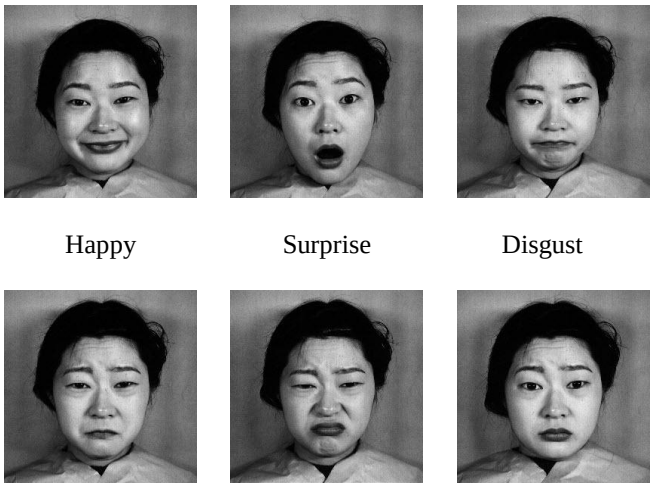

Figure 1: Six Basic Human Expressions [3].

In this paper, we focus on various feature methods for recognizing human facial expression. A number of approaches have been developed for extracting features from face images are Principal Component Analysis (PCA), Linear Discriminate Analysis (LDA), Gabor Filter/Energy, Line Edge Mapping (LEM), Neural Network and Independent Component Analysis (ICA), Local Binary Pattern (LBP), Support Vector Machine, Active Appearance Model (AAM) and using SIFT descriptor [5-10].

II. TECHNIQUES AND METHODS

Facial Expression recognition can be categorized in to two major approaches. 1) Appearance based and 2) Model based recognition techniques [11] [12] [13] [14].

Jyh-Yeong *et al.* proposes automated facial expression recognition system using neural network classifiers. In this paper [15], they use Rough Contour Estimation Routine (RCER) to get feature of eyebrows, eyes, mouth with the help of Point Contour Detection Method (PCDM) [16] to improve the precision of eye and mouth. They used Action Units (AU) [17] which describes the basic movements of face muscles. Using AU to recognize Facial Expression, they defined 30 facial characteristic points for eye, mouth and eyebrow. For that, they use 80 face images with 128 x 128 pixel resolution and identical environments in terms of illumination, distance and background. After applying the approach, they obtained 92.1% recognition rate.

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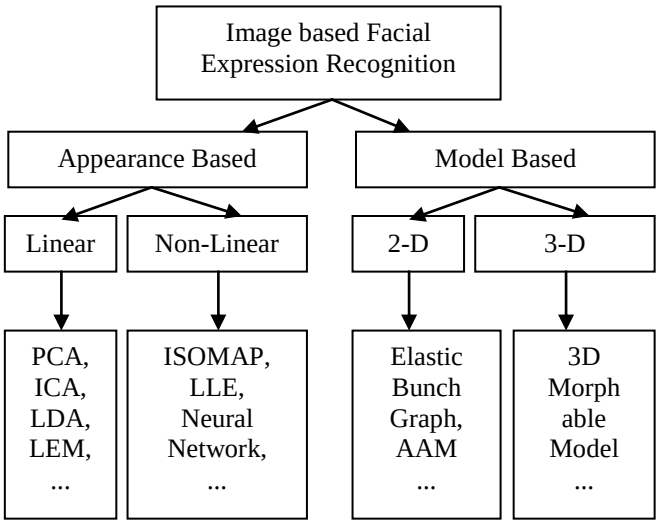

Figure 2: Category of Facial expression recognition.

Manal Abdullah *et al.* proposes optimize approach for Face Recognition using PCA (Principal Component Analysis) from digital face image. In this paper [18], they decompose image into small sets of features images or eigen face. First of all they create training dataset to compare result. Once inputted face image is pre-processed and compare with training dataset which are already computed. Highest matching can be achieved by multiple face images but it needs high computation time. They uses FACE94 database and obtained 35% less time over original PCA. They also got 100% recognition rate with this improved method.

Murthy *et al.* [19] presented a method for facial expression recognition using eigenfaces in which PCA is used to extract features from input image and test out with training dataset but based on the idea, they divided the training set into six basic classes according to universal expression shown in figure 1. They uses CK (Cohn-Kanade) [20] and JAFFE (Japanese Female Facial Expression) [21] database.

