Face Localization based on Skin Color

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ABSTRACT
Face detection plays an important role in many applications of face biometrics. With so much of digitalization, many color images and different color models have evolved in recent years. To detect a face in such image, localizing the face from other background objects have also been a challenging task. Segmenting an image based on skin color as feature had been the motive of this paper. The paper implements region based skin color detection using L*a* b color model and a hybrid color model. Face is localized by a bounding box. Both the color models have been implemented to localize face for a set of database images, for some of real time images and have an accuracy of 92% and 93% respectively.

Keywords
Face localization, Skin color, L*a*b, Hybrid color, Region based, Bounding box.

1. INTRODUCTION
Face Biometrics has gained popularity in many applications for authentication, education, medical assistance, expression analysis for psychometrics. To recognize a face and classify facial expression the basic step is face localization. Skin color is a distinguishing feature to localize a face from the background objects. Many skin color models are surveyed for face localization and detection[1] which includes RGB color model, L*a*b color model, YCbCr Model and the techniques like connected component labeling , Gaussian model, ellipitical boundary model. Oliver Jesorsky et.al have localized face using Sobel edge operator and Hausdorff Distance[2]. Vandana S. Bhat et.al have combined three color models and localized face using Gaussian model [3]. Dazhi Zhang et.al have applied illumination compensation and localized face by finding eyes[4].

Ali Atharifard and Sedigheh Ghofrani have facial features to detect the face in an image [5]. Sayantan Thakur have used RGB-HS-Ycbcr to detect multiple faces in an image[6].Since then many research articles exist in face localizing based on knowledge based approach, feature based approach and template matching and detection of face using Local Binary operator and moment invariants[7]. The main objective of the paper is to localize the face using skin as feature. The authors of this paper have developed two color models L*a*b and a hybrid color model using which skin region for face is localized using region labelling and a bounding box is drawn over the localized face. This paper also compares the implemented two color models.

2. SEGMENTATION BASED ON SKINCOLOR
Segmentation based on skin color is classified as pixel based skin detection[8] and region based skin detection[9]. Pixel based skin detection classifies each and every pixel as skin or non-skin. The time consumption in implementing pixel wise reduces the efficiency of the pixel method. The region based skin detection considers spatial method of segmenting the image using connected component labelling. Two skin color models that were developed in this paper to extract skin color regions of the image are region based models where face is localized using connected labelling.

3. SKIN COLOR MODELS
3.1 L*a*b Model
A Lab color space is one among the color models. It has dimension L for lightness and a for one color opponent dimension and b for another color-opponent dimensions, based on nonlinearly compressed CIE XYZ color space coordinates. L*a*b* separates intensity from a and b color components. The ‘a’ component stands between green and red/magenta wherein the ‘b’ component stands between blue and yellow. Lab color is designed to approximate vision of human. It projects to perceptual uniformity, and its L component closely matches human perception of lightness.

The input image is converted into L*a*b color model as in Figure.2. The color image is converted into two binary images based on global threshold values for each of the color components ‘a’ and ‘b’. The global threshold value is used to convert an intensity image to a binary image. The threshold is a normalized intensity value that lies in the range [0 1]. A scalar multiplication of the binary images results in skin area segmented image. Then face is localized using bounding box.The binary images are given in Figure.3 and Figure.4.

Figure.5 shows the skin area segmented image. Using connected labelling the skin segmented image is labelled and then the maximum connected area is localized and a bounding box is drawn as in figure.6.

3.2 Hybrid Color Model
The hybrid color model is derived by combining the different color components of three models HSV color model , YCbCr color model and the L*a*b color model. HSV model has three components Hue, Saturation and Value. Value is the Luminance component of the image. Hue is the dominant color representation of the image, saturation measures the colorfulness of an area in proportion to its brightness. YCbCr has the chrominance blue as ‘Cb’ component and chrominance red as ‘Cr’ component and Y is the luminance component of the image. In this model the input image is converted into each color model and the color components are separated from the image.

When the input image is converted into HSV model the resulting image is further separated into hue image and saturation image . When the image is converted into YCbCr model the resulting image is separated into Cb Component image and Cr Component image. Similarly the ‘a’ and ‘b’ color component images of L*a*b color model is also derived. The color components hue and saturation of HSV, ‘Cb’ component of YCbCr and ‘b’ component of L*a*b are combined to derive the hybrid color model. Each of the color component image is converted to binary image based on a global thresholding. The global threshold value is used to convert an intensity image to a binary image. The threshold is a normalized intensity value that lies in the range [0 1]. A scalar multiplication of the three binary images resulted in final skin area segmented image. Then face is localized using a bounding box.

