Human Front-Facial Expression Recognition: A Survey

Harshik Patel[1], Ronak Doshi[2], Ghanshyam Prajapati[3]

Department of Information Technology, Shri S'ad Vidya Mandal Institute of Technology, Bharuch, Gujarat, India.

***Abstract*----Facial expression is non-verbal cue to communicate with each other in real world. This paper presents various methods for Facial Expression Recognition (FER) and pointing the important points of methods implemented by researchers. First, face is detected from images by implementing different types of algorithm like viola jones, exhaustive search, etc. Next, performing feature extraction to detect the proper expression using SVM, SOM, SIFT Descriptors, etc. on the basis of movement observed in key points, then the accurate expression is detected. In expression recognition mechanism, keypoints of components like lips, nose, eye and wrinkles are should be track correctly. Many methods for recognizing expression are not up to the mark and some of the methods works slowly due to their complex algorithm structure. Methods like ACO and PSO providing less accuracy in expressions like "Angry" and "Sad". Also discussed about robot NAO who can communicate with human by recognizing face and expressions in this paper. The Challenging tasks like pose and illumination for Computers are presented.**

Index Terms*---- *CUDA, GPU, PCA, SVM, ICA, SIFT, MATLAB, HCI, DCT, ACO, PSO, BU-3DFE, SIFT.

I. INTRODUCTION

Face expression is powerful signal for communication with each other non-verbally. Anybody can understand what's happening in the mind of the humans and response them according to their moods. This concept of facial expression is spreading like disease in this field since 1990s, when Ekman [1] proposed his theory for facial expression. Human expressions plays significance role in understanding others effect and helps in building HCI (Human Computer Interface).

In today's world, Technology is growing faster and faster in the field of Automation. In this field, fast processing is more important than accuracy. Many Researchers have implement the various methods using different platform like CUDA [2] (Compute Unified Design Architecture), MATLAB (Matrix Laboratory) etc. for Facial Expression Recognition to achieve better accuracy.

Aldebaran developed Robot Nao in 2006 [3] who can communicate with humans. This Robot can moves from one place to another, can talks with us by recognizing our face. He is called the Star in World of Education because he can teach you operations like multiplication, Subtraction, square root, etc., also can wake up you early in morning and monitors your home as well.

But on other hand, challenging tasks like Pose and Illumination which affects the accuracy.

A. Pose: Due to vary in images position, person facing towards camera in frontal or non-frontal style that makes difficult to detect eyes and nose. To overcome this challenge, techniques like rotation, translation and scaling are implemented so that they are detect perfectly.

B. Illumination: Suppose that images are taken in darkness then expressions are recognized in accurately. So, this recognition rate is low and face is not detected. To solve this problem, we perform the technique like normalization, etc.

This paper presents related work in section II. Section III describes the Facial Feature Parameters Extraction andSection IV describes the Facial expression Parameters.

II. RELATED WORK

From last few decades, many researchers are working on facial expression. They have put their efforts to find better accuracy to detect the correct expression.The Researcher's contributions in this field as mentioned below:

Akshat Garg and Vishakha Choudhary [4] implemented the PCA Method to recognize facial expressions. They have recognized Six Expression i.e. Anger, Fear, Surprise, Sadness, Joy, Disgust.

Melanie Dumas[5] performed SVM method for Facial Expression Recognition. They implemented SVM method with POFA datasets to attain highest accuracy and obtained 88.1% accuracy by SVM using Linear Kernal with C-SVC Formulation.

Iordanis Mpiperis, Sotiris Malassiotis, Vassilios Petridis and Michael G. Strintzisv[6] implemented algorithms like Wang, PSO, ACO using the concept of Swarm Intelligence to achieve maximum accuracy to detect correct Facial Expressions in 3D. They obtained 92.1% recognition rate using ACO/PSO algorithm with BU-3DFE database. The confusion between Anger and Sad remain unsolved.

