Available Online at www.ijcsmc.com

International Journal of Computer Science and Mobile Computing

A Monthly Journal of Computer Science and Information Technology

ISSN 2320–088X

IJCSMC, Vol. 2, Issue. 3, March 2013, pg.127 – 136

RESEARCH ARTICLE

Face detection using a hybrid approach that combines HSV and RGB

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***Abstract*— The concept of face detection is very useful in many applications like face recognition, facial expression recognition, face tracking, facial feature extraction, gender classification, identification system, document control and access control, clustering, biometric science, human computer interaction (HCI) system, digital cosmetics and many more [1]. In literature [2]- [10] there are many well-known face detection techniques, which are used to detect a face, but among them we have chosen a very simple and robust skin color based face detection technique. Before that we would like to describe three color spaces namely RGB, HSV, YCbCr [14, 15] for skin color segmentation. After that, we will explain our proposed algorithm, which is basically a combination of HSV and RGB with higher accuracy. Experimental results are used to show that, the proposed method is good enough to achieve 90% accuracy to localize a face in both single and multiple face images.**

Key Terms: - Face detection, color space, skin color segmentation, localization, RGB, HSV, YCbCr.

I. Introduction

Human face perception is currently an active research area in the computer vision community [19]. Human face localization and detection is often the first step in many applications such as video surveillance, human computer interface, artificial intelligence, content-based image retrieval, face recognition and facial expressions analysis.

'Face detection' as the keyword itself reveals it's meaning that it concerns about where a face is located in an image. Now it may seem very easy but in reality we have to consider many constraints like single face or multiple faces, image rotation, pose etc. So there may arise some false detected regions of an image, which do not contain any face. In spite of all these problems there are lots of techniques like Knowledge based [2], template matching [11, 12], neural networks [8], Eigen face decomposition [13], support vector machine [14], pattern recognition [14], which are effectively applied in face detection. Each algorithm has its own advantages and disadvantage in terms of accuracy, speed, complexity based on the prior information and knowledge.

Though detection of face can be done using various techniques, but among them skin color based technique is considered as the simplest one. Color is an important parameter of human face. Skin color based segmentation technique has several advantages over other. Color processing is much faster and robust in nature. Also under certain lighting conditions, color is orientation invariant. Apart from these advantages there are some disadvantages like sensitivity to illumination intensity, different cameras produce significantly different color values even for the same person under the same lighting conditions and skin color differs from person to person. In order to use color as a feature for face tracking, we have to solve these problems. It is also robust towards changes in orientation and scaling and can tolerate occlusion well.

In this paper we use color based segmentation technique to detect or localize a face region from both single and multiple face images. There are lots of color space models, which are used to detect a face but for simplicity we will describe only three of them, which are RGB, HSV and YCbCr [14, 15]. Now in case of color based segmentation, choosing an effective color space is very important because this may cause different output. Hence in this paper we have considered the combination of HSV and RGB technique to achieve better performance. The algorithm developed was found to be reasonably fast taking on an average of 10 to 15 seconds to run with the accuracy of nearly 90%.

II. COLOR BASED SEGMENTATION

In recent years, the study of skin color based segmentation is gaining popularity due to its active research in content-based image representation. Segmentation is the concept of subdividing an image into its constituent regions or objects. Here, region or object means a face boundary. Now once we locate the face region, we can use it for image coding, editing, indexing or other user interactivity purposes. Furthermore, face localization also provides a good stepping-stone in face recognition and facial expression studies. The level up to which the subdivision is carried out is application dependent. The skin color of a person is dependent on some biological property like melanin, pigmentation etc. But this color range belongs to the subspace of the total color space (the person should not be framed with any unnatural color. The algorithm takes the advantage of face color correlation to limit face search to areas of an input image that have at least the correct color components. In the literature [14, 15] there are many color based face detection algorithm, but the proposed algorithm uses only two color spaces namely, RGB and HSV.

