EMOTION EXTRACTION IN COLOR IMAGES USING HYBRID GAUSSIAN AND BEZIER CURVE APPROACH

Navleen Kaur[1], Madhu Bahl[2]

[1]M.Tech Student, Department of Computer Science, CEC, Landran.Punjab (India)

[2]Assistant Professor, Department of Computer Science, CEC, Landran.Punjab (India)

ABSTRACT

As multi-media technology especially image processing is going through a rapid development and the requirement to study how human beings reflect to environments in affective computing, facial expression extraction and synthesis has become an important technological and research issue. Emotion extraction systems have been proposed to extract emotions from a human face. These systems play an important and effective role in Human-Computer Interaction and also find their applications in customer services, game and entertainment industries, security systems, animations, etc. In this paper emotion extraction is done using hybrid Gaussian and Bezier curves approach to get more accurate recognition rates and to achieve higher performance. The idea behind this paper is to extract emotions from eyes and lips along with the classification of different facial expressions into one of the five basic human emotions, viz. Smile, Angry, Sad, Neutral and Surprise.
Keywords: Emotion Extraction, Gaussian models, RGB and YCrCb Color space, Bezier Curves.

1. INTRODUCTION

Image segmentation is the process of partitioning a digital image into multiple segments (sets of pixels, also known as super pixels). The main goal of segmentation is to simplify and change the representation of an image into something that is more meaningful and easier to analyze [1]-[2]. The major applications of image segmentation are face detection and recognition and emotion extraction as well.

1.1 Emotion extraction
The review of facial expression analysis goes back to the nineteenth century. Darwin demonstrated in 1872 the universality of facial expressions and their continuity in man and animals. Ekman and Friesen postulated six primary emotions in which each possess distinct content in 1971 and these prototypic expressions are also called basic emotions. These emotions comprises of happiness, sadness, fear, disgust, surprise and anger [3]. As facial expressions provide a key mechanism for understanding and conveying emotion, emotion extraction through facial expression recognition has attracted great attention in both scientific research and practical applications in recent years [4]. Every Emotion Recognition System includes three main steps as shown in Figure 1:
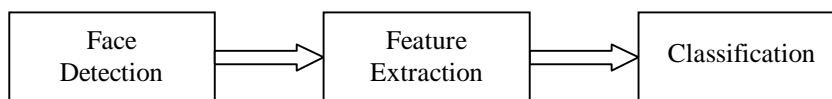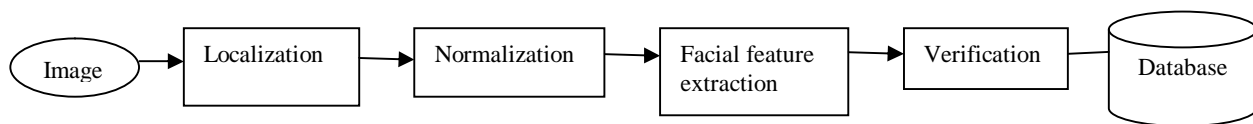1. Face Detection.
2. Feature Extraction.
3. Classification. [5]

Face Detection → Feature Extraction → Classification

Figure 1: Steps of Emotion Extraction

1.1.1 Face Detection and Feature Extraction
Face detection is a computer technology that determines the locations and sizes of human faces in arbitrary (digital) images [6]. The main steps of this process are shown in Figure 2:
a) Localization: In this step the region of an image is located where the face is located.
b) Normalization: Using normalization process, the face region is aligned in such a way that all the facial features are in their proper location.
c) Facial feature extraction: In this step of face detection, various facial features like eyes, nose, lips, etc are extracted from the detected face region.
d) Verification: In the verification process, the relationships are verified between various features with some database entry containing a huge number of faces.

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Figure 2: Steps of Face detection and feature extraction

1.1.2 Classification

The main goal of emotion classification is to create a system which can identify specific human features and use them to convey information. By observing face, it can be decided whether one is serious, happy, thinking, sad, feeling pain and so on [7]. Mehrabian found that when people are communicating feelings and attitudes, 55% of the message is conveyed through facial expression alone, 38% of the message by vocal cues and the remaining 7% is through verbal cues. Ekman and Friesen did rigorous study on facial expression and came to conclusion that facial expressions are universal and innate [8].So after detecting the face and extracting the features from the face; the different emotions are classified.

