Facial Expression Recognition

Mamta Santosh[1]
M.M. College of Engineering
MMU, Mullana
mloura112@gmail.com

Ashok Kumar[2]
M.M. College of Engineering
MMU, Mullana

ABSTRACT

Facial Expression Recognition has been active research topic in recent years. Several techniques have been proposed for face detection, feature extraction and emotion classification. This paper presents a view of the effective methods proposed in recent years, brief introduction of the system, the applications of automatic face expression recognition system, the databases that have been used for the purpose.

.

General Terms
Classification, Expression Recognition, Databases

Keywords
Facial Expression Recognition, Emotion Recognition

1. INTRODUCTION

Emotions play an important role in human life. The era of human emotions is complex. An emotion is not just about facial expression; it is more about situation and feeling but human being have common way of expressing these emotions. Human face reflects these emotions by facial expressions. Humans are capable of producing several kinds of facial actions during communication. These actions can vary in intensity, meaning and the emotion behind it.

Facial expressions have higher impact than voice intonation or spoken words during communication. Facial expression recognition involves artificial intelligence, image processing, pattern recognition, machine Vision, computer graphics, artificial intelligence and other disciplines, has become a hot research area in Human-Machine Interaction (HMI). Facial Expression System will help robots and machine to have real time communication with humans. And even more, it has a broad application prospect, such as safe driving, intelligent monitoring, intelligent detector, medical monitoring, abnormal behavior detection based on expression recognition etc.

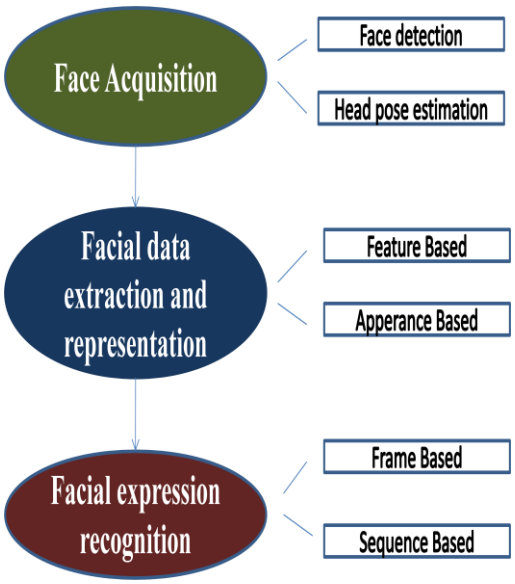
Expressions play a major role in communication. According to Mehrabian the verbal part of human communication contributes 7%, the vocal part contributes 38% and expression contributes 55% to the communication, means expression plays a major role [23]. These expressions have been categorized by Ekman into six basic emotions [21] - anger, fear, disgust, joy, surprise, sadness. In many disciplines emotion detection has been an active topic: human computer interaction, human robot interaction, human support system, clinical psychology, pain assessment, and lie detection [18].

Fig 1: Examples of facial expressions [In the top row(L to R): Disgust, Happy, Surprise, Fear (CK+ Database). In bottom row (L to R): Angry, Contempt, Sadness, Neutral (CK+ Database)

The general approach to Facial Expression Analysis (FEA) consists of three steps:

- Face Acquisition
- Facial Data Extraction and Representation
- Facial Expression Recognition

Fig 2: The general approach to Facial Expression Analysis



1.1 Face Acquisition

Face Acquisition is a processing stage for automatically finding the face region. Images used can be static images or image sequences. An image sequence contains temporal information of an expression.

After detecting the face, the pose of the head is detected. Along with head pose estimation, image is pre-processed. Image Pre-processing includes noise removal, brightness, segmentation etc.

1.2 Facial Data Extraction and Representation

Facial data extraction converts pixel data into a higher-level representation. The extracted representation is used for expression categorization. Two kinds of methods for facial features extraction are used:

i) Feature Based/Geometric Based

ii) Appearance based

Feature Based/Geometric based methods: These features present the shape and locations of facial components (including the mouth, eyebrows, and nose). The facial components such as mouth, eyes, nose, eyes, brows are extracted to form a feature vector. These feature vectors represents the face geometry.

