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Face Detection using RGB Color Model

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***Abstract*—Face is our primary focus of attention for conveying identity. Human face detection by computer systems has become a major field of interest. Detection of faces in a digital image has gained much importance in the last decade, with application in many fields. RGB color model is used in skin color segmentation to separate the human skin pixels. The specific values of red, green and blue components for human skin are described in this research paper. Filtering & labeling of an image and some morphological operations are used to find out face candidate. The different geometrical properties of human face are used to reject the non-human face region. Specific advantages of this approach are that skin color analysis method is simple and powerful, and the system can be used to detect multiple faces. This face detector has been applied to several test images, and satisfactory results have been obtained.**

Keywords—Face Detection; Color Based Segmentation; RGB color space; Region Properties.

I. INTRODUCTION

Detection of the human face is an essential step in many computer vision and biometric applications such as automatic face recognition, video surveillance, human computer interaction (HCI) and large-scale face image retrieval systems. The first step in any of these face processing systems is the detection of the presence and subsequently the position of human faces in an image.

Face detection in color images [1] has also gained much attention in recent years. Color is known to be a useful manner to extract skin regions, and it is only available in color images. This allows easy face localization of potential facial regions without any consideration of its texture and geometrical properties. A Robust Face Detection Algorithm [2] is developed by using Skin Color.

Most techniques up to date are a pixel-based skin detection method [3], which classifies each pixel as skin or "non-skin" individually and independently from its neighbors. Early methods use various statistical color models such as a single Gaussian model [4], Gaussian mixture density model [5], and histogram-based model [6].

A survey of skin color detection can be found in [7]. An automatic face detection system is based on human skin detection, natural properties of faces and the classification strength of Local Binary Patterns (LBPs) and embedded Hidden Markov Models (eHMMs) [7, 8]. A robust multi-face detection system which overcomes several current challenges in the field such as facial expression, occlusion, face rotation, face pose etc. An improved face detection system based on color information, Local Binary Patterns (LBPs) histogram matching, embedded Hidden Markov Models (eHMMs) [7, 8].

A multi-view face detection method uses the edge-based feature vectors [9]. An image based face detection and recognition [10] technique is developed by using Local Binary Patterns (LBPs) and Support Vector Machines (SVMs).

Neural Network method is used in a novel approach for recognition of human face [11]. Artificial Neural Network and Principle Component Analysis are used in Facial Expression Recognition [12].

A new face detection and recognition technique [13] uses skin color modeling and template matching.

Face detection is a challenging task because of variability in scale, presence or absence of structural components, location, facial expression, illumination, orientation (rotated face) and pose (frontal, profile). Those factors are as follows:

Pose: The image of a face varies due to the relative camera-face pose (frontal, 45 degree, profile, and upside down).

Presence or absence of structural components: Facial features such as beards, mustaches, and glasses may or may not be present and there is a great deal of variability among these components including shape color and size.

Facial expression: The appearance of faces is directly affected by a person's facial expression.

Occlusion: Faces may be partially occluded by other objects. In an image with a group of people, some faces may partially occlude other faces.

Image Conditions: When the images is formed, factors such as lighting (Spectra, source distribution and intensity) and camera characteristics (sensor response, lenses) affect the appearance of a face.

Face size: In the image, human face can exist with different sizes. Sometimes, size of existed face is too small or big to describe clearly facial components information.

The motivation of this research is to develop a face detection algorithm that is very robust against illumination, focus and facial expression. In section II, the proposed face detection algorithm is described.

The proposed algorithm has three primary stages such as, Skin color segmentation, face candidate localization and rejection of non-human face region. RGB color model is used to find out human skin areas from RGB image. Face candidate localizer is described, which is used to find out face candidates. Rejection of non-human face is described by regions properties. Section III represents the experimental results. Finally, conclusions are given in section IV.

II. OUR PROPOSED ALGORITHM

Our proposed approach has three parts: A) Skin color segmentation, B) Face candidate localization and C) Rejection of non human face skin regions. Fig.1 shows that the flowchart of our proposed approach. Skin Color Segmentation phase uses RGB color space for finding skin pixels from an input image. Selection of RGB color space is the R components is always the strongest one of human skin which has the special expression of blood color. In our analysis, different value of R, G & B components have chosen for the skin pixels.