In image processing, a Gabor filter, named after Dennis Gabor, is a linear filter used for edge detection. Frequency and orientation representations of Gabor filters are similar to those of the human visual system, and they have been found to be particularly appropriate for texture representation and discrimination. In the spatial domain, a 2D Gabor filter is a Gaussian kernel function modulated by a sinusoidal plane wave. The Gabor filters are self-similar: all filters can be generated from one mother wavelet by dilation and rotation.

$$g(x,y;\lambda,\theta,\psi,\sigma,\gamma) = \exp\left(-\frac{x'^2+\gamma^2y'^2}{2\sigma^2}\right)\exp\left(i\left(2\pi\frac{x'}{\lambda}+\psi\right)\right)$$

Equation 1: Complex part of 2-D Gabor Filter

$$g(x,y;\lambda,\theta,\psi,\sigma,\gamma) = \exp\left(-\frac{x'^2+\gamma^2y'^2}{2\sigma^2}\right)\cos\left(2\pi\frac{x'}{\lambda}+\psi\right)$$

Equation 2: Real part of 2-D Gabor Filter

$$g(x,y;\lambda,\theta,\psi,\sigma,\gamma) = \exp\left(-\frac{x'^2+\gamma^2y'^2}{2\sigma^2}\right)\sin\left(2\pi\frac{x'}{\lambda}+\psi\right)$$

Equation 3: Imaginary part of 2-D Gabor Filter

Where,

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

In this equation, λ represents the wavelength of the sinusoidal factor, θ represents the orientation of the normal to the parallel stripes of a Gabor function, φ is the phase offset, σ is the sigma of the Gaussian envelope and γ is the spatial aspect ratio, and specifies the ellipticity of the support of the Gabor function.

The Gabor function for the specific values of the parameters "wavelength", "orientation", "phase offset", "aspect ratio", and "bandwidth" will be calculated and displayed as below image with different size, length and orientation. (Light and dark gray colours correspond to positive and negative function values, respectively.)

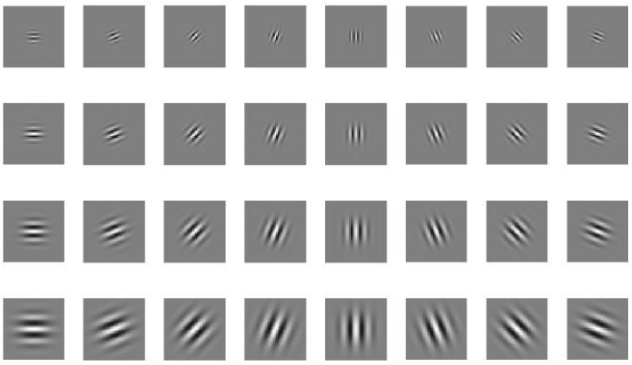

Figure 3: Gabor Filter with various size, length and orientation.

Gabor filters (Michal et al. 2005) are efficient in reducing image redundancy and robust to noise. Such filters can be either convolved with the whole image or applied to a limited range of positions. In such a case, a region around a pixel is described by the responses of a set of Gabor filters of different frequencies and orientations, all centered at that pixel position [22].

Hong-Bo et al. proposes a facial expression recognition system based on Gabor feature using a novel local Gabor filter bank. In this paper [23], they present a methodology for the classification of human emotions which is based on Gabor coefficients of the fiducial points. Experiment Results shows that average recognition rate on JAFFE dataset is 97.33%.

Face recognition and expression classification from video image sequences are explained by Praseeda Lekshmi V *et al.* [24] in which Frames were extracted from image sequences. Skin color detection method is applied to detect face regions. The whole face was considered for the construction of Eigen space. After the face recognition phase, their system could efficiently identify the expression from the face. The combined ratio of expression recognition from extracted faces and frames is 88%.

Jacob *et al.* [25] investigated two computer vision techniques designed to increase both the recognition accuracy and computational efficiency of automatic facial expression recognition. In particular, they compared a local segmentation of the face around the mouth, eyes, and brows to a global segmentation of the whole face. Their results indicated that, surprisingly, classifying features from the whole face yields greater accuracy despite the additional noise that the global data may contain. They attribute this in part to correlation effects within the Cohn-Kanade database. They also developed a system for detecting FACS action units based on Haar features and the Adaboost boosting algorithm. This method achieves equally high recognition accuracy for certain AUs but operates two orders of magnitude more quickly than the Gabor+SVM approach. Finally, they developed a software prototype of a real-time,

automatic signed language recognition system using FACS as an intermediary framework.

Peng Yang *et al.* [26] present a novel approach of facial action units (AU) and expression recognition based on coded dynamical features. In order to capture the dynamical characteristics of facial events; we design the dynamical HAAR-like features to represent the temporal variations of facial events. Inspired by the binary pattern coding, we further encode the dynamic HAAR-like features into binary pattern features, which are useful to construct weak classifiers for boosting learning. Finally the Adaboost is performed to learn a set of discriminating coded dynamic features for facial active units and expression recognition. Experiments on the CMU expression database and our own facial AU database show its encouraging performance.

Neeta *et al.* proposes a method which is implemented using 2D appearance-based local approach [27] for the extraction of intransient facial features and recognition of four facial expressions. The algorithm implements Radial Symmetry Transform and further uses edge projection analysis for feature extraction and creates a dynamic spatiotemporal representation of the face, followed by classification into one of the expression classes. The algorithm achieves an accuracy of 81.0% for facial expression recognition from grayscale image.

