

# Hybrid Approach of Facial Expression Recognition

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**Abstract**— In recent year facial expression recognition system has gained much popularity in the field of security because facial expression recognition system integrates with the face recognition system make entrenched and improve its strength. Automatic recognition of facial expression achieves greater attraction of researcher and human facial expressions have the ability to communicate emotion and play a major role in the study of psychological phenomena and the progress of nonverbal communication. This paper present facial expression detection method by first skin color segmentation for detecting face and then extract facial feature like eyes and lips after finding the interest point on these facial landmark. Then drawing Bezier curve of these facial points and on the basis of changes in muscles around the eyes, nose and mouths we recognize the three basic facial expressions and achieved expected results.

**Keywords**— Facial expression recognition, Bezier curve, Haar like feature, corner points, muscles movement.

## I. INTRODUCTION

In today's world the face identification and facial expression recognition of human face automatically done by the computer due to the speedy progress of computer software and hardware technology [4]. Human facial expressions have the ability to communicate emotion and regulate interpersonal behavior and facial expression of emotion was an innate, adaptive, and physiological response which could provide evidence of an individual's internal mental state [5]. The common Facial expressions are smile, sadness, surprise and anger where smile indicates happiness, enjoyment or satisfaction and sad indicates depression, gloominess and surprise indicates shock, amazement, astonishment. There are many application areas of emotion recognition systems in the image processing world. In human computer interaction (HCI) scenarios, emotion recognition is a crucial task and one of the main application areas of facial expression recognition is human-robot communication. Artificial Intelligence has long relied on the area of facial emotion recognition to gain intelligence on how to model human emotions convincingly in robots. Continuous improvements in this area have encouraged the researchers to extend the applicability of facial emotion recognition to areas like chat room, video conferencing. The ability to recognize emotions can be valuable in face recognition applications as well. Suspect detection systems and intelligence improvement systems meant for children with mind progress disorders, Clients facial expressions can also be collected by service providers as implicit user feedback to boost their service are some other beneficiaries. Rest of the paper followed in this manner Section II describes the literature survey, Section III

describes how to extract the face eyes and mouth automatically in query image, Section IV describes the feature extraction for detecting corners and wrinkles, Section V describes the Drawing Bezier Curve on Eye and Mouth, Section VI describes proposed methodology and Section VII describes conclusion.

## II. LITERATURE SURVEY

Caifeng Shan et al [1] recognized facial expression based on statistical local features, Local Binary Patterns. They used Boosted-LBP to extract the most discriminant LBP features and support vector machine classifiers for achieving best recognition performance. LBP features perform stably and robustly over a useful range of low resolutions of face images, and yield promising performance in compressed low-resolution video sequences captured in real-world environments. Zhengyou Zhang [2] works within an architecture which is based on two layer perceptron and applied Gabor wavelet coefficients as a feature. Akinori Ito et al [6] detect smile, they firstly used the skin color detection for the detection of face area. Then detect the feature points like two eyes nose and mouth and on the basis of lip length, lip angle and mean intensity of cheeks area measure the smile and achieve 80% accuracy. Caifeng Shan [3] used the intensity differences between pixels in the grayscale face images as features and provides 85% accuracy by examining 20 pairs of pixels and 88% accuracy with 100 pairs of pixels on GENKI database. Shinohara and Otsu [10] applied a hybrid approach of Higher order Local Auto-Correlation (HLAC) features and Fisher weight maps. HLAC features are computed at each pixel in an image. These features are integrated with a weight map to obtain a feature vector. The optimal weight map, called a Fisher weight map, is found by maximizing the Fisher criterion of feature vectors. Fisher discriminant analysis is used to recognize an image from the feature vector and claim result of 97.9% on JAFFE database. P.Li et al [11] applied a neural architecture that combines fixed and adaptive non-linear 2-D filters. The fixed filters are used to extract primitive features, whereas the adaptive filters are trained to extract more complex features for facial expression classification and method is test on JAFFE and claim the result of 99.0%. Soetedjo [8] used the method based-on the normalized RGB chromaticity diagram for detecting the smile and achieve the result of 94%. Matthew S. Ratliff and Eric Patterson [13] create an active appearance model (AAMs) of still image to represent shape and texture variation and parameters of AAMs are used for recognizing facial expressions of human face.

### III. EXTRACTING FACE, EYES AND MOUTHS

#### A. Face Detection

We applied method of face detection which is based on the Viola and john [7], [9] algorithm. They breakthrough in research of face detection using an Integral image, simple Haar like feature and adapt Adaboost algorithm for converting weak classifier into strong classifier and get outperform than existing face detection algorithms.

