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A REVIEW ON AUTOMATIC FACIAL EXPRESSION RECOGNITION SYSTEMS

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ABSTRACT

The automatic facial expression recognition (FER) system is an important concept in human computer interface (HCI), as human face is a part that gives information about the state of user's behavior through various expressions. This study of recognizing facial expression is one of the challenging research areas in image analysis and computer vision. Since last 2 decades many researchers are working to make HCI machines to operate with more reliability and efficiency even in the worst conditions. In this paper, we studied different FER methods such as face detection, feature extraction and expression classification where techniques like Knowledge-based, Feature-based, Principal Component Analysis (PCA), Independent Component Analysis (ICA), Gabor filters, Local Binary Patterns (LBP) with a range of classifiers like a SVM, Adaboost, HMM etc are been compared.

KEYWORDS: Facial expression recognition (FER) system, Facial expression, Face detection, Feature extraction, Expression classification.

INTRODUCTION

Fundamental mode of communicating human emotions is FACIAL expressions. Facial expression, body language, paralinguistic features of speech, , physiological signals (e.g. Electromyogram (EMG), Electrocardiogram (ECG), Electrooculogram (EOG), Electroencephalography (EEG), Functional Magnetic Resonance Imaging (FMRI), etc.) are few examples of Signals which can be used for recognition. The detection of six basic emotions like happiness, sadness, anger, fear, disgust and surprise is the base of the research on facial expression analysis. Since last few decades, a number of facial expression recognition techniques have been proposed. For effective expression analysis, dependencies are based upon the accurate representation of facial features. Using this feature we have several applications in the field of human-computer interaction (HCI), like social signal processing, social robots, deceit detection, interactive video and behavior monitoring.

Automatic FER systems consist of three major steps:- Face detection, Feature extraction and Facial expression classification. Firstly in any FER system face detection is carried out for detecting features like eyes, eyebrows, nose and mouth. Secondly feature extraction is done. There are several methods used for feature extraction purpose; but most of the existing algorithms are based on geometric and appearance based features. In geometric-based method the shape and size of the face and facial components is been tracked like eyes, eyebrows, nose, mouth (lip corners) etc., and classify the expressions based on relative location of these facial features. Some researcher categories the facial expression using shape models. In many practical situations, it is difficult to achieve tracking of facial landmarks, and for that these methods usually require very accurate and reliable detection. The distance between facial landmarks is different in different person, thereby making the person independent expression recognition system less reliable. To overcome this appearance-based method can be applied which involves a number of filters such as Gabor, Wavelets, Local Binary Pattern (LBP) etc. They are applied to either whole face or at the précised part of it to encode the texture. Principal component analysis (PCA), independent component analysis (ICA), linear discriminant analysis (LDA) etc. are certain dimensionality reduction methods which are used in appearance based as in this high dimensional vectors are generated which further has to be represented in lower dimensional subspace.

Lastly expression classification is performed in the learned subspace. Many researchers state that accurate extraction of facial features can be achieved by dividing the face into several components. But this approach fails with inappropriate face alignment and occlusions. Based on training data, features from certain face regions, mostly determine the facial regions that contribute more towards expression discrimination. And the positions and sizes of the facial patches are differing in this kind of approaches, making it difficult to conceive a generic system.

BRIEF OVERVIEW OF EXISTING TECHNIQUES FOR AUTOMATIC FER SYSTEMS
This section explains step by step various tasks and techniques related with them like face detection, feature extraction and classification of expression for automatic FER systems.

A. Face Detection
The first step involves detection of face in the given image or video sequence. This is termed as face detection or localization in which face and facial components are been located within the given image. Hence, this section covers the different face detection algorithms that have been used by various FER researchers in past few years.

1. Knowledge Based
In Y. Buhee's [1] proposed work knowledge on human face (ex. skin color and shape) is directly set to the window size and color signature for computing color distance.