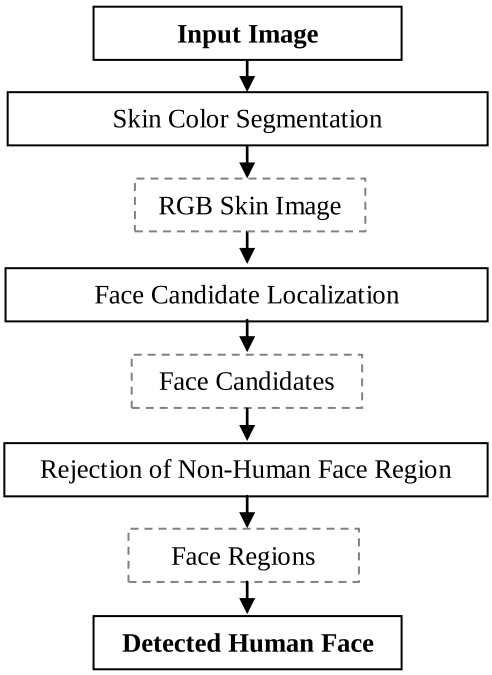


Fig. 1: Face Detection Approach.

Face Candidate Localizer is used to find out most probable face candidate for a human. Morphological operations are used in this term. By applying height and width ratio of each region, face candidates are found. In the 'Rejection of non human face skin regions' part, the most probable face regions are found by using some regions properties such as: area, eccentricity, bounding box, combination of bounding box and area, centriod.

A. *Skin Color Segmentation*

The purpose of skin color segmentation RGB color model is used to find out skin pixels from the input image. Skin color segmentation is shown in fig.2.

The RGB color space consists of the three additive primaries: red, green and blue. Spectral components of these colors combine additively to produce a resultant color.

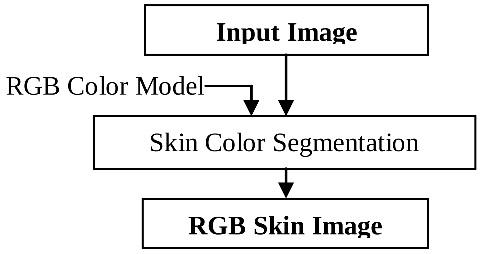


Fig. 2: Skin Color Segmentation

The RGB model is represented by a 3-dimensional cube with red, green and blue at the corners on each axis (Fig.3). Black is at the origin. White is at the opposite end of the cube. The gray scale follows the line from black to white. In a 24-bit color graphics system with 8 bits per color channel, red is (255, 0, 0). On the color cube, it is (1, 0, 0).

The RGB model simplifies the design of computer graphics systems but is not ideal for all applications. The red, green and blue color components are highly correlated.

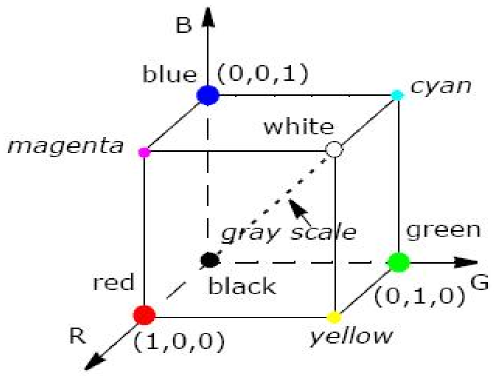


Fig. 3: RGB color space.

Color is a useful piece of information for skin detection. The skin detection is the most common and first approach for detecting meaningful skin color [2], skin color detection may avoid exhaustive search for faces in an entire image. For skin detection task, many color spaces with different properties have been applied. Many researchers have achieved some results with RGB, normalized RGB, HSI, YCbCr and RGB-space ratios.

However, there are many challenges in this task such as different illumination conditions, human faces, and similar skin colors. Our way is to build a skin classifier to define explicitly the boundaries of skin cluster in RGB space which is shown in equation (1).