A. RGB Color Space

The RGB color space consists of the three color components: red, green and blue. Spectral components of these colors combine additively to produce a resultant color. A 3-dimensional cube with red green and blue at the corners represents the RGB model on each axis (Figure 1). 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. This makes it difficult to execute some image processing algorithms. Many processing techniques, such as histogram equalization, work on the intensity component of an image only.

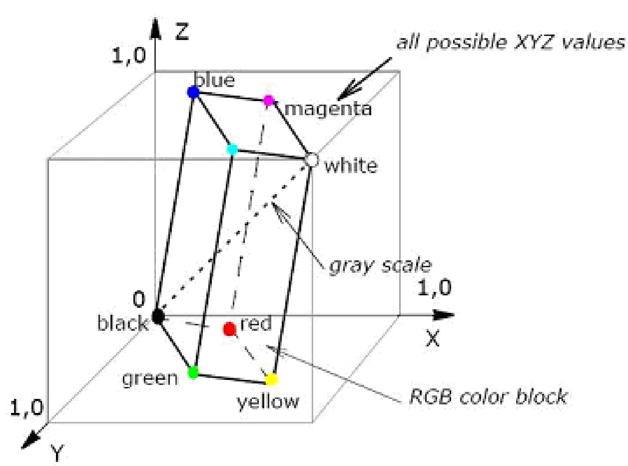


Figure 1. RGB color space for skin tone

B. HSV Color Model

One major problem associated with RGB (Red, Green, and Blue) color space is that, it does not consider the luminance effect on skin color, which may cause some incorrect information. HSV provides color information as Hue (or color-depth), Saturation (or color-purity) and intensity of the Value (or color-brightness) as shown in figure 2. Hue refers to the color of red, blue and yellow and has the range of 0 to 360. When using the HSV color space, you don't need to know what percentage of blue or green is required to produce a color. You simply adjust the hue to get the color you wish. Saturation means purity of the color and takes the value from 0 to 100%. To change a deep red to pink, adjust the saturation. Value refers the brightness of the color and provides the achromatic idea of the color [16, 17]. Value takes the range from 0 to 100. From this color space, H and S will provide the necessary information about the skin color. The skin color pixel's H and S components should satisfy the following conditions.

$$0 <= H <= 0.25; 0.15 <= S <= 0.9 \quad \text{-----------(1)}$$

Many applications use the HSV color model. Machine vision uses HSV color space in identifying the color of different objects. Image processing applications such as histogram operations, intensity transformations and convolutions operate only on an intensity image. These operations are performed with much ease on an image in the HSV color space.

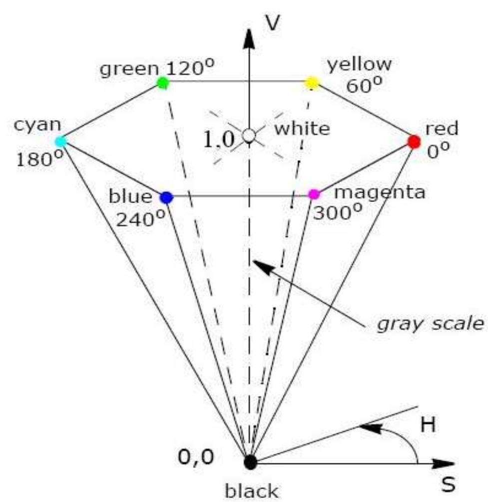


Figure 2. HSV color space for skin tone

C. YCbCr Color Model

It is more advantageous than the RGB & HSV model and extracts the skin portion of an image using chrominance values. The skin portion of an image should satisfy the following equation,

$$135 < Y < 145 \; ; \; 100 < Cb < 110 \; ; \; 140 < Cr < 150 \quad \text{-----------(2)}$$

Hence, whether a pixel is skin pixel or not is determined by the above equation. After that the skin color segment is extracted from the image. YCbCr space segments the image into a luminosity component and chrominance components. The main advantage is that influence of luminosity can be removed during the processing of an image. Using the reference images different plots for Y, Cb and Cr values for face and non-face pixels were plotted and studied to find the range of Y, Cb and Cr values for face pixels as shown in figure 3. After experimenting with various threshold the best result were found by using the above rules for detecting the skin pixel