2. Feature Based
Feature based methods are nothing but geometric methods or local feature methods. In this facial expressions are recognized using a set of facial features like eyes, eyebrows and lips. These geometric based features are again classified into three categories namely-

i.   Model-based Method
ii.   Contour-based Method
iii.   Optical-flow based Method

i. Model-Based Method
In this method facial features are described using different associated models. As eyes, mouth and eyebrows are the most main facial features its detection differs from one another. Pantic and Rothkrantz [2] proposed an integrated system for FER which defines a geometric face model. The goal is to increase the face model quality.

ii. Contour-Based Method
It gives good approximation about the salient facial features shape. Hammal [3] used parametric deformable models to automatically extract the contours of each facial feature and then build a skeleton of facial expression.

iii. Optical-flow Based Method
It detects facial movements using motion temporal video information. Most of these methods have used optical flow analysis to recognize facial expressions. Yacoob and Davis [4] represented face movements using optical flow techniques in order to identify the 6 universal facial expressions. Their approach is based on tracking face regions and computing optical flow of points whose intensity gradient is high.

3. Template Matching
In C. Shan's proposed work [5] statistical local features represent face, local binary patterns (LBP) are used for person independent expression recognition in which texture analysis is carried out using SVM.

4. Appearance Based
Author [6] applied eigenface based algorithm to various images taken under different lighting conditions and backgrounds, where the size of an image is 180*200 and required durations is 4.5456 sec.

B. Feature Extraction
This method is used for facial recognition purpose. Pixel data is converted into high-level representation like shape,

color, texture and special configuration of the face or its features. This extracted image is used for following expression classification. Feature extraction generally reduces the dimensionality of the input space, which is also an important task in pattern recognition system.

Facial Feature Extraction using-

1. Principal Component Analysis (PCA)

It is one of the popular methods for facial expression recognition [9], also known as Eigen face approach. Its main objective is to lower the dimensionality for effective face indexing and recovery. By using linear projection as shown in the figure below it maximizes the projected sample scattering [8].
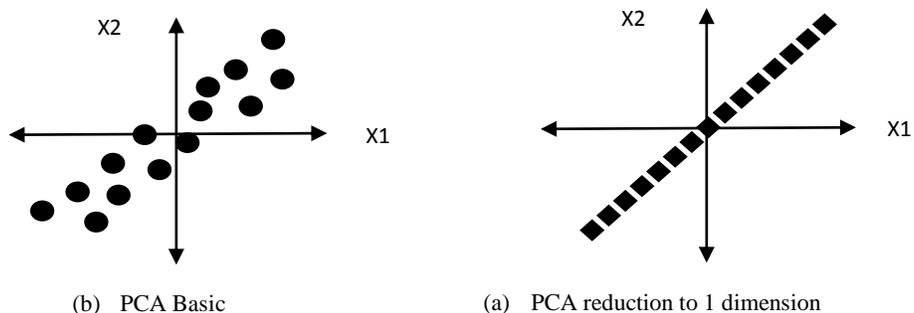

(b) PCA Basic   (a) PCA reduction to 1 dimension

Fig.1.The concept of PCA

2. Independent Component Analysis (ICA)

In order to improve performance additional discriminant analysis is required. ICA presents more powerful data representation than PCA as its goal is to provide an independent representation; hence ICA is also known as the simplified version of PCA [8] because according to the author PCA extracts only the most expressive features those are not related to actual face detection.

3. Linear Discriminant Analysis (LDA)

Chen et. al. [10] has proposed very efficiently and accurately a stable method to calculate the discriminant vectors based on LDA where a two phase procedure is applied. In the first step the identical regions of a face image are grouped as similar partition based on geometric characteristics, later the mean gray value is used for pixel within the partition region and thus the face image is reduced as feature vectors. And in the second step the discriminant projection axes based on the proposed LDA are determined using the feature vectors. The vectors are clustered using K-means clustering method with each changed samples.