Anitha *et al.* discussed in the paper [28] about the various Facial expression databases are available with different variations like illumination, expression, size, shape, color, and texture. They describe the following dataset list as show in table 1:

Frank *et al.* [29] compare performance ration on JAFFE database of facial expression recognition. They investigate different feature representation and classification schemes to recognize 6+1 expressions (happy, angry, disgust, sad, fear, surprise and neutral). They obtained 95.71% recognition rate using 2D-LDA (Linear Discriminant Analysis) and SVM (Support Vector Machine) and it will take 0.0357 second to process one image of size 256 × 256.

Wai Kin *et al.* [30] consider 2-D gabor filter to obtain palm print and texture feature extraction for authentication. They describe five modules to get satisfactory results which are Palmprint Acquisition, Preprocessing, Textured Feature Extraction, Matching, and at last Database is used to store template.

III. RESULT

The following table-2 list out the result derived from the respective techniques which are used for facial expression recognition. In the section, there are many useful methods such as Neural Network, Independent Component Analysis (ICA), PCA, Gabor Filter Energy and some of them are the combination of 2 or more method for better performance provides 85+ % recognition rate in Face Recognition as well as Facial Expression Recognition. Table-2 covered list of most recent techniques and their relevant information like Dataset, Accuracy, Conclusion and Future work in any.

Sr. No	Method/ Technique(s)/ (Database)	Result/Accuracy	Conclusion	Future work
1	Neural Network + Rough Contour Estimation Routine (RCER) [15] (Own Database)	92.1% recognition Rate	In this paper, they describe radial basis function network (RBFN) and a multilayer perception (MLP) network.	-
2	Principal Component Analysis [18] (FACE94)	35% less computation time and 100% recognition	Useful where larger database and less computational time	They want to repeat their experiment on larger and different databases.
3	PCA + Eigenfaces [19] (CK, JAFFE)	83% Surprise in CK, 83% Happiness in JAFFE, Fear was the most confused expression	Compared with the facial expression recognition method based on the video sequence, the one based on the static image is more difficult due to the lack of temporal information.	Future work is to develop a facial expression recognition system, which combines body gestures of the user with user facial expressions.
4	2D Gabor filter [22] (Random Images)	12 Gabor Filter bank used to locate edge	Multichannel Gabor filtration scheme used for the detection of salient points and the extraction of texture features for image retrieval applications.	They work on adding global and local colour histograms and parameters connected with the shapes of objects within images.
5	Local Gabor Filter + PCA + LDA [23] (JAFFE)	Obtained 97.33% recognition rate with the help of PCA+LDA features	They conclude that PCA+LDA features partially eliminate sensitivity of illumination.	-
6	PCA + AAM [24] (Image sequences from FG-NET consortium)	The performance ratios are 100 % for expression recognition from extracted faces,	The computational time and complexity was also very small. Improve the efficiency	Extend the work to identify the face and it's expressions from 3D images.

		88% for expression recognition from frames and 88 % for the combined recognition.		
7	Gabor + SVM approach HAAR + Adaboost [25] (Cohn-Kanade database)	99.54% for Mouth AU in G+S and 82.81% with H+A.	The Haar+Adaboost method achieved comparable accuracy to the Gabor+SVM method for AUs of the eye and brow regions, but it performed very poorly for AUs of the mouth.	They are going to establish a large, publicly available AU database with singly-occurring AUs to facilitate future research.
8	Dynamic HAAR-like features [26] (CMU expression Database + Own Database)	Experiments on the CMU facial expression database and our own facial AU database showed that the proposed method has a promising performance.	They extracted dynamical HAAR-like features to capture the temporal information of facial AUs and expressions, and then further coded them into binary pattern features.	This method can be extended to video based face recognition.
9	2D appearance-based local approach + Radial Symmetry Transform [27] (JAFFE)	83% for expressions of happy and surprise and an accuracy of about 78% for expressions of anger and sad.	In the face, they use the eyebrow and mouth corners as main 'anchor' points. The system, based on a local approach, is able to detect partial occlusions.	-
10	2D-LDA and SVM [29] (JAFFE)	The recognition rate of this method is 95.71% by using leave-one-out strategy and 94.13% by using cross-validation strategy.	They investigate various feature representation and expression classification schemes to recognize seven different facial expressions on the JAFFE database. Experimental results show that the proposed system using DWT, 2D-LDA and linear one-again-one SVMs outperforms others.	-
11	2-D Gabor Filter [30] (Palm print database)	24 verification tests are carried out for testing the 12 sets of parameters on the two databases and their results in table 1 [30].	They proposed Gabor Filter to extract features in different angle, size and phase offset.	-

IV. CONCLUSIONS

In this paper, By observing various techniques such as PCA, LDA, Gabor Filter, Local Binary pattern, LEM, Neural Network, ICA, and SVM with the help of appropriate Datasets [Table 1] to detect Human Facial expression and recognize them on the basis of accuracy and computational time. But some of them contain drawbacks in term of recognition rate or timing. The most accurate recognition rate can be achieved though combination of two or more technique, extract features as per our requirements and final comparison will be performed to evaluate the results. The success of methods depends on pre-processing on the images because of illumination and feature extraction.

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