Appearance-based methods: Appearance features are extracted by recording appearance changes of the face. Image filters such as Gabor wavelets, are applied to either the whole face or specific regions in a face image to extract the appearance features.

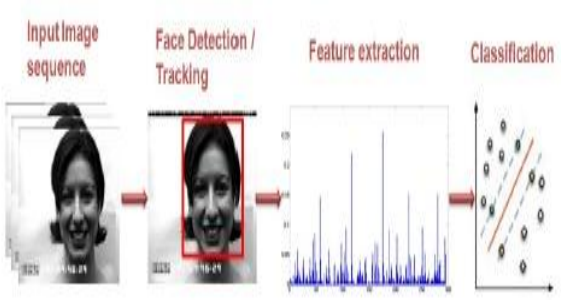
1.3 Facial Expression Recognition

Classifier is used for the expression categorization. Two types of approaches are used for expression recognition:

Frame-Based Expression Recognition – Frame based expression recognition uses the information of current input image with or without a reference frame. The input image can be a static image or a frame of a sequence that is treated independently. Methods used are Neural Networks, Support Vector Machines, Linear Discriminant Analysis, Bayesian Network etc. Some of the frame based classifiers are CMU S1, UIUC S2 and UCSD S1.

Sequence-Based Expression Recognition – to recognize the expressions of one or more frame the sequence-based expression recognition uses the temporal information of the sequences. To use the temporal information Hidden Markov Model (HMM), recurrent neural networks, and rule-based classifier are used. The general steps for facial expression recognition algorithm are shown below in the image (Fig 3).

Fig 3 Generic pipeline for facial expression recognition algorithms

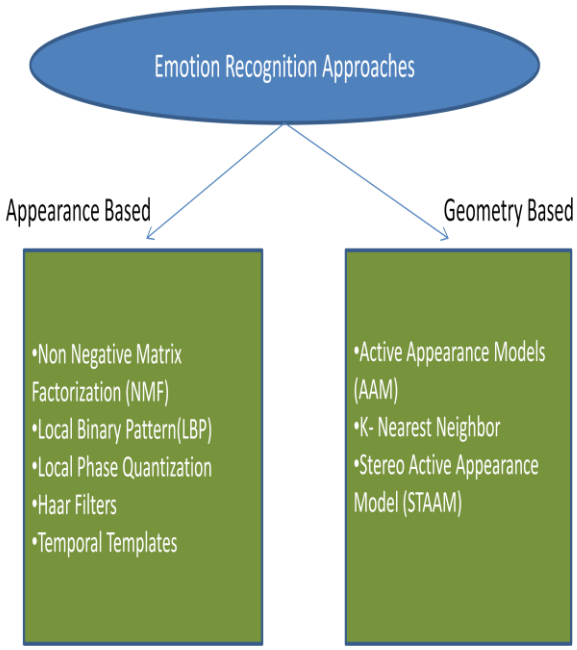


An ideal facial expression analysis system should be able to recognize accurate expression for subjects of different age, gender and of different intensity. It should be able to recognize expression in different lightening, image resolution, head motion in real time.

2. LITERATURE SURVEY

Emotion Recognition approaches cab be mainly categorized according to their feature extraction and classification techniques.

Fig 4 Emotion Recognition Approaches



2.1 Existing Techniques

Drume at al. [11] proposed multi level classification using Support Vector Machine and Principal Component Analysis. Accuracy of PCA at level 1 was boosted by SVM at level 2. Recognition rate of 93.58% was achieved. Sadeghi et al. [10] proposed fixed geometric model for elimination of geometric variability. Then Local Binary Patterns were utilized to represent facial appearance features. They used SVM classifier for expression recognition and achieved better results than the existing work done on CK+ Database.