4. Gabor Filter

In image processing these filters are also known as linear filters which are used for edge detection purpose. In Z. Zhang's work [11] the facial images are preprocessed and then the evaluation is done separately with different Gabor filters where these filters are used to separate different expression. The classifier assumes the discriminate function to be a linear function of the feature data. In this case the data is the feature vector obtained. Its advantage is reduction in dimension of feature space and computation complexity.

5. Local Binary Pattern (LBP)

It is used to label the pixels of an image. In this process the similar neighborhood pixels of an image were summed which results into a binary image. It is very efficient and yet simple texture operator. The simplest implementation

of thresholding is to choose an intensity value as a threshold level and the values below this threshold become 0 (black) and the values above this threshold become 1 (white).

Let, Th be the global threshold of image f(x, y) while g(x, y) be the threshold image, then:

$$g(x,y) = \begin{cases} 1, & f(x,y) \geq Th \\ 0, & Otherwise \end{cases} \qquad (1)$$

The basic LBP is the summing the threshold differences weighted by two's power. The operator P and R of the LBP is defined as-

$$LBP_{P,R} = \sum_{P=0}^{P-1} S(g_p - g_c)2^p \qquad (2)$$

Where,

g_c = gray intensity value of the central pixel,

g_p = intensity value of the neighbor pixel,

P = the total number of neighbors

R = radius of the neighborhood.

In [12] the authors have proposed a new FER system, which uses the active shape mode (ASM) algorithm to align the faces, then extracts local binary patterns (LBP) features and use SVM classifier to detect the facial emotion.

C. Expression Classification

1. Hidden Markov Model (HMM) as Classifier

The hidden markov model is a probability and statistical based model which can be used in pattern recognition techniques. In speech recognition applications the probabilistic modeling of non-stationary vector time series based HMM has been proved to be very successful. Faces were impulsively divided into regions such as the eyes, nose, mouth, jaw etc., which can be associated with the states of HMM. The images should be altered into either 1D temporal series as HMMs need a 1D observation series and images are two-dimensional.

2. Adaboost Classifier

According to the author C. S. Fahn [13] the frontal face in an image sequence is classified into seven classes like neutral, joy, sad, surprise, anger, fear, disgust. Here the recognition system is done without characteristic blocks. In this paper skin color detection techniques are used for face detection that is YCbCr, HSI, and RGB is applied for the images. Then the skin color region is distinguished from non skin color region by means of lower and upper bound threshold. Later the facial feature detections is done (using color space transformation), followed by face region verification (face segmentation) and pupil detection by considering the height and width of the face. Thus the landmarks regions like eyes, eyebrows, mouth of the facial features are extracted and finally the facial expressions is distinguished by the displacement of land mark features in the face by the algorithm proposed by the author using Adaboost based classifier.

3. Support Vector Machine (SVM)

According to Bartlett [14] to locate the frontal face region every video frame is scanned in real-time and then it is scaled into image patches of same size by using the linear filters. The filtered image is given as an input to recognition classifier which codes expression into different dimensions. The facial features are chosen from the Gabor filters using Adaboost which is again trained with SVM. The author developed end to-end system that provides different facial expression codes at 24 frames per second and animates a computer generated characteristics.

Table 1. **A Review of Previous Research Papers on FER Systems**

Sr. No.	Name Of Author/ Paper/Approach.	Method	Advantages	Disadvantages	Performance
GEOMETRIC APPROACH					
1.	M. Pantic and L. J. M. Rothkrantz, [2]	Geometric approach model based method.	Frontal and profile combination increases the face model quality.	Complexity is high as model has to be fitted on the face due to interpersonal different facial expression.	Author proposed an Integrated system for facial expression recognition which defines a geometric face model using 19 points to represent the face in frontal view and 10 points to describe the face in profile view.
2.	Z. Hammal, et al. [3]	Geometric approach contour based model.	Gives good approximation of salient facial feature shape.	Significant confusion errors arose between different facial expression classes.	Author used parametric deformable models to automatically extract the contours of each facial feature and then built a skeleton of facial expression.
3.	M. J. Black and Y. Yacoob, [4]	Geometric approach optical flow based method.	Facial expressions are detected from motion temporal video information.	This method does not discriminate between the optical flow caused by facial features movement and those produced	Author presented new approach on parameterized model and local optical flow technique. Rigid head movements were analyzed using an approximate planar face. Then a refined model curves was used

