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# A Review: Facial Expression Detection with its Techniques and Application

Neha Bhardwaj[1] and Manish Dixit[2]

[1]*Department of CSE/IT, MITS Gwalior*
[2]*Department of CSE/IT, MITS Gwalior*
[1]*nehabharadwaj26@gmail.com* ,[2]*dixitmits@gmail.com*

***Abstract***

*Facial expression recognition performs a critical role in the human-machine interaction area. The security of information is becoming very significant and difficult. Security cameras are presently common in airports, Offices, University, ATM, Bank and in any locations with a security system. Facial Expression Recognition system is used in security. During the past years recognition of face has received most important attention as one of the most significant image application understanding and analysis. Many algorithms have been implemented on different static and non static conditions (uncontrolled conditions).Static conditions include static and uniform background, identical poses, similar illumination, neutral frontal face .Non static conditions include position, partial occlusion orientation; varying lighting conditions and facial hair, which makes recognition process a complex problem. Facial expression recognition is a example where computer and humans underperforms. It has most importance for the video retrieval and video based management classification. It may be used in behavior psychology and science.*

***Keywords****: Techniques;Facial Expression; Face Detection, Face Recognition; Application*

## 1. Introduction

Emotion recognition can be done through different modalities, such as speech, facial expression, body gesture *etc*.. Emotion recognition through facial expression has attracted a lot of interest in last few decades. Expression of our face says a lot without speaking. A facial expression is one or more position of muscles beneath the skin of the face. According to one set of controversial theories, these movements convey the emotional state of an individual to observers. Facial expression is form of non verbal communication. They are primary means of conveying social message between humans. Darwin

In the year 1872 was the first to suggest the correlation between the facial expression and emotion. According to Darwin emotions and their expression were biologically innate and evolutionary adaptive and that similarities in them could be seen phylogenetically [1]. In the year 1972 Ekman, Friesen and Ellsworth [2] works on the idea of Darwin and found that according to psychology perspective facial expression were culture specific like any culture had its own verbal language; emotion had its own language of facial expression. Mc Carter and Tokmins[3]in the year 1964 gives the first study demonstrating that facial were reliably associated with certain emotional state. In the psychological research one can express his feelings and attitude by speaking *i.e.*, by saying up to 7%, through his vocal expression up to 38% and 55% through his facial expression [4-5]. This show that facial expression plays an important role for an individual too express their intention attitude, feelings and emotional state and other non-verbal messages in speech communication. Facial expression shows the mood or emotional state of an individual

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how he is feeling at a particular moment like sad, happy, anger. The Paul Ekman [6] gives the six universal emotions namely sad, happiness, anger, fear, disgust and surprise. Emotion recognition via facial expression has been getting a lot of interest due to its increase in application such as Robotics where the communication between and human is to be enhance. In Automobile it helps to decrease the accidents. Other applications of emotion recognition are surveillances, security, biometrics, customer care center and human computer interaction. Face detection the first step of emotion recognition in which the face is identify from the raw image. The raw image has many objects in it like a image has man and back ground object out that face detection technique determines the face only rejecting all other objects. In the wake of recognizing the face from the crude picture second step is to separate the elements which will help in feature extraction. The feature extracted in the second step of feature extraction is taken as information in the last step grouping to the classifier which thusly gives back a pre characterized classification of emotion. This paper is study of the different procedures utilized as a part of the three stages of emotion recognition *i.e.*, different techniques for face detection, feature extraction and last is classification.

## 2. Related Work

Emotion recognition is process of extracting feature which helps to recognize the mood and future perception of the individual. The lot of work is done in the field of emotion recognition. The basic emotions are the Anger, Happiness, Disgust, Fear, Surprise and Sad. Emotion recognition via facial expression is given by Ekam[6].His work was based on Psychology. Ira *et al.* [8] gives architecture of hidden markov models which automatically segment and detect human facial expression from video sequences. Spiros *et al.* [9] give the method for feature extraction and emotion recognition was based on video sequences. He recognizes emotions of user's emotional state that could be robust to facial expression variations among different users. Chakraborty *et al.* [10] uses fuzzy relational approach to recognize human emotions from facial expressions. They uses three different fuzzy sets : HIGH, LOW, MODERATE using only three facial features eye opening, mouth opening and the length of eyebrow constriction and recognized six basic emotions with the accuracy of 89.11% for adult males, 92.4% adult females and 96.28% for 8-12 years children. Maglogiannis *et al.* [11] recognize four basic emotions through eyes and mouth using edge detection and by measuring the gradient of eye's and mouth's region. The accuracy of feature detection and emotion recognition was 82.14%. Pantic and Rothkrantz [12] uses rule based reasoning and develop an automated system to recognize facial gestures in static, frontal and/or profile – view color face image.