1) *Integral Image*: It is the intermediate representation of the original image was firstly used by Viola and john in image processing and by using this integral image rectangle feature is calculating very fast. The integral image at the location p, q contains the sum of the pixels above and to the left of p, q inclusive:

$$II(p, q) = \sum_{p' \leq p, q' \leq q} I(p', q')$$

where  $ii(p, q)$  is the integral image and  $i(p, q)$  is original image. Integral image computed in one pass over the original image using the following pair of recurrences:

$$x(p, q) = x(p, q-1) + i(p, q) \quad (a)$$

$$ii(p, q) = ii(p-1, q) + x(p, q) \quad (b)$$

where  $x(p, q)$ =cumulative row sum,  $x(p, -1) = 0$  and  $ii(-1, q) = 0$ .

2) *Haar Like Feature*: Haar like feature in Fig. 1 [15] is

like wavelet Haar feature and before introducing this calculation of features of an image was computationally costly. These features in form of intensity are calculated via integral window (integral image) process over the original image, sum of pixels in black region is subtracted from sum of pixels in white region. Although feature calculated by each sub window are extremely greater than pixels that's why an Adaboost algorithm is used for reducing the complexity of feature selection.

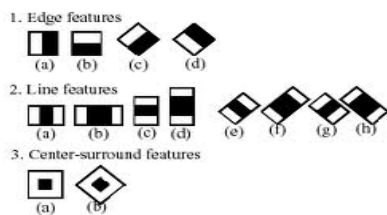


Fig.1 Haar like Feature

3) *Adaboost*: Adaboost in Haar cascade method is for training by supervised learning to classifying positive and negative sample, to classifying two decisions and Adaboost learn weak classifier by cascading weak classifier whose output is just random gauss and make strong classifier therefore reduced the computation time. At each stage of the cascade, apply more strict rules for adding less and more different Haar feature and features which not indicates to face is rejected. When an image is given to a cascade of classifiers and if it passes all the classifiers then this will represent the presence of face with high probability. Figure 2 shows query image and detected face.

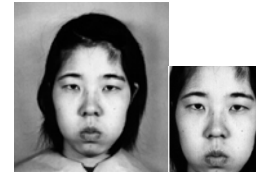


Fig. 9 Bezier Curve of facial feature

#### B. Eye Detection

For extracting the eye region, firstly we convert RGB image into gray image. Then we find the width and height of the extracted face. We use the relative distance between the eyes and other facial landmark and crop the region. Figure (3) shows average relative distance between the facial features. Got the region in which both eye are presents. For extracting both eyes separately left side of the left eye is the starting width of the image and the right side of the right eye is the ending width of the image. Then we cut the upper position, lower position, left side and the right side of the two eyes from the image. Fig.4 and fig. 5 shows the single and both cropped eye respectively.

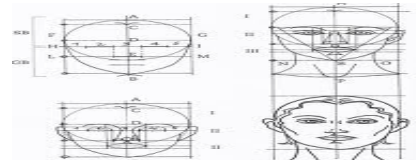


Fig. 3 Dimension of Facial landmark



Fig.4 Cropped single Eye



Fig. 5 Cropped both Eyes

#### C. Mouth Detection

For extracting mouth region same process is repeated as we done for detecting eyes except the dimensions of width, height, x axis and y axis are different here. Fig. 6 shows the cropped mouth.



Fig. 6 Cropped Mouth

### IV. FEATURE EXTRACTION FOR DETECTING CORNERS AND WRINKLES

For discovering the feature points firstly we have to set the searching region of the points. We have considered face region, eye region, lip region and nose region as the searching area for the feature points and we process all of these regions for locating the feature points separately. We used two different methods of extracting feature, first for detecting corner features points on lips and eyes and another for extracting feature point for detecting the mussel's movement around eyes and mouth. Fig. 7 shows the corner points on the facial feature and around the facial feature.

We detect the interest points on the facial feature by Shi and Tomasi [14] method which calculates minimum of two eigenvalues of the matrix instead of calculating the score from the function F. Complete algorithm describe in following manner-

$$F(u, v) = \sum_l \sum_m w(l, m) [i(l + u, m + v) - i(l, m)]^2$$

Where: F is Sum of squared differences between the original and moved window, u - l is direction window displacement,

v - m is direction window displacement, w(l, m) is Weighting function of the window, either a gaussian or a window of ones, i(l + u, m + v) is intensity of the moved window, l x m is window size.