Abdat et al. [13] proposed an automatic expression recognition system for real time emotion recognition. they developed Anthropometric model for localization of facial feature points. The variations of 21 were used to code the facial expression. Then SVM classifier was used for classification. They performed experiment on FEEDTUM database. Experimental results demonstrated 90% result in real time facial expression recognition. Wang et al. [1] proposed expression recognition approach in which they extracted the features by using Principle Component Analysis and then the classification was done by combining Fuzzy SVM and K-Nearest Neighbor (KNN). Their algorithm achieved good recognition accuracy with reduced computational complexity.

Fan et al. [3] proposed multi-class SVM classification. Features were extracted using PHOG-TOP (Pyramid Histogram of Gradients - Three Orthogonal Planes)and Dense Optical Flow. They evaluated result on CK+ dataset and MMI dataset. On MMI dataset they achieved 74.3% recognition rate and on CK+ they achieved 83.7% recognition rate.

According to FERA 2015 [6], automatic estimation of expression intensities is still a challenge. They have defined three sub challenges: the detection of AU occurrence, the estimation of AU intensity for pre-segmented data, and fully automatic AU intensity estimation. Zhang et al. [7] proposed NN-based and multi-class Support Vector Machine (SVM) based classifiers. The Multi-class SVM with the

radial basis function kernel enabled the robot to outperform the NN-based emotion recognizer. To train NN based classifier 380 training examples were used. 477 test examples were used to test the SVM classifiers. They evaluated that neural network based facial emotion recognizer performed with 76% accuracy for the detection of the six emotions.

Table 1: Recent Techniques

Author and year	Feature Extraction	Classification	Database	Sample size	Result/Conclusion
F. ABDAT, C. MAAOUI and A. PRUSKI, 2011	Anthropometric model with Shi&Thomasi method	SVM Classifier	Cohn-Canade Database and FEEDTUM Databse	25 frame per second for 320*240 images	90% facial expression recognition in real time. The tracking of the detected were done with Lucas-Kanade algorithm.
DevDrume, Anand Singh Jalal, 2012	Image processing tool	PCA + SVM	Local dataset	290 images having480*640 dimensions,	Expressions were divided into parent class and sub classes. success rate of93.58% was achieved.
Sadeghi, H.; Raie, A.-A.; Mohammadi, M.-R.,2013	Local Binary Patterns	SVM	Extended Cohn-Kanade database (CK+)	123 subjects with all prototypic emotions	fixed geometric model was used for geometric normalization of facial images. Higher success rate was achieved than existing work on CK+
Xiao-Hu Wang, An Liu, Shi-Qing Zhang 2015	Principal Component Analysis	Fuzzy SVM(FSVM) KNN	JAFFE	7 different expressions of 10 Japanese.	They calculated regions to be classified by computing Euclidean distance and improved recognition rate with reduced computational complexity.
S SBavkar, J S Rangole and VU deshmukh, 2015	Anthropometric model	SVM and RBFNN	Cohn Kanade databases	40 Expressions were used for training and 10 for testing	Detected feature points were tracked using Lucas-Kanade algorithm. 91% recognition rate was achieved
Xijian Fan, TardiTjahjadi, 2015	PHOG-TOP +Dense Optical Flow	Multi-class SVM	CK+ and MMI datasets	327 image from CK+ Database,203 images from MMI dataset	Happiness and Surprise were easily recognized. On MMI Database highest recognition rate 74.30 was achieved and 83.7% on the CK+ dataset
Zhang, Youmei Zhang, Lin Ma, Jingwei Guan, Shijie Gong, 2015	Structured regularization	Multimodel learning network	CK+ andNVIE database	105 subjects under front, 111 under left and 112 under right illumination respectively	Texture and landmark modalities were integrated to boost FER performance. Better performance than existing methods
Happy, S.L.;	PHOG as shape	LDA for	JAFFE and	183 images	Both shape and appearance