			by noise.	to model feature movements (eyes, eyebrows and mouth).
		GLOBAL APPROACH		
4.	M. Phillip and R. Kaliouby [15]	Global approach (uses filters like Gabor wavelets).	Simple yield important recognition rate.	The main drawback is their sensitivity to image illumination variation which affects face appearance.	These methods rely on a training phase where in different artificial techniques such as neural networks, SVM's etc are being used.
		APPEARANCE APPROACH		
5.	L. Sirovich and M. Kirby [9]	Principal Component Analysis (PCA).	Reduces the dimensionality for effective face indexing and retrieval.	The only single factor can be varied.	PCA is also known as the eigenface approach are one of the popular methods for FER systems. In this feature extraction is done based on 1D vector.
6.	P. N. Belhumeur, J. P. Hespanha and D. J. Kriegman [8]	Fishers linear discriminant (FLD)	The recognition rate is higher than PCA.	Global feature vectors are generated.	FLD reduces the scattering of projected sample since it is a class specific method. The Error rate is reduced when compared to PCA.
7.	B. A. Draper, K. Baek, M. S. Bartlett and J. R. Beveridge [16]	Independent Component Analysis (ICA)	The recognition rate is improved as compared to PCA and FLD	Computationally expensive than PCA.	Independent component analysis (ICA) generates statistically independent basis vector.
8.	T. Barbu [17]	2D Gabor Filter Bank.	Higher recognition rate then PCA,	Low and high frequency component	One of the most important feature extraction techniques in

			LDA, 2DPCA, Global eigen approach.	attenuation.	FER systems.
9.	S. Moore and R. Bowden, [18]	Local Gabor Binary Pattern.	Better recognition rate than Gabor filter bank. Its important advantage is its illumination tolerance.	The color information is not included.	Appearance based features encodes specific details about human faces so are used for face recognition purpose. In this facial image is divided into sub blocks and similarities between sub-blocks are obtained.
10.	SL Happy and A. Routray[19]	LBP using SVM.	Less execution time. Provide solution for different resolution.	Not useful for motion pictures.	In this author used appearance features of selected facial patches.

CONCLUSION

The study of various techniques and methods for automatic facial expression recognition system revals that the techniques are categorized in two main approaches i.e. feature and global. Where feature approach is again distributed in three different methods i.e. model-based, contour-based and optical flow based method. The model-based method's main limitation is complexity to fit the model on face due to interpersonal different facial expressions. The contour-based methods gives good approximation of the salient facial features shape and it has been observed that significant confusion errors arose between different facial expression classes. The optical flow based method detect facial movements using motion-temporal video information, but this method do not discriminate between the optical flow caused by facial features movement and those produce by noise. The global approach depends on training phase in which it include different artificial techniques like neural networks and support vector machine (SVM). These methods are simple and yield important recognition rates, and their main drawback is their sensitivity to image illumination variation which affects face appearance. Besides all this there is another method which is widely used nowadays is appearance based method it includes PCA, LDA, ICA, Gabor, wavelets and LBP etc. The study of techniques conclude that LBP features are derived very fast in a single scan through the raw input image and it still maintains discriminative facial information in a solid representation. LBP features are robust to the noise and fast and simple calcutation with more aacurate result.

REFERENCES

[1] Y. Buhee and Sukhanlee, "Robust Face Detection Based on Knowledge-Directed   Specification of Bottom-Up Saliency", ETRI Journal, Volume 33, No.4, August 2011

[2] M. Pantic and L.J.M. Rothkrantz, "Expert System for Automatic Analysis of Facial Expression", Image and Vision Computing J., vol. 18, no. 11, pp. 881-905, 2000.