Jawad Nagi, Syed Khaleel Ahmed Farrukh Nagi[7] performed SOM (Self Organizing Map) with DCT (discrete

cosine transform) vectors features to check whether the input image is present or not in image database and if present then image is recognized successfully. They just worked to recognize correct image and obtained recognition rate of 81.36%.

Stefano Berretti, Boulbaba Ben Amor, Mohamed Daoudi, Alberto del Bimbo [8] automatically detect key points for 3D facial expressions recognition using Sift Descriptors. They used Yale database for expression.

Ming-Hsuan Yang Dan Roth Narendra Ahuja[9] have implemented Snow Based approach to detect the face from images. They performed primitive features and multi-scale features to obtained good accuracy. Using Primitive features achieved the accuracy of 94.2% and multi-scale features achieved the accuracy of 94.8%.

Shivashankar J. Bhutekar, Arati K. Manjaramkar[2] implemented parallel computing concept to detect face using CUDA which C-based programming language on NVIDIA GeForce GTX 770 GPU because this system provides compute capability of 3.0. They have performed only face detection and face recognition.

III. FACIAL PARAMETER EXTRACTION

A. Eye and Eyebrow Extraction.

Eye Detection is the first technique to detect face from the input image and Eyebrow extraction is used to study the facial expression of the human. It is essential to note that the angle of eye changes when the face gets rotated at same angle.

Here,the Fig.1 shows the result for Eye Detection.

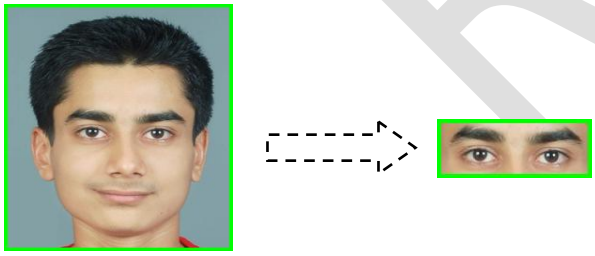

Fig. 1 Extraction of Eyes

Eye Detection Methods:

1) Dynamic Time Wrapping:

It is optimal search type algorithm but this algorithm is not practically more successful like Neural networks methods. Using this algorithm with DTW[10], the researchers have tried to increase the efficiency to detecting the eye region from facial images using database provided by University of Bern, Switzerland. The accuracy for eye detection was 60% and applying histogram equalisation using DTW with same datasets accuracy jumps to 76.67% and then, applying histogram equalisation and weighing scheme using DTW that increased accuracy to 95%. Problem with algorithm is of time complexity.

2) Line Edge Map Template:

Researchers have implemented Line Edge Map Template [11] to detected Eye and Iris regionsfrom input images. First of all, the original image is scaled to required resolution pixels. Next, the coloured image is converted to gray scale to detect eye. They used Cal Tech and Georgia Tech datasets to detect both Iris and Eye. Table 2 represents the Eye detection Results

TABLE I
RESULTS OF EYE DETECTION [11]

Database	Detection Type	Result
Cal Tech	Eye Center	92.50%
	Iris Center	96.67%
Georgia Tech	Eye Center	90.83%
	Iris Center	94.12%

B. Lip and Contours Extraction:

From last few decades, manyresearchers have tried to achieve better accuracy in Lip detection. Working on the movement of lips that helps in face recognition and facial expression as well.Here, the Fig.2 shows the result for Lip Detection.

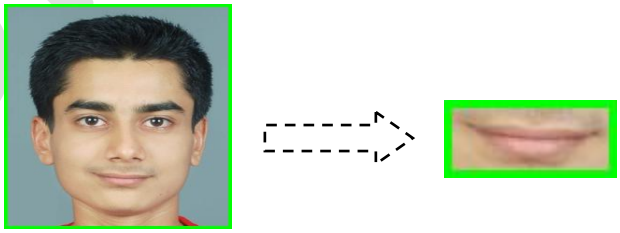

Fig. 2Extraction of Lips

Few methods implemented by researchers has discussed below:

Lip Extraction Methods:

1) Using Deformable Model[12]:

In this technique, the Geometric model of Lip structure is used and then compared with the face image to extract the lip region. The Lip accepted results achieved was 99% but image of poor quality is discarded for feature extraction process.