1.2 Applications of Emotion Extraction

a) Recognizing the expression of a man can help in many of the areas like in the field of medical science where a doctor can be alerted when a patient is in severe pain. It helps in taking prompt action at that time.

b) Face detection and recognition, as an important component of pattern recognition, has a wide range of applications on virtual reality, videophone system and security system etc. [9].

c) Facial expression recognition has been a subject of investigation in the last years due to the great number of potential day-to-day applications such as human–computer interaction (HCI), emotion analysis, automated tutoring systems, smart environments, operator fatigue detection in industries, interactive video, indexing and retrieval of image and video databases, image understanding, and synthetic face animation [10].

d) Other applications that use emotion recognition are customer services, intelligent automobile systems, game and entertainment industry, automated systems that provide aid to psychologists, behavioral and neuroscience researchers [5].

e) Facial expression recognition systems can also provide a less intrusive method to apprehend the emotion activity of a person of interest [10].

f) Apart from the two main applications, namely robotics and affect sensitive HCI, expression recognition systems find uses in a host of other domains like Telecommunications, Animations, Affect sensitive music juke boxes and Educational Software [11].

2. METHODOLOGY

In the proposed work, extraction of human emotions is done using an integrated approach. Gaussian models and Bezier curves algorithms have been used. In this research effort, the fact has been taken into account that emotions are most widely represented with eyes and mouth expressions. The proposed system uses color images and it is consisted of different three modules. Three well differentiated modules defined in the system are:

• Face Extraction
• Facial Feature Extraction
• Facial Emotions Classification

The first module implements skin detection, using Gaussian model which defines the RGB color space and YCrCb color space. A set of several colored images with human faces have been considered as the training set. Face detection is the first step in emotion extraction system. Face extraction can be performed based on several cues such as Skin color, Motion, Facial/Head shape, Facial Appearance or combination of these parameters. Skin color is the main distinguishing feature in the human faces [12]. In RGB Color space the color is encoded as an additive combination of three primary colors: red(R), green (G) and blue (B). This model fails when there is some more skin region like legs, arms, etc while skin color model based on the Cb and Cr values can provide good coverage of different human races. The thresholds are chosen as [Cr1, Cr2] and [Cb1, Cb2], a pixel is classified to have skin tone if the values [Cr, Cb] fall within the thresholds The skin color distribution gives the face portion in the color image.Then a skin detector is used which transforms a given pixel into an appropriate color space and then use a skin classifier to label the pixel whether it is a skin or not. Skin detection means detecting image pixels that contain skin-tone color. The second module is responsible for eye and mouth detection and extraction. After face is detected in the image frame, then facial features like mouth and eye are extracted. It is assumed that there is no prior knowledge about the location of the eyes and mouth at his point [12]. Firstly the face, eyes and mouth are localized within the entire input image. In this case, the facial feature algorithm which finds the three different boxes i.e. left eye box, right eye box and the lip box is applied in order to find the positions of the eyes and mouth. The third module extract the emotions pictured in the eyes and mouth and measure the gradient of eyes and mouth region using edge detection and Bezier Curves. All extraction related to human faces and their expressions are stored into database so that it can be used later for retrieval process from the images.

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A. Face Extraction Algorithm

The skin color model developed for this work is built based on the Gaussian model that is computed using the normalized RGB, HSV and YCrCb color spaces. The three models used to represent skin with the values are given below:-

RGB Model: $0.836G – 14 < B < 0.836G + 44 =>$ Skin OR $0.79G -67 < B < 0.78G + 42 =>$ Skin