They recognize 32 individual facial muscle actions (AUs) with the rate of 86.3%. Kharat and Dudul [13] uses various feature extraction techniques such as discrete cosine transform(DCT), Fast Fourier Transform (FFT) and Singular value Decomposition and recognize basic emotion and neutral using Support Vector Machine(SVD) with the average rate of 92.86%. Khan and Bhuiyan [14] works especially on eyes and lips and uses Bezier curves representing the relationship between the motion of features and changes of expression. In his paper he uses 3rd order Bezier curve to identify the face outlines and expressions. They recognize four different facial expressions of 200 individual persons with the average rate of 94.4%.Rizon *et al.* [15] extracts lips and eye features to classify human emotions through irregular and regular ellipse fitting and use the genetic algorithm to classify the features. Khanum *et al.* [16] comprises Fuzzy Logic and Case based Reasoning and extract six basic emotion with the average rate of 90.33%.Gomathi *et al.* [17] propose Multiple Adaptive Neuro-Fuzzy Inference system (MANFIS) in which facial image is initially segmented into three regions from which the uniform local binary pattern (LBP) texture feature distribution are extracted and represented as a histogram descriptor. They recognize the six basic features and accuracy was 94.29%. Esau et al[18] proposed the fuzzy video- based emotion recognition system

 

VISBER that allows analyzing facial expression in video sequences using Fuzzy classification and extract four basic emotions and neutral with the rate of 72%. Setyati *et al.* [19] constructed Active Shape Models to extract facial features from face images. Active shape models are pre-generated and then the facial images are iteratively matched with the model and then corresponding features are calculated.

## 3. Basic Steps of Emotion Recognition through Facial Expression

The basic steps for the emotion recognition given by various researchers can be easily understood by the figure 1[20]. First the input image is given and face is detected. This process of detecting face is called face detection. The detected face may have various problems like noise, illumination *etc.*. To remove noise, illumination problem image preprocessing is done. The preprocessing has many steps like normalization, noise removal *etc.*. Normalization is done to remove the illumination problem. Normalization is the process that changes the range of pixel intensity values. Normalization against variation of pixel position or brightness is done.

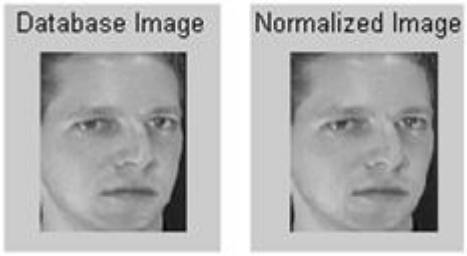


**Figure 1. Shows Original and Normalized Image**

The next step is to extract feature. This process is called feature extraction. There is various feature extraction methods are defined below. The feature extracted is now classified using various classification techniques. The steps of emotion recognition are explained in detail below.