2) Novel Method[13]:

Using Novel Algorithm,Roland Gocke, J Bruce Millar, Alexander Zelinsky, and Jordi Robert-Ribes extracted the feature points from the face-images. First of all, they calculate openness property of mouth by extracting the mouth region.

Next, from mouth-extracted image they find the lip corner and lastly, stated the lip extracted points using corners of lips.

3) Adaboost Classifier:

First detected face from image using concept of Haar-like features and using Adaboost Classifier[14], they detected the mouth region. Then, by implementing sobel-edge detectoron the mouth detected images, lip contour extracted.

C. Comparison and Performance Analysis.

From discussion about the methods of Eye detection and Lip contour, comparison table presented below:

TABLE II
EYE DETECTION METHODS

Method	Recognition Rate	Important Points
DWT[10]	60%	False Rate is high
DWT using histogram equalisation [10]	76.67%	To achieve accuracy implemented with Histogram Equalisation.
DWT using histogram equalisation and Weighing Scheme [10]	95%	Low false Rate comparison to others.
Line Edge Map template[11]	92.50%	Using Cal Tech Database
Line Edge Map template[11]	90.83%	Using Georgia Tech Database

IV. FACIAL EXPRESSION PARAMETER POINTS EXTRACTION

A. Facial Points Extraction.

Feature extraction is difficult and one of the most important task for developers. The system based on transients and permanent features success rate is over 95%. Face Tracker mechanism developed by Tao Huang was used by Cohen et al [15] called PBVD Tracker. First of all, after face tracker detects the face, then they detect local deformation of facial points. This each deformations are called Motion units. As the movement in the key point is observed when the human changes expressions and expression are detected.

Fig. 3 Facial PointsExtraction

B. Methods for recognising Human Expression.

1) SVM[5]:

This technique works on the concept of support vectors. Structural Risk Minimization is performed by support vector algorithm. Here, LIBSVM is used as SVM package which have four types of Standard Kernel i.e. Linear, Polynomial, Radial Basis Function and Sigmoid kernels.

They achieved the accuracy of 88.1% using Linear Kernel with the help of POFA dataset which contains 13 subjects having 93 examples with 40,600 features and identifying 6 expressions like Sad, Happy, Surprise, Angry, Afraid and Disgust.

2) SIFT Descriptors:

Key points and Feature Detector mainly included in SIFT[8]. SIFT detects the key points from corners in order to detect the significant face points from the images. They have implement this technique in 3D to overcome the demerits of 2D. They obtained the recognition rate of 78.1% using BU-3DFE datasets which is discussed later in this section.

3) Using ACO and PSO Approach:

Researchers proposed classifier based on the concept of Swarm Intelligence [6] in 3D. They worked on Happy, Sad, Anger, Fear, Disgust and Surprise using BU-3DFEdatasets and obtained the accuracy of 92.3% using PSO, 85.53% using ACO and 83.6% using WANG.

4) SOM:

SOM[16] is unsupervised learning algorithm of neural network that transforms pattern of arbitrary dimensionality into response of one or two dimensionality array of Neurons. After detecting face, they located facial regions like Nose, Mouth and Eyes to extract the key points on face which is essential to recognise the expression correctly. They obtained accuracy of 93.2% using Cohn-Kannade[17] and 87.6% using FG-Net[18] datasets.

For this work, they used Cohn-Kannade and FG-Net datasets which contains basic six common expression like Fear, Anger, Sad, Surprise, Happy and Disgust.

5) DCT and SOM Neural Networks:

DCT [19] techniques is used to extract the features from input face images based on skin color. SOM (Self Organized Map) used DCT as classifier to check whether the input image is present or not in datasets. They implemented this techniques in MATLAB using image dataset have total 25 face images of 5 subjects and each subjects have 5 images with different expressions. The overall recognition rate accuracy is 81.36%.