HIS/HSV Model: $19 < H < 240 =>$ Not skin

YCrCb Model: $140 < Cr < 165 =>$ Skin OR $140 < Cr < 195 =>$ Skin

Firstly, a color image is taken as input and it is converted into RGB color space. The pixels which lie in the above boundaries of different models, they represent a skin. Then after detecting the skin, the required face region is cut. Figure 3(a) shows the flow chart for this module and Figure 3(b) shows the implementation of this module.
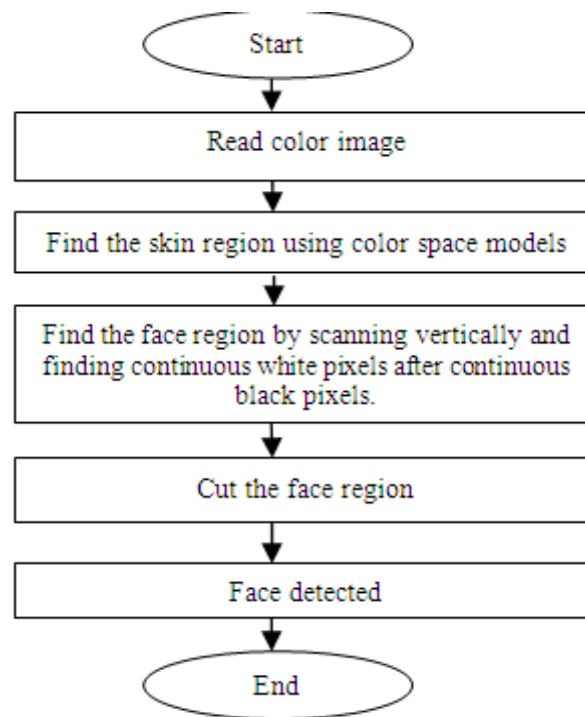

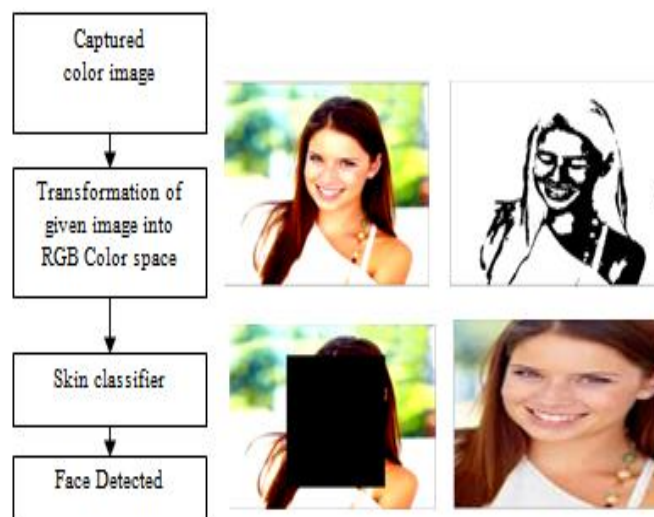**Figure 3(a):** Flowchart of Face Extraction Module

Figure 3(b): Implementation of Face Extraction Module

B. Facial Feature Extraction   Algorithm

After the face is detected from the color image, and then facial features like eyes and mouth are located and extracted. Firstly the eyes and mouth are localized within the input image. In this search mode, the search space for face in subsequent color image is reduced to the small area surrounding the eyes and mouth. The eye boxes and lip box is extracted from the detected face. Figure 4(a) shows the flow chart for this module and Figure 4(b) shows the implementation of this module.
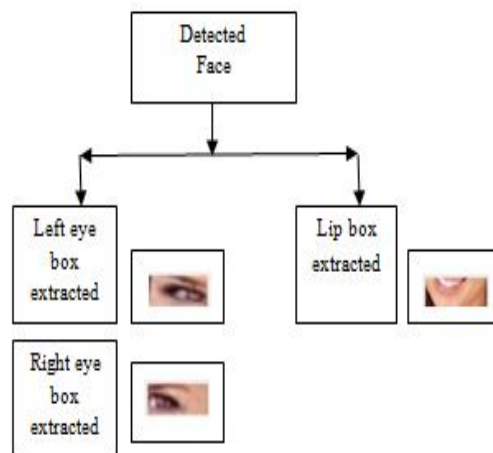
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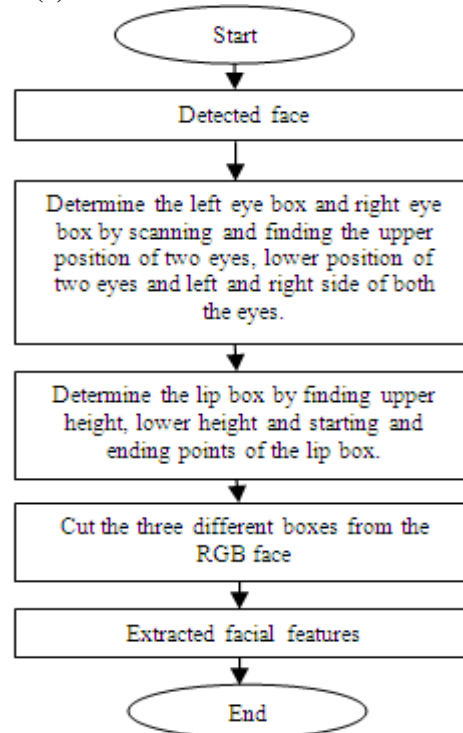**Figure 4(a):** Flowchart of Feature Extraction Module