Taylor series approximation of i(l + u, m + v) - i(l, m) are:

$$F(u, v) = \sum_l \sum_m w(l, m) [i(l, m) + u i_u + v i_m - i(l, m)]^2$$

Now, matrix form of this approximation is-

$$F(u, v) = \sum_l \sum_m [u \quad v] w(l, m) \begin{bmatrix} i_u^2 & i_u i_m \\ i_u i_m & i_m^2 \end{bmatrix} \begin{bmatrix} u \\ v \end{bmatrix}$$

Then structure tensor form of final matrix is-

$$S = \sum_l \sum_m w(l, m) \begin{bmatrix} i_u^2 & i_u i_m \\ i_u i_m & i_m^2 \end{bmatrix} \begin{bmatrix} u \\ v \end{bmatrix}$$

Now calculating the two eigenvalues (e<sub>1</sub>, e<sub>2</sub>) of S and take one which is minimum and consider as the corner point or interest point-

$$E = \min(e_1, e_2)$$

We detect the corner points around the facial feature by the Rosten & Drummond [16] method which compares Local Intensity of pixel for determining that a pixel is a possible corner if it has either, contiguous valid bright surrounding pixels, or contiguous dark surrounding pixels. The value of contiguous pixel is depend our requirments. Suppose that p is the pixel under consideration and j is one of the pixels surrounding p. I<sub>p</sub> and I<sub>j</sub> are the intensities of pixels p and j, respectively. Pixel j is a valid bright surrounding pixel if I<sub>j</sub> - I<sub>p</sub> ≥ T. Similarly, pixel j is a valid dark surrounding pixel if I<sub>j</sub> - I<sub>p</sub> ≤ -T. In these equations, T is the value you specified for the Intensity comparison threshold parameter.

$$R = \max(\sum_{l,j} w(l, j) |I_j - I_p| - T, \sum_{l,j} w(l, j) |I_j - I_p| + T)$$

### V. DRAWING BEZIER CURVE ON EYE AND MOUTH

The Bezier curve [12] is more specific curve used for automobiles, ship hull, string art, and pen tool of computer graphics also used the Bezier curve for image manipulation. In general Bezier curve is used to smoothing the path by engendering the contour points and all these contour points are engenders by taking whole shape information into account. Curve is formed by passing through first and last points and these points are control points of Bezier curve. In 2d shape if we have n+1 control points then position is defined as P<sub>i</sub>: (X<sub>i</sub>, Y<sub>i</sub>), 0 ≤ i ≤ n.

Integrated these coordinate points to form P(°), which describes the path of Bezier polynomial function between P<sub>0</sub> and P<sub>3</sub>, where u is the equidistant parametric function and by changing the values of u from 0 to 1 we got the values of various points of Bezier curve. Fig. 8 shows the Bezier curve of four points.



Fig. 7 Detected corner points on the facial feature and around the facial feature

$$p(u) = \sum_{k=0}^M \frac{M!}{(M-k)!k!} u^k (1-u)^{M-k} P_k, 0 \leq u \leq 1$$

Here 0! and u<sup>0</sup> = 1 when u and k are both 0

$$P(u) = \sum B_{r,M}(u) P_r \text{ or } \sum_{k=0}^n P_k B_k(u), 0 \leq u < 1$$

Where blending function B<sub>r,M</sub>(u) are given by

$$B_{r,M}(u) = C(M, r) u^r (1-u)^{M-r}, C(M, r) = M! / (M-r)! r!$$

and if P<sub>1</sub> P<sub>2</sub>, P<sub>3</sub>... P<sub>n</sub> are the position vector of the N+1 vertices of generalized characteristic polygon.

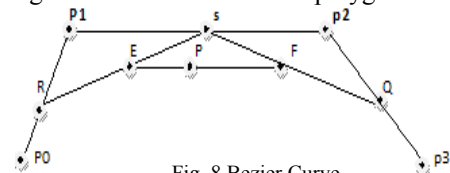


Fig. 8 Bezier Curve

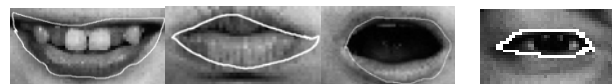


Fig. 9 Bezier Curve of facial feature

General shapes of the Bezier curve for smiley, sad and surprised mouth are shown in the image first, second and respectively and fourth image shows the Bezier curve on eye. Fig. 9 shows the general Bezier Curve of facial feature.