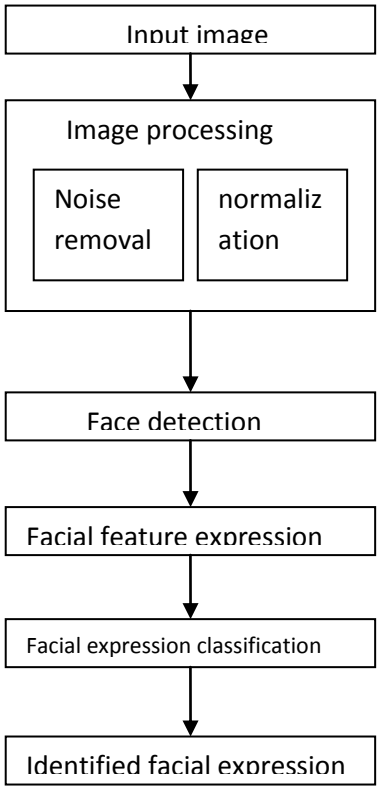


**Figure 1. Steps of Emotion Extraction**

## 4. Face Detection

Face detection is the very first step of emotion recognition based on facial expression and also in face alignment, face relighting, face modeling, face recognition gait recognition and in many more areas. Face detection is used to identify the any face in the image and if the face is present then return its location and extent of each face. To understand the mood of people, it is very important that computer recognizes face very well. During the face detection various problems are to be analyzed like viewing geometry (front and non front), illumination (Color, shadowing and self shadowing), the imaging process such as resolution, focus, imaging noise and perspective effects and there are other factors to be considered like occlusion [20-21]. There are many methods to determine the face from still images and videos, but the four categories of face detection given by the yang *et al.* [22] are knowledge-based approach, Feature invariant approach, Template matching based approach and Appearance-based approach**. Knowledge-based approach** detects the face using a set of rules (like human face has two eye, nose, mouth and lips within a certain distance and position relative to each other) based on human knowledge. **Feature invariant approach** is based upon structural features of the face in which a structural classifier is trained and then used to differentiate between facial and non facial regions. **Template matching** approach also known as image matching uses predefined or parameterized face templates to locate and detect faces and then determine the correlation value between template and the input image**. Appearance-based approach** depends on a set of delegate training face images to find out face models. Generally, appearance-based methods are used for face detection with eigen face values. Appearance-based methods have shown superior performance compared to others.

 

## 5. Feature Extraction

The facial feature extraction is the second step of the emotion recognition via facial feature extraction. As the feature plays an important role in emotion recognition therefore selecting the set of feature point is an important task. There are many approaches have been given for the feature extraction and some of the hybrid methods also been given. The some of the feature extraction methods are Gabor wavelet, Principal Component Analysis (PCA), Discrete Cosine Transform (DCT), Linear Discriminant Analysis (LDA), Dual Tree-complex wavelet Transform (DT-CWT), Discrete wavelet Transform (DWT), Bezier curve and many hybrid methods are also present.

### A. Principal Component Analysis (PCA)

Principal Component Analysis also known as eigenface method which defines a feature space. The PCA is one of the popular methods which reduces the dimensionality of the original data space and also used for feature selection. The PCA algorithm work as follows for feature extraction: The image of rectangular matrix is converted into column vector which contains the mean value of the each row. Normalization vector is calculated by determining the difference between column vector of an image and the mean vector calculated from all column vectors.

$$\mu = \left(\frac{1}{m}\right)\sum_{n=1}^{m} x_n$$

$$c = \left(\frac{1}{m}\right)\sum_{n=1}^{m}(x_n - \mu)(x_n - \mu)^T \quad (1)$$

The mean and covariance matrix is calculated by using equation (1). This normalization vector is given as an input to the principal component analysis which returns score in the image. The rows of scores correspond to the observations and columns to the components [23]. Principal component returns latent *i.e.*, a vector containing the Eigen values of the covariance matrix of the image. Rows in the matrix X, represents the observations and the columns correspond to the variables. The economy of principal component returns only the elements of latent that are not necessarily zero. There is also some drawback of PCA like poor discriminating power within the class and it has large computation also.

### B. Linear Discriminant Analysis

Linear Discriminant Analysis overcomes the drawback of PCA of poor discriminating power. LDA is the generalization of the Fisher's linear Discriminant. LDA reduces dimensionality while preserving the class discriminatory information as much as possible. LDA linearly transform the original data space into low dimensional feature space where the data is well separated. Sometimes combination of PCA and LDA is also use as PCA reduce the dimension of filtered feature vector and LDA extracts the features [24]. LDA is used to decrease the number of features to a more manageable number before classification. Each of the new dimensions is a linear combination of pixel values, which form a template. The linear combinations obtained using Fisher's linear discriminant are called Fisher faces, while those obtained using the related principal component analysis are called Eigen faces.