Routray, A., 2015	descriptors and LBP as appearance features	dimensionality reduction + SVM	CK+	from JAFFE and 328 images from CK+ having resolution of 96*96	features were used for better recognition. Promising accuracy in recognizing all expressions. They achieved 94.63% recognition rate on CK+ and 83.86% on JAFFE database.
Li Zhang; Hossain, A.; Ming Jiang, 2014	NN-based Upper & Lower AU Analyzers	NN-based and multi-class Support Vector Machine (SVM) based classifiers	Local Dataset	380 training examples to Train neural network-based emotionclassifier.477 test examples test the SVM classifiers.	The upper facial AU recognition achieved 80.73% accuracy while the lower facial AU detection achieved a 77.93% recognition rate. Neural network based facial emotion recognizer performed with 76% accuracy for the detection of the six emotions.
MihaiGavrilescu 2013	multi-state face model	Neural Network and Haar-Cascade Classifier	MMI and CK dataset	24 frames/sec in 800x600resolution	11.5% better emotion recognition rate for CK database and 14.2% better emotion recognition rate for MMI database as compared to recent approaches
MouhebLahbiri et al. 2013	Distance vector	Hidden Markov Model	Local Dataset	25 facial images for each emotion	it used images in the neutral state as references to create the sequences of observations. For some emotions, recognition rate was >90%.

Happy et al. [5] proposed approach that combined shape and appearance features. Pyramid of Histogram of Gradients was used as shape descriptor and Local Binary Patters was used as appearance feature. Rather than processing the whole face, active patches were extracted that reduced computational cost. Linear Discriminant Analysis was used for dimensionality reduction, then SVM was used for classification. Their approach achieved 94.63% recognition rate on CK+ and 83.86% on JAFFE database. They evaluated that integrated framework achieved better performance than using individual descriptor separately.

Bavkar et al [2] proposed facial expression recognition technique using geometric features. To detect feature points anthropometric model was used. The distance vector between static and dynamic points was used for classification. They used SVM and RBFNN(Radial Basis Function Neural Network) classifier and achieved 91% recognition rate for Cohn Kanade Database.

Gyanendra et al [12] proposed emotion recognition approach based on pattern analysis. The assimilated spatial and intensity variation of pixels were appreciated by the means of texture features extracted from the promising region of interest (ROI) on facial images.

2.2 Databases

Table 2: Databases

Year	Database Name	Elicitation (posed/ spontaneous)	Size	Expressions description
2006	FEEDTUM	spontaneous	399 video sequences from 18 subjects	Six basic expressions + neutral face
2010	NVIE	Posed and Spontaneous	For spontaneous - 103, 99, 103 subjects under front, left, and right illumination respectively, For posed – 107 subjects.	Six basic emotions
1998	JAFFE	posed	213 images of seven emotional states. Each emotional state contains more than thirty 256×256 images of different Japanese.	Six basic emotions + neutral
2000	CK Dataset	posed	486 sequences from 97 subjects. Age range from 18 to 30 years.	Six basic emotions
2005	MMI	Posed and spontaneous	19 subjects with 79 expressions. Age ranging from 19 to 62. Video frames at 720*576 spatial resolution.	Six basic emotions + neutral face
2010	Extended CK+ dataset	Posed and Spontaneous	593 image sequences by 120 subjects. Age range from 18 to 30 years.	Seven expressions – Anger, Contempt, Disgust, Fear, Hapiness, Sadness and Surprise.

3. APPLICATIONS

Facial Expression Recognition system has vast applications. Some of these are:

- Security: Facial expression recognition can be used to predict the intensions of the criminals.
- Entertainment: In entertainment, the multimedia content can be displayed by analyzing the human's mood/behavior. The videos or songs can be changed according to the expressions of user.
- Effective Computer Tutor: Facial expression recognition can solve an important role in effective teaching. It becomes very easy for the computer tutor to analyze feedback of students through the expressions of students. A computer tutor can present an easy question for the student if it finds the student tensed/confused.
- Intelligent Home Robotics: For social robots, it is also important that they

should be able to recognize different human emotions and respond accordingly in order to have effective communication.