### VI. PROPOSED METHODOLOGY

We studied general rules for recognizing facial expression of emotion like if we smile our mouth is opened, and eyes became small. If we sad our mouth is closed and eyes are small. If we surprise our eyes are opened and our mouth also opened. Main difference between opened mouth of smile and surprise is that in smiley opened mouth lip distance horizontally increased but in surprisingly opened mouth lip corner distance is vertically increased. We also studied when our facial expression changed mussels movements also changed. We use Genki and JAFFE

database. The faces with expressions are compared against the model face database images consisting of neutral face, smiley face, sad face and surprised face. The Bezier points are interpolated over the principal lines of facial features. For detection of facial emotion, we need to compute the curvature of the curve line correspondence of region between an input image and the images in the database. Then, apply threshold on the calculated parameters and take decision of facial emotion recognition. Fig. 10 shows the complete process of facial expression recognition.

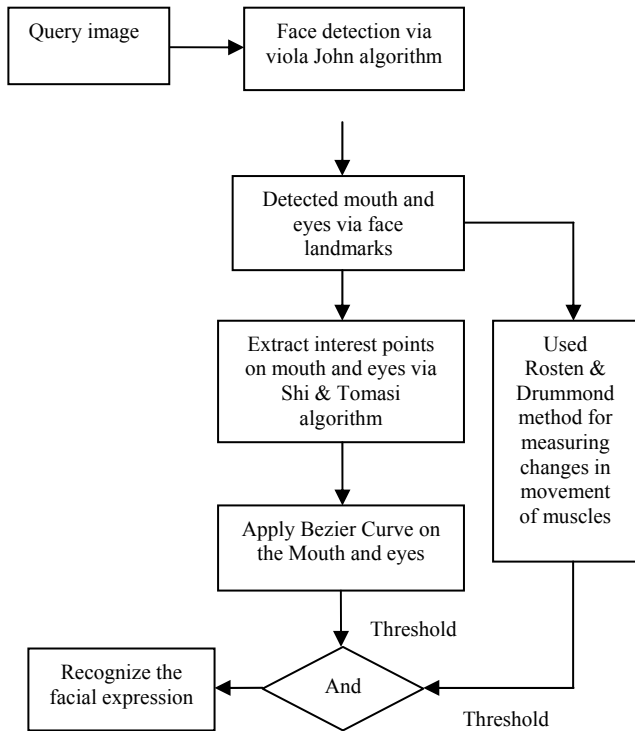


Fig. 10 Complete process of facial expression recognition

Calculating the derivative of the line of best fit, the concavity of the points is determined, and from that recognized the facial expression of particular face. We take three facial expression smile, sad and surprised in images and if we take four points on lips and applying these point as input of Bezier curve and taking the value of u is 0.1, get 11 points which shown by Table (1) and Table(2) respectively. We find that for best smiling face the no of corner around the facial feature should be greater than 12 and optimum value of the threshold parameter which is calculated after fitting the curve is 0.0112 and for the sad face is 0.001.

TABLE I Control points

Smile expression		Sad expression		Surprised expression	
P(x)	P(y)	P(x)	p(y)	P(x)	p(y)
99	186	112	198	108	209
129	186	192	199	126	199
129	206	129	206	129	221
155	188	196	190	143	205

TABLE. II Bezier points

Smile expression		Sad expression		Surprised expression	
P(x)	p(y)	P(x)	p(y)	P(x)	p(y)
107.1560	186.620	116.0510	196.7560	112.9760	206.8900
113.8480	188.2240	119.3280	196.4480	117.2080	206.2800
119.4120	190.4014	122.0170	196.8120	120.8520	206.7500
124.1840	192.7520	124.3040	197.5840	124.0640	207.8800
128.5000	194.8750	126.3750	198.5000	127.0000	209.2500
132.6960	196.3680	128.4160	199.2960	129.8160	210.4400
137.1080	196.8290	130.6130	199.7080	132.6680	211.0300
142.0720	195.8560	133.1520	198.3240	135.7120	210.6000
147.0720	193.0470	136.2190	196.000	139.1040	208.7300

VII. CONCLUSION

In this paper we have used a hybrid method of recognizing facial expression for emotion which based on Bezier curve of mouth interest points and eye interest points and on the basis of mussels movements. We achieve accuracy up to 83 percent on Genki database for detecting smile, if the face is detected by the viola and john algorithm correctly and two other facial expressions tested on JAFFE(Japanese Female Facial Expression) database and achieve accuracy up to 70%. The main problem to achieving high accuracy is that mouth shape is different from one person to other and we have only one single query image for the measurement.

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