C. Database Information.

1) CMU PIE Database:

CMU-PIE is abbreviated as Carnegie Mellon University-Pose, Illumination, and Expression. CMU PIE[20] consists 41,368 images of 68 subjects that were taken between October and December 2000. Each subject with 13 different poses taken at specific angles and 4 different expressions under 43 different illumination conditions are captured in CMU 3D Room.

2) BU-3DFE Database:

This database [21] is developed for 3D facial scans by Binghamton University (BU) which includes 100 subjects with 2500 facial expressions model. The database contains 100 subjects with 56% female and 44% male that covers the range of 18 to 70 years old including all kinds of humans like White, Black, East-Asian, Indian and Hispanic Latino.

Each subjects performed seven types of Expressions in front of 3D face scanner covers the expressions like Sad, Anger, Happy, Surprise, Neutral, Fear and Disgust. The images are captured at two views +45° and -45°. This results database consists of 2,500 texture images and 2,500 geometric images.

D. Comparison of various Human Expression Recognition Methods.

Table III shows the comparison among the different methods with their Recognition Rate.

TABLE III
METHODS COMPARISON

Reference	Method	Database	Recognition Rate	Important Points
Emotional Expression Recognition[5]	SVM	POFA Dataset	85.99%	Highest possibility accuracy attainable with the sum of POFA datasets.
3D Facial Expression Recognition UsingSwarm Intelligence [6]	PSO	BU-3DFE	92.3%	High Confusion Rate occurs between Sad and Angry expression.
	ACO	BU-3DFE	85.53%	ACO applies to discrete attributes.
3D Face Recognition[8]	SIFT Descriptors	BU-3DFE	74.1%	Key points on face covers less regions (only 9 key points).
An SOM-based Automatic Facial Expression Recognition System[7]	SOM	FG-NET	87.1	High Confusion Rate in Disgust Expression.
		Cohn-kannade	93.2	Less accuracy in Fear expression compare to others.

Where, SVM = Support Vector Machine, PSO = Particle Support Optimization, ACO = Ant Colony Optimization, SIFT= Scale invariant features Transfer.

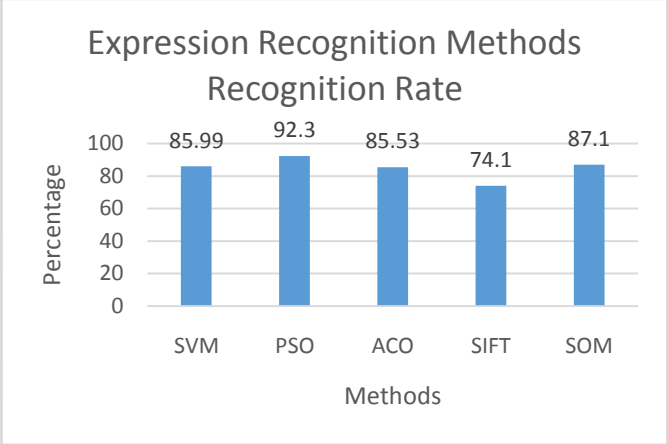

Fig. 4Expression Recognition Methods Recognition Rate

V. CONCLUSION

In this survey paper, methods of Eye detection have been discussed with their recognition rate. Using CalTech and Georgia database provides better accuracy in Eye detection.This paper also represents the techniques to recognise the facial expression accurately. The accuracy of expression recognition depends on the type of datasets. The BU-3DFE database provides variations in face images to obtain high accuracy for 3D. For FER(Facial Expression Recognition), Swarm Intelligence using PSO and ACO algorithm, higher accuracy is obtained in 3D using BU-3DFE database. And future work to obtain high accuracy in "Sad" and "Angry" expression.

REFERENCES

[1] Paul Ekman. https://en.wikipedia.org/wiki/Paul _Ekman visited on 10th July, 2015.
[2] Shivashankar J. Bhutekar, Arati K. Manjaramkar (IJCSIT) International Journal of Computer Science and Information Technologies, Vol. 5 (2), 2014, 2013-2018.
[3] NAO- speaking robot. https://www.aldebaran.com/en/humanoid-robot/nao-robot visted on 11th July, 2015
[4] Akshat Garg Vishakha Choudhary, "Facial Expression Recognition By Principal Component Analysis", International Journal of Scientific Research Engineering &Technology (IJSRET) Volume 1 Issue4 pp 039-042 July 2012.