- Automated Detection of Driver Fatigue: Facial Expression of driver can be analyzed to check whether the driver is attentive or not. An alert can be set if the system found driver tensed/anxious.
- Smart Homes: The smart houses could be equipped with systems that will automatically adjust the lighting conditions, room temperatures based on the facial expressions of the inhabitants.
- Behavioral Science and Clinical practice

4. CHALLENGES

Although in the literature, several techniques have been proposed for human emotion recognition. Many of them show promising result. Still Human Emotion Recognition has several challenges. Some of these are:

- Most approaches assume that the subject has a frontal face view. The effective system should be able to detect the expression under non-frontal head positions and environmental factors.
- The system should be able to recognize the expression even in abnormal lightening conditions. Multiple sources of light can cause multiple shadows on the face.
- For an effective recognition, the system needs to be trained. But for training facial expression recognition system, size of training set becomes very large which adds computational cost and time.
- Security system, visual surveillance requires facial expression recognition system that works adequately on low resolution images.
- Most of the researchers have focused on six basic emotions: happiness, sad, anger, disgust, surprise, fear. But the era of human emotions is far more complex. An emotion can be single emotion or can be a blended emotion. The emotions such as pain, love, hate, and mental states such as agreeing, disagreeing, thinking, lie, frustration, thinking etc. should also be focused as they have numerous application areas.
- The human expression recognition system should be able to detect the emotion in real time.
- The researchers experimented their results on different data sets. So there is no such standard protocol to compare the techniques with one another.
- The detection of AU occurrence, estimation of AU intensity for pre-segmented data and fully automatic AU intensity estimation are three sub-challenges.

5. CONCLUSION

Various techniques have been proposed in literature for Facial Expression Recognition. Some techniques out-perform other techniques in many factors. This paper listed recent techniques used for Facial Expression Recognition and databases used for the purpose. But developing 100% accurate recognition system is still a challenging task.

6. ACKNOWLEDGEMENT

We are thankful to University Grand Commission for providing Junior Research Fellowship for carrying out research work.

7. REFERENCES

[1] Xiao-Hu Wang, An Liu, Shi-Qing Zhang, New facial expression recognition based on FSVM and KNN, Optik - International Journal for Light and Electron Optics, Volume 126, Issue 21, November 2015, Pages 3132-3134, ISSN 0030-4026

[2] S SBavkar, J S Rangole and V U Deshmukh. Article: Geometric Approach for Human Emotion Recognition using Facial Expression. International Journal of Computer Applications 118(14):17-22, May 2015.

[3] Xijian Fan, TardiTjahjadi, A spatial-temporal framework based on histogram of gradients and optical flow for facial expression recognition in video sequences, Pattern Recognition, Volume 48, Issue 11, November 2015, Pages 3407-3416, ISSN 0031-3203

[4] Wei Zhang, Youmei Zhang, Lin Ma, Jingwei Guan, Shijie Gong, Multimodal learning for facial expression recognition, Pattern Recognition, Volume 48, Issue 10, October 2015, Pages 3191-3202, ISSN 0031-3203

[5] Happy, S.L.; Routray, A., "Robust facial expression classification using shape and appearance features," in Advances in Pattern Recognition (ICAPR), 2015 Eighth International Conference on , vol., no., pp.1-5, 4-7 Jan. 2015

[6] FERA 2015 - Second Facial Expression Recognition and Analysis Challenge

[7] Li Zhang; Hossain, A.; Ming Jiang, "Intelligent Facial Action and emotion recognition for humanoid robots," in Neural Networks (IJCNN), 2014 International Joint Conference on , vol., no., pp.739-746, 6-11 July 2014

[8] M. Gavrilescu, "Proposed architecture of a fully integrated modular neural network-based automatic facial emotion recognition system based on Facial Action Coding System," *Communications (COMM), 2014 10th International Conference on*, Bucharest, 2014, pp. 1-6.