Decision rules of our skin modeling are as follows:

$$\delta(P(X,Y)) = \begin{cases} 1; & \textit{if a set of conditions is satisfied} \\ 0; & \textit{Otherwise} \end{cases} \quad \ldots \quad (1)$$

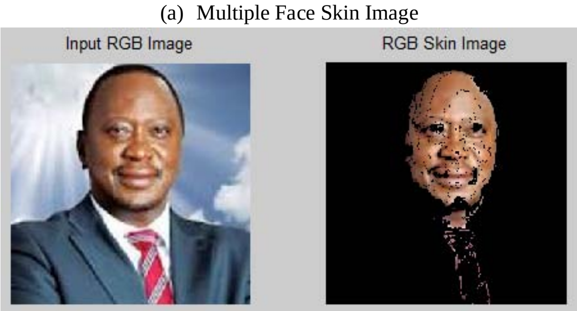
where, *P(x,y)* is a pixel of color image and a set of conditions are listed in Table 1.

Table 1: A Set of Conditions Defining Skin Pixels

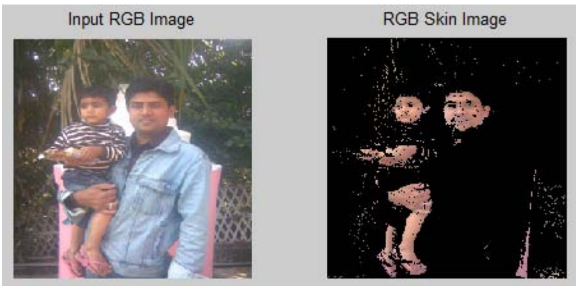
R	R-G	G-B	R-B	(R-G)-(G-B)	B	G
[70,85]	[30,55]	[-5,35]	-	-	[20,255]	[30,255]
[86,100]	[30,60]	[-5,40]	-	-	[30,255]	[40,255]
[101,150]	[0,17]	[-2,10]	[15,75]	-	-	-
	[18,30]	[-255,-10] or [25,45]	-	[-15,285]	-	-
	[31,70]	[-5,90]	[-255,120]	[-20,285]	-	[50,255]
	[71,75]	[-5,0]	[-255,70]	-	-	[50,255]
[151,200]	[15,20]	[0,40]	[20,255]	[-20,285]	-	-
	[21,30]	[-5,0]	[20,255]	[35,285]	-	-
	[31,85]	[-15,70]	[20,255]	[0,285]	[40,255]	[40,255]
[201,255]	[5,25]	[40,70]	-	[-30,285]	-	-
	[26,100]	[0,70]	-	[-15,285]	-	-

The strongest component among R, G & B decides the color. For skin color, generally R component is always the strongest one because human skin has the special expression of blood color. The color is not skin color if the difference between R, G and B are too big or small or R value is smaller than 70. The level of red color affects the decision rule of our skin model. Approximately, the proposed algorithm divides R component into five ranges. The values of R component is must be greater than 70 because, if the value of R component is less than 70 then the color can be dark red, brown, green or black. Few skin detection result shown in fig.4 in various conditions.

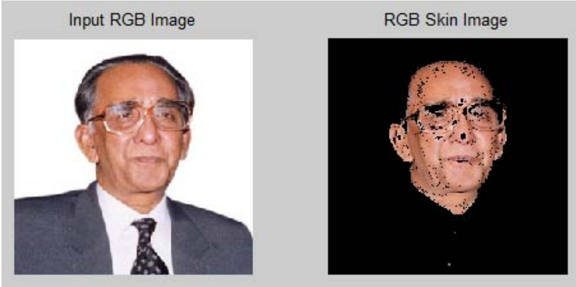
(a) Multiple Face Skin Image



(b) Single Face Skin Image



(c) Multiple Face Skin Image



(d) Single Face Skin Image

Fig. 4: Skin Color Segmentation;

B. *Face Candidate Localization*

Face candidate localizer used to find out the most probable face candidate. The algorithm of this part is shown in fig.5. In the approach of face candidate localization, connected component algorithm is used to label connected skin region. Among those regions, the region which area is smaller than the threshold is rejected by proposed algorithm. In our work, the threshold value is 110 pixels considered as a half of the smallest face size to be detected. This step is called 'Reducing Small Region by Filtering'.