### C. Gabor Wavelet

Gabor Wavelet is applied to images to extract features aligned at particular angles called orientation. The Gabor Wavelet extract the local features and provides optimal resolution (localization property) in both spatial and frequency domain. Gabor phases are

sensitive to local variation and they can discriminate between patterns with similar magnitude that is they provide more detailed information about the local image feature. The set of 40 Gabor kernels with magnitude at 5 scale and 8 different orientations [24-26]. The Gabor wavelet (kernel filter) can be defined as follows

$$G_{u,v}(x,y) = e^{\frac{((u^2+v^2)(x^2+y^2))}{2\sigma^2}}(e^{i(ux+vy)} - e^{\sigma^2/2}$$

Where, $u = \left(\gamma/_{fnu}\right)\cos\left(pi * mu/_8\right)$,

$v = \left(-\gamma/_{fnu}\right)\sin\left(pi * mu/_8\right)$, $\gamma = pi/_2$

and $f = \sqrt{2}$

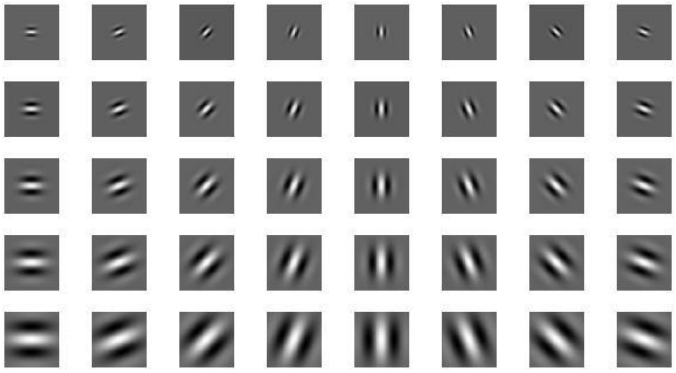

**Figure 3. Different Scales and Orientations of Gabor Filters**

The Figure 3 shows the 40 different scales and orientations of Gabor filters [25]. The advantage with the Gabor filter is that it concentrates on important component of face such as eyes, mouth, and nose. Gabor features are invariance to illumination, rotation, scale and transform and have optimal localization property, But the Gabor wavelet is time consuming.

### D. Discrete Cosine Transform (DCT)

The Discrete cosine transform is used to extract the global features. The large area illumination variations are also alleviated by discarding the first few low frequency DCT coefficients. The basic DCT equation to compute the i,jth entry of the image [26].

$$D(i,j) = \frac{1}{\sqrt[2]{2N}}\, c(i)c(j)\sum_{x=0}^{N-1}\sum_{y=0}^{N-1} p(x,y)\cos\left[\frac{(2x+1)i\pi}{2N}\right]\cos\left[\frac{(2y+1)j\pi}{2N}\right]$$

$$c(u) = \begin{cases}\frac{1}{\sqrt{2}}, & if\ u = 0\\ 1 & \text{if } u \geq 0\end{cases}$$

When we apply the DCT for feature extraction from the N*N image then we get a 2D coefficient matrix in this matrix high frequency components are located at the top left corner of the matrix and the low frequency component are located at the bottom right corner of the matrix. DCT uses cosine functions; the resulting matrix depends on the horizontal, diagonal, and vertical frequencies. The DCT has many advantages such as energy compaction, orthogonality and seperability, image compression but the DCT is sensitive to changes in the illumination direction is the disadvantage.

### E. Dual Tree- Complex Wavelet Transform (DT-CWT)

The DT-CWT has two DWTs mainly named as Tree-a and Tree-b. The Tree–a is the real part of the transform where as the Tree-b is the imaginary part. The DT-CWT is

 

introduced to overcome the drawbacks of DWT. [27]. The 2-D DT-CWT will give four distinct sub-bands from the raw image consist of complex coefficients. . There will be six oriented complex high pass sub-images at each level and a low frequency part of the image which contain most significant information. In 2-level DT-CWT implementation, magnitude part of six sub-images of all 2 levels and the low frequency part are used for representing the cropped eye and mouth regions [28].