3.3 Morphological Operations

Skin color tone depends on the luminance. As only the color components of each models are processed using thresholding, so it is inevitable to have noises after the segmentation. Noise may occur in connection with the face region. Inorder to remove noises morphological operations are applied. Two fundamental operations erosion – shrinking the foreground, dilation expanding the foreground are applied to remove noises and extract the region of interest. Erosion fills up internal holes and removes background noises[10]. Figure 11 is skin segmented image obtained after scalar multiplication of all the three figures 8,9 and 10 followed by morphological operations dilation and erosion. The resulted image is filled up for holes that is present in the image and thereby the facial skin image is extracted as in figure.11. Using connected labelling the skin segmented image is labelled and then the maximum connected area is localized and a bounding box is drawn as in figure12.

4. RESULTS AND PERFORMANCE EVALUATION

The color models were tested with Indian face database[11] which consists of female and male subjects with different expressions and postures and some of the real time images.

The L*a*b worked well with database images and lacked performance in real time images but the hybrid color model was tested and evaluated with its performance in both database and real time images.

The performance of the color models were evaluated using the performance metrics precision rate and recall rate[12]. The table shows four classification metrics like true positives, true negatives, false positives and false negatives.

Precision rate:

In the field of information retrieval, precision is the fraction of retrieved documents that are relevant to the search.

Precision = TP / TP+FP (1)

Recall rate:

Recall in information retrieval is the fraction of the documents that are relevant to the query that are successfully retrieved.

Recall = TP / TP+FN (2)

A number of model performance metrics [13] can be derived from the confusion matrix. The most common metric is accuracy defined by

Accuracy=TP +TN / TP+TN+FP+FN (3)

TP –True Positive, TN- True Negative, FP – False Positive, FN – False Negative.

Table-I and II shows the detection result of L*a*b color and Hybrid color model. Table – III shows the performance evaluation of both the color models.

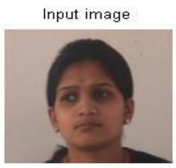

Figure:1 Input Image

Figure :2 L*a*b form

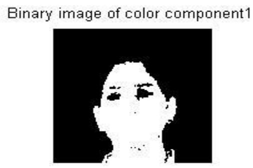

Figure:3 Binary image 1

Figure:4 Binary image 2

Figure:5 Skin image

Figure:6 Face Localized image

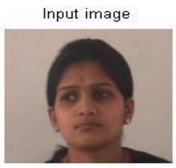

Figure :7 Input Image

Figure :8 Hue and Saturation

Figure :9 Blue chrominance

Figure :10 ‘b’ color of L*a*b

Figure :11 Skin image

Figure :12 Face Localized image

Table-1 Face Localization based on L*a*b color model

Images	True Positives	False Positives	True Negatives	False Negatives
100 Database Images + 20 non face image	97%	3%	98%	13%

Table-2 Face Localization based on Hybrid color model

Images	True Positives	False Positives	True Negatives	False Negatives
150 Database Images and real time images + 20 non face image	91%	5%	95%	9%

Table –3 Performance Evaluation

Algorithm	Images	Precision rate	Recall rate	Accuracy
Face Localization based on L*a*b color model	100 Images contain single face(database)+ 20 non face image	97%	88%	92%
Face Localization based on Hybridcolor model	150 Images contain single face(real time +database)+ 20 non face image	95%	91%	93%

Table 3 shows the performance between the two color models for face Localization using skin as a feature. It was found that the Hybrid color model has a good recall rate and accuracy than the L*a*b color model because of the combination of different color components. Figure 13 shows the comparison chart between the two color models evaluated for localizing the face from an image.

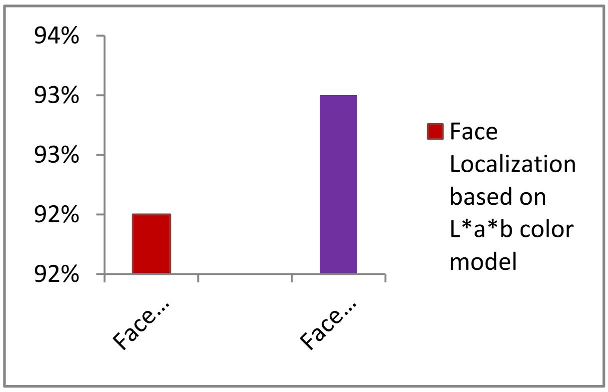

Figure. 13 Comparison chart for face localization

5. CONCLUSION AND FUTURE WORK

Different features are available to localize a face from static images but this paper deals with localizing the face from set of images using skin color as a feature for detection. While taking skin as a feature, an optimal model is needed to show a high accuracy in localizing the face. Thus the authors have applied two different color models for the same of set of database images with a global thresholding and have proved that the hybrid color model is more suitable than the L*a*b model. Also the Hybrid color model has been tried with some of the multiple face images and localization of the faces were successful. The future work can be extended to face recognition, facial expression classification and face matching based on classifiers.

6. REFERENCES

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