Figure 4(b): Implementation of Feature Extraction Module

C. Emotion Recognition using Bezier Curves

This research work makes use of Bezier curves for detecting various emotions viz. Smile, Sad, Angry, Normal and Surprise because of which the emotional state in the color image can be found out. The inputs to the system are the features extracted from the face i.e. the eyes and lip boxes and output is the emotion extracted from these features. Then the extra portion is removed from the boxes and largest connected region is found out. In the eyes box; eyes are the largest connected regions and in the lip box; lip is the largest connected region. Then Bezier curve is applied by finding the starting and ending pixel of the eyes and lip in horizontal. Two tangents are drawn on upper lip from the starting and ending pixel and similarly on lower lip. Two Bezier curves are drawn for the lip, one for upper lip and one for lower lip. Similarly for both the eyes Bezier curves are drawn. The Bezier curves generates contour points considering global shape information with the curve passing through the first and last control points and if L+1 control points are present, the position is defined as $P_k(x_k, y_k), 0 \le k \le L$ considering 2D shapes. These coordinate points are then blended to form $P(t)$ that explains the path of Bezier polynomial function between $P0$ and PL:

$$P(t) = \sum_{k=0}^{L} P_k \, BEZ_{k,L}(t)$$

In this Bezier blending function $BEZ_{k,L}(t)$ is known as the Bernstein polynomial and the coordinates of individual Bezier curve are represented by the following pair of parametric equations:

$$x(t) = \sum_{k=0}^{L} x_k \, BEZ_{k,L}(t)$$

$$y(t) = \sum_{k=o}^{L} y_k \, BEZ_{k,L}(t)$$

3. EXPERIMENTAL SET UP AND RESULTS

The images of jpg format have been used to show the performance of the proposed system. The image shown in the Figure 5 (a) is the input image and Figure 5(b) shows the extraction of emotion from the given input image. Extraction of human emotion using Gaussian models and Bezier curves considers the sets of several colored images with human faces as the training set. This hybrid algorithm acquires the correct emotions from the different colored images. This technique has significantly improved the results.

Figure 5(a): Input image

Figure 5(b): Result image showing the expression "Smile"

The above experiment was carried out on 160 different images and the Table 1 shows the results for the same. The system gives 91.25% accuracy for Emotion Extraction. The table results proved that the proposed technique enhances the recognition rate of emotions thereby improving the performance of the system.

Table 1: Table showing the percentage of different expressions extracted

RECOGNIZED EMOTIONS	NO. OF IMAGES	CORRECT EXTRACTION	ERROR IN RESULTS	% ACCURACY
SMILE	25	23	2	90.00%
SURPRISE	70	65	5	92.85%
SAD	20	18	2	90.00%
ANGER	30	27	3	92.00%
NORMAL	15	13	3	86.66%
TOTAL	160	146	15	91.25%

4. CONCLUSION

Emotion extraction has become one of the most active research areas due to its contribution to human computer interaction analysis. In this paper a hybrid algorithm of Gaussian models and Bezier Curves was proposed in order to extract emotions from different colored images. It is an improvement over previous techniques as it takes into consideration the obstructed features of a human face and it demonstrates high recognition rates and also the errors were small as compared with the conventional method. The newly proposed and implemented algorithm evaluated on 160 images is much faster and has given much better results for extraction of emotions from the human face.

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