[9] M. Lahbiri, A. Fnaiech, M. Bouchouicha, M. Sayadi and P. Gorce, "Facial emotion recognition with the hidden Markov model," *Electrical Engineering and Software Applications (ICEESA), 2013 International Conference on*, Hammamet, 2013, pp. 1-6.

[10] Sadeghi, H.; Raie, A.-A.; Mohammadi, M.-R., "Facial expression recognition using geometric normalization and appearance representation," in Machine Vision and Image Processing (MVIP), 2013 8th Iranian Conference on , vol., no., pp.159-163, 10-12 Sept. 2013

[11] Drume, D.; Jalal, A.S., "A multi-level classification approach for facial emotion recognition," in Computational Intelligence & Computing Research (ICCIC), 2012 IEEE International Conference on , vol., no., pp.1-5, 18-20 Dec. 2012

[12] Gyanendra K. Verma, Bhupesh Kumar Singh,"Emotion Recognition based on Texture Analysis of Facial Expression", International Conference on Image Information Processing (ICIIP 2011) © 2011 IEEE

[13] Abdat, F.; Maaoui, C.; Pruski, A., "Human-Computer Interaction Using Emotion Recognition from Facial Expression," in Computer Modeling and Simulation (EMS), 2011 Fifth UKSim European Symposium on , vol., no., pp.196-201, 16-18 Nov. 2011

[14] Michael J. Lyons, Shigeru Akemastu, Miyuki Kamachi, JiroGyoba. Coding Facial Expressions with Gabor Wavelets, 3rd IEEE International Conference on Automatic Face and Gesture Recognition, pp. 200-205 (1998)

[15] Pantic, M., Valstar, M., Radermaker, R., and Maat, L. (2005). Web-based Database for Facial Expression Analysis, in: Proceedings of the 13th ACM International Conference on Multimedia, pp. 317-321.

[16] Michael J. Lyons, Shigeru Akemastu, Miyuki Kamachi, JiroGyoba.Coding Facial Expressions with Gabor Wavelets, 3rd IEEE International Conference on Automatic Face and Gesture Recognition, pp. 200-205 (1998)

[17] Frank Wallhoff, Bjorn Schuller, Michael Hawellek, Gerhard Rigoll, "Efficient Recognition of Authentic Dynamic Facial Expressions on the Feedtum Database," 2012 IEEE International Conference on Multimedia and Expo, pp. 493-496, 2006

IEEE International Conference on Multimedia and Expo, 2006

[18] Lee Y. B., Moon S. B., Kim Y. G., "Face and facial expression recognition with an embedded system for human-robot interaction," Lect. Notes Com put. Sci., pp.271-278, 2005.

[19] Patrick Lucey, Jeffrey F. Cohn, Takeo Kanade, Jason Saragih , Zara Ambadar," The Extended Cohn-Kanade Dataset (CK+): A complete dataset for action unit and emotion-specified expression", 978-1-4244-7030-3/10/$26.00 ©2010 IEEE

[20] Shangfei Wang, Zhilei Liu, SiliangLv, YanpengLv, Guobing Wu, PengPeng, Fei Chen, Xufa Wang, A Natural Visible and Infrared Facial Expression Database for Expression Recognition and Emotion Inference,IEEE Transactions on Multimedia, Vol. 12, No. 7, Page(s): 682-691, NOVEMBER 2010.

[21] Paul Ekman, "Basic Emotions", Handbook of Cognition and Emotion © 1999 John Wiley & Sons Ltd.

[22] Kanade, T., Cohn, J. F., &Tian, Y. (2000). Comprehensive database for facial expression analysis. Paper presented at the Fourth IEEE International Conference on Automatic Face and Gesture Recognition.

[23] Mehrabian, A., "Communication without words," Psychology Today Vol. 2, pp.53-55, 1968.