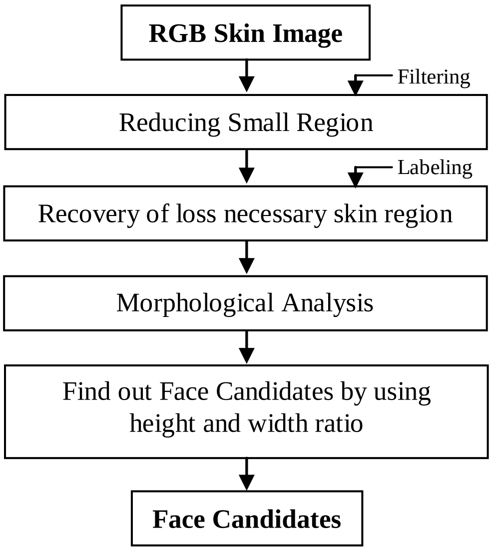


Fig. 5: Face Candidate Localization Method.

Generally skin segmentation is affected by different lighting condition; some real face regions may be lost. To recovery of these necessary regions labeling operation is used to connect non-skin region in each skin regions and change them to skin ones. This process ignores non-skin regions connecting directly to boundaries of their skin regions.

The face candidate localization system involves the use of morphological operations in the next step to refine the skin regions extracted from the segmentation step. Firstly, fragmented sub-regions can be easily grouped together by applying simple dilation on the large regions. Hole and gaps within each region can also be closed by a flood fill operation.

The regions properties – box ratio are used to examine and classify the shape of each skin region. The box ratio property is simply defined as the width to height ratio of the region bounding box. Height/width of a human face is not greater than two times of width/height. Proposed algorithm rejects those regions which are not satisfied by equation (2).

$$\delta(H,W)=\begin{cases}1; & if\,(H<W<2*H)or(W<H<2*W)\\ 0; & Otherwise\end{cases} \quad ... \quad (2)$$

where, H is the height and W is the width of particular region.

C. *Rejection of Non-Human Face Region*

To find out the most probable face region which contains human face only, a new algorithm is proposed which used regions properties. A binary image of candidate regions is the most probable human face region. Each face candidates may be real face region if it satisfies some regions properties of human face.

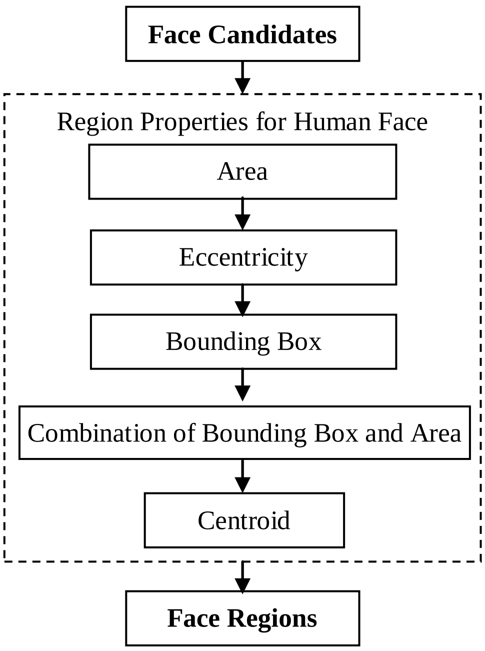


Fig. 6: Rejection of Non-Human Face Region.

These are area (total pixel of particular region), bounding box properties, centroid, eccentricity like oval estimation and combination of these features. A binary image of face candidate passes through these steps, and then these stages of this step remove non human face like regions by using their properties which are fixed according to the human face. The algorithm of this part is shown in fig.6.

Average area of human skin like regions of binary image is calculated to compare this average area with each skin regions of binary image. If any skin region is less than average value, then that skin region will be rejected. Area of any skin region is calculated by counting number of skin region pixels. This method is helpful for removing small skin regions from a binary image and proceeds to next stage for removing non human face skin like regions.