[3] Z. Hammal, "Segmentation des traits du visage, analyse et. reconnaissance d'expressions faciales par le Modèle de Croyance Transférable", PhD Thesis in Cognitive Science, University of Joseph Fourier, 2006.

[4] Y. Yacoob and L. S. Davis, "Recognizing human facial expressions from long image sequences using optical flow",IEEE Trans. Pattern Analysis and Machine Intelligence, vol. 18, pp. 636–642, 1996.

[5] C. Shan, S. Gong and P. W. Mcowan, "Facial expression recognition based on Local Binary Patterns: A comprehensive Study", Image and Vision Computing 27, 803-816, 2009.

[6] Y. Tayal, P. Pandey and D. B. V. Singh, "Face Recognition using Eigenface", International Journal of Emerging Technologies in Computational and Applied Sciences (IJETCAS) 3 (1), pp. 50-55, Dec.12-Feb.2013.

[7] M. Turk and A. Pentland, "Face recognition using eigenfaces", Proceeding of IEEE Conference on Computer Vision and Pattern Recognition, Maui, HI, USA, pp. 586–591, June 1991.

[8] P. N. Belhumeur, J. P. Hespanha, and D. J. Kriegman, "Eigenfaces vs. Fisherfaces: recognition using class specific linear projection", IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 19, no. 7, pp. 711–720, Jul. 1997.

[9] L. Sirovich and M. Kirby, "Low Dimensional Procedure for Characterization of Human Faces", J. Optical Soc. Am., vol. 4, pp. 519-524, 1987.

[10] L. F. Chen, H. Y. M. Liao, M. T. Ko, J. C. Lin and G. J. Yu, "A new LDA-based face recognition system which can solve the small sample size problem", Pattern Recognition 33, 1713-1726, 2000.

[11] Z. Zhang, X. Mu and L. Gao, "Recognizing Facial Expressions Based on Gabor Filter Selection", 4th International Congress on Image and Signal Processing, 2011.

[12] X. Wang, X. Liu, L. Lu and Z. Shen, "A New Facial Expression Recognition Method Based on Geometric Alignment and LBP Features", 2014 IEEE 17th International Conference on Computational Science and Engineering (CSE), pp. 1734-1737, 19-21 Dec. 2014.

[13] C. S. Fahn, M. H. Wu and C. Y. Kao, "Real-time Facial Expression Recognition in Image Sequences using an Adaboost based Multi-classifier", Proceedings of 2009 APSIPA Annual Summit and Conference, Sopporo, Japan, October-2009

[14] G. Littlewort and M. S. Bartlett, "Dynamics of facial expression extracted automatically from video", Image and Vision Computing 24, 615-625, 2006

[15] M. Philipp and R. Kaliouby, "Real Time Facial Expression Recognition in Video using Support Vector Machines", ICMI'03, 2003.

[16] B. A. Draper, K. Baek, M. S. Bartlett and J. R. Beveridge, "Recognizing Faces with PCA and ICA", Computer Vision and Image Understanding: special issue on face recognition, in press.

[17] T. Barbu, "Gabor filter-based face recognition technique", Proceedings of the Romanian Academy, vol.11, no. 3, pp. 277 – 283, 2010. S. Moore and R. Bowden, "Local binary patterns for multi-view facial expression recognition", Comput. Vis. Image Understand., vol. 115, no. 4, pp. 541–558, 2011.

[18] S. Moore and R. Bowden, "Local binary patterns for multi-view facial expression recognition", Comput. Vis. Image Understand., vol. 115, no. 4, pp. 541–558, 2011.

[19] S. L. Happy and A. Routray, "Automatic facial expression recognition using features of salient facial patches", IEEE transaction on affective computing, vol.6, no.1, January-march 2015.

[20] G. Hemalatha and C. P. Sumathi, "A Study of Technique for Facial Detection and Expression Classification", IJCSES, vol.5, no.2, April 2014.

[21] A. K. Tiwari and S. Lade, "An Exploratory Review of Face Recognition Techniques and Algorithms", IJCSIT, vol.5 (6), 8041-8045, 2014.