## 6. Classification

The classification of facial expression to recognize the emotion is the third or may be the last step of emotion recognition in which the classifier is used to classify the emotion of the given input image [29]. After face detection and feature extraction is done from the image, and then these extracted features are given as input to the classification system which in turn returns a predefined category of emotion. There are various types of classification method namely classification can be done through neural network techniques like Multilayer Perceptron, Radial Basis function, Error Back Propagation and *etc.*. The other classification techniques are Support Vector Machine (SVM), Naive Bayesian (NB) classifier and many hybrid methods are also use. The emotion classification method used mainly focused on the universally defined six emotion namely sad, happy, fear, disgust, surprise and anger. There are also some non-universal emotions like wonder, amusement, greed and pity, but most of the work is done for universal emotions.

### A. Naïve Bayesian (NB) Classifier

This is a Probabilistic method that has been shown very effective in many classification problems. This method considers that the presence of a particular feature of a class is unrelated to the presence of any other feature. The formula for classification used is $C = \text{argmax}\{P(C_i) \prod P(f_i/C_i)\}$
Where $P(f_i/C_i)$ are conditional tables or conditional density learned in training using examples. Naïve Classifier has shown very good classification results for many real datasets [30].

### B. Radial Basis Function (RBF)

RBF has been used in many applications like prediction, function approximation and classification. It is more robust and efficient than any other conventional neural network. The RBF has fast learning speed due to the locally tuned neurons. Radial Basis Function also consider as an approximate neural network [26].

### C. Multilayer Perceptron (MLP)

MLP is a feed forward artificial neural network that maps sets of input data onto a set of appropriate output. MLP follows supervised learning technique. This supervised learning method also called back propagation for training the network. MLP is an improvisation of the standard linear Perceptron and can distinguish data that are not linearly separable[ 31]. Hayet Boughrara ·Mohamed Chtourou Chokri Ben Amar and Liming Chen [32] in their study of Facial expression recognition based on a MLP neural network using constructive training algorithm works with MLP of Three layer. The number of input neurons is equal to the size of related feature vector. Same as, the number of output neurons is equal to the number of facial expressions to be recognized. In the learning phase, the desired output neuron has 1 for the correct input pattern and 0 for all others output neurons. The hidden layer is constructed using the proposed constructive training algorithm. There are two steps on the realization of the facial expression recognition system using the MLP architecture: the training step and the testing step. The

learning algorithm used this study is the standard back-propagation [33].MLP requires the network architecture definition before the training. This is known that there is no general answer to the problem of defining neural network architecture for the given problem but MLP works well if the network architecture is properly chosen. MLP neural network is by a trial and error procedure. An alternative is to use constructive algorithms which try to solve the problem by building the architecture of the neural network during its training.

### D. KNN Classifier

Suja P., Shikha Tripathi and Deepthy[27] use the K- nearest neighbor classifier as a classification technique. They have worked as suppose we have C classes of N samples each, then the distance between the test sample and each of the samples is calculated. The test data belongs to the class with which the distance is minimum. They use the Euclidean Distance method to calculate the distance. In which they consider two points in the XY-plane; the shortest distance between the two points is along the hypotenuse, which is the Euclidean distance. Euclidean Distance = $\sqrt[2]{\sum_{i=1}^{n}(x_i - y_i)^2}$ where X = [x1, x2, x3,…… xn] and Y = [y1, y2, y3,…… yn]

### E. Support Vector Machine (SVM)

SVM is one of the most important classification techniques. The SVM classifier views the classification problem as a quadratic optimization problem. As the SVM classify the data with the set of support vectors by minimizing the structural risk, the average error between input and their target vectors is reduced. SVM is used in various recognition problems like face recognition, pattern recognition, and emotion recognition and in many more applications. The SVM classifier giver better generalization results than traditional neural network classifier [24-28].

## 7. Conclusion

Development of an automated system that accomplishes facial expression recognition is difficult. Numerous methods have been made towards recognition of robust facial expression, using different image detection, feature extraction, analysis and classification methods. This paper has briefly overviewed the methods of facial expression recognition. In this study paper various outward appearance acknowledgment routines and its related regions are being outlined. In prior outward appearance acknowledgment plan, execution is dissected on the exactness' premise, computational time and acknowledgment rate. This works objective was to introduce the recent advances in face appearance recognition and also associated areas in a particular manner that should be understandable even by the new researchers who are working in this area but have no background knowledge on the same. In order to do so, we have surveyed at the various aspects of facial expression recognition in detail.

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