[5] Melanie Dumas, Department of Computer Science University of California, San Diego La Jolla, CA 92193-0114. "Emotional Expression Recognition using Support Vector Machines"
[6] Iordanis Mpiperis, Sotiris Malassiotis, Vassilios Petridis and Michael G. Strintzis "3D Facial Expression Recognition Using Swarm Intelligence."
[7] Jawad Nagi,Syed Khaleel Ahmed Farrukh Nagi "A MATLAB based Face Recognition System using Image Processing and Neural Networks". 4th International Colloquium on Signal Processing and its Applications, March 7-9, 2008, Kuala Lumpur, Malaysia.
[8] Stefano Berretti, Boulbaba Ben Amor, Mohamed Daoudi, Alberto del Bimbo."3D facial expression recognition using SIFT descriptors of automatically detected key points", Published online: 30 June 2011© Springer-Verlag 2011.
[9] Ming-Hsuan Yang Dan Roth Narendra Ahuja, Department of Computer Science and the Beckman Institute University of Illinois at Urbana-Champaign Urbana, IL 61801.,"A SNoW-Based Face Detector"
[10] Somaya Adwan and Hawzah Arof International Journal Of Innovative Computing Information and Control Volume 8, Number 1(A), January 2012. "Modified integral Projection Method for Eye Detection using Dynamic Time Wrapping".
[11] Mihir Jain, Suman K. Mitra, Naresh D. Jotwani, , "Eye Detection using Line Edge Map Template".
[12] Alan Wee-Chung Liewa ,Shu Hung Leungb, Wing Hong Laua, "Lip contour extraction from color images using a deformable model", Pattern Recognition 35 (2002) 2949 – 2962.
[13] Roland Gocke, J Bruce Millar, Alexander Zelinsky, and Jordi Robert-Ribes, "Automatic Extraction of Lip Feature Points".
[14] Zahedi Morteza and Mohamadian Zahra, "A Fully Automatic and Haar like Feature Extraction-Based Method for Lip Contour Detection" Research Journal of Recent Sciences Vol. 2(1), 17-20, January (2013).
[15] Ira Cohen, Nicu Sebe, Ashutosh Garg, Lawrence S. Chen, and Thomas S. Huanga, "Facial expression recognition from video sequences: temporal and static modelling".
[16] Mu-Chun Su, Chun-Kai Yang, Shih-Chieh Lin,De-Yuan Huang, Yi-Zeng Hsieh, andPa-Chun Wang. "An SOM-based Automatic Facial Expression Recognition System", International Journal on Soft Computing, Artificial Intelligence and Applications (IJSCAI), Vol.2, No.4, August 2013.
[17] Yin Tian, Jeffrey Cohn and Takeo Cannade, "Facial Expression Analysis".
[18] P.Jonathan Philips, "FERET evaluation methodology for Face-Recognition Algorithm." IEEE Transactions on Pattern Analysis and Machine Intelligence, volume 22, no.10
[19] Mu-Chun, Chun-Kai Yang, Shih-Chieh Lin, De-Yuan Huang, Yi-Zeng Hsieh, and Pa-Chun Wang. Department of Computer Science & Information Engineering, National Central University, Taiwan, R.O.C., "An SOM-based Automatic Facial Expression Recognition System", International Journal on Soft Computing, Artificial Intelligence and Applications (IJSCAI), Vol.2, No.4, August 2013.
[20] Terence Sim, Simon Baker, and Maan Bsat.
"CMU Pose, Illumination and Expression Database of Human Faces.", CMU-RI-TR-01-02.
[21] BU-3DFE (Binghamton University 3D Facial Expression) Database (Static Data) http://www.cs/binghamton.edu /~lijun/Research/3DFE/ 3DFE_Analysis.htmlvisited on 12th July,2015