Generally, shape of human face is likely to oval shape, so the region which has an oval shape these are not rejected by this stage, and those regions whose shape likely to line are rejected. An ellipse (skin region) whose eccentricity is 0 is actually a circle, while an ellipse whose eccentricity is 1 is a line segment. The oval shape of a face can be approximated by an ellipse so eccentricity of all skin connected regions are calculated and to discard all skin regions whose eccentricity greater than by 0.89905 and less than 0.3.

Proposed approach rejects non human face skin region based on height to width ratio [4, 6, and 8]. Generally, height to width ratio of skin regions is measurable factor because it is also big factor for rejecting non human face regions. If height to width ratio of skin region is greater than by threshold value, then this skin region will be rejected. Here, the threshold value for height to width ratio is decided as 1.902.

The proposed approach calculates skin region area bounded by bounding box and also calculates this bounding box area. Skin area is the skin pixels bounded by bounding box. Bounding box area is the multiplication of height and width of bounding box. If two times of skin area is less than bounding box area, then this skin region will be rejected.

Generally, the human faces are evenly distributed in the centre, which means the human faces are not present in the side of images. Center of a face region means the center of the skin pixels. Therefore, the centroid of a face region should be found in a small window. Y-axis average centre is calculated from bounding box properties. The proposed approach rejects these skin regions which are not satisfied by equation (3),

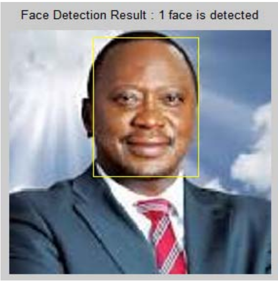
$$\delta(\mathrm{P}(\mathrm{X},\mathrm{Y}))=\begin{cases}1; & if\,(Pc\approx Py)<10\\ 0; & Otherwise\end{cases} \quad ... \quad ... \quad (3)$$

where, $P(x,y)$ is a pixel of binary image, P_c is the center of a skin region and P_y is the Y-axis average center.

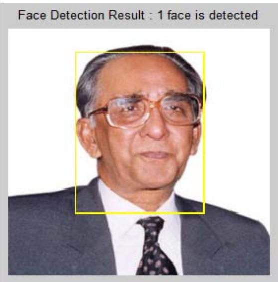
III. EXPERIMENTAL RESULT

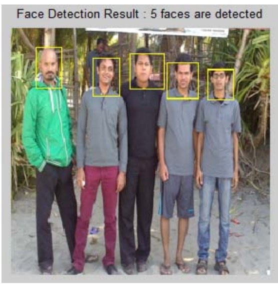
The proposed face detection method was implemented with MATLAB 7.0. More than 150 images have tested by the proposed algorithm, in which there are many single or multiple faces. These are shown in fig.7.

(a) Detection of multiple face (b) Detection of multiple face



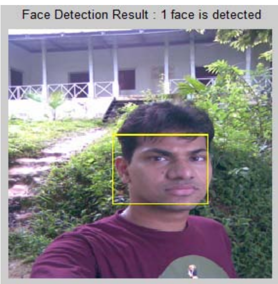
(c) Detection of single face (d) Detection of single face





(e) Detection of single face (f) Detection of multiple face

(g) Detection of single face (h) Detection of single face



(i) Detection of single face (j) Detection of single face

(k) Detection of multiple face (l) Detection of single face

Fig. 7: Detected Human Face;

IV. CONCLUSION

The objective of our research work is to develop an acceptable and efficient face detection algorithm to solve the challenge in face detection technology. In this paper, a strong approach for face detection is applied; the human skin areas are estimated by using skin color segmentation method. RGB color space is used for the color segmentation. Different value of R, G and B had chosen for human skin color. There are many conditions of the difference between R, G and B. After choosing the skin color, some morphological operations are applied and then apply the regions properties such as area, euler number, eccentricity, bounding box, centriod etc. The present algorithm works well for any human face detection.

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