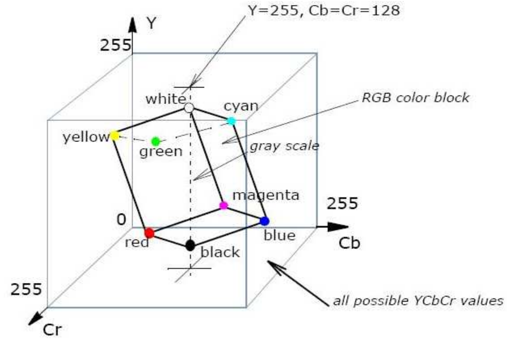


Figure 3. YCbCr color space for skin tone

All these above techniques will perfectly localize the face region provided that there is not so much body exposure of the other part of the body. But, their performance differs with each other in case of multiple face images. Furthermore, though RGB and YCbCr efficiently detect face from a multiple face image but HSV will fail to do so and will produce some false detected region, which do not carry any face region.

III. PROPOSED APPROACH

In this section we have described a new algorithm based on the combination of RGB and HSV algorithms. As the literature states that the above three algorithms work very well under the condition that there is only one face is present in the image. In case of multiple face images it will result some false detection (segmenting some region which do not contain a face). But the proposed algorithm will give better result locating only the face region for both single face and multiple face images. In the implementation of this algorithm there are eight steps whose flow diagram is given below.

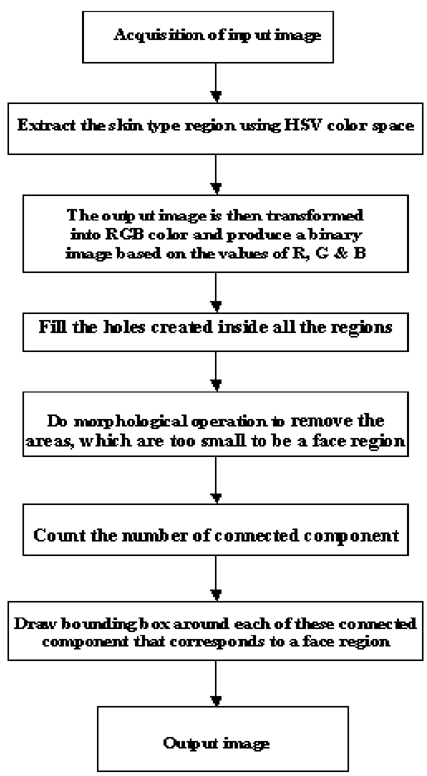


Figure 4. Flow diagram of the proposed algorithm

A. Acquisition of input image

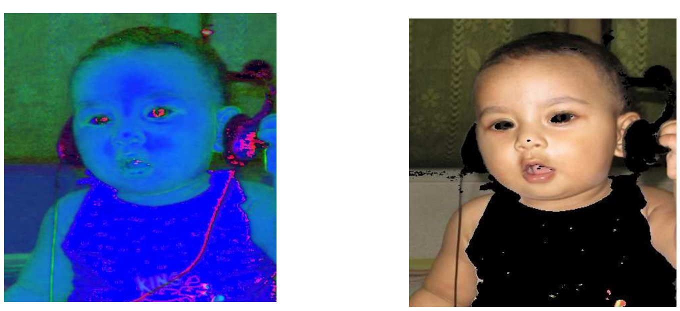
Before we execute our algorithm, we need to acquire the input image. Now, there are various ways like, we can take some picture using a camera or database images can be used for quicker access of a huge amount of images. The later one is more effective because, the debugging process become much more faster. But, in our algorithm we use the earlier technique that means we use camera to capture our input image and load them manually into our program. An example image is shown in the figure 5 on which we want to execute our proposed algorithm.

Figure 5. Original image containing a single frontal viewed face.

B. Extract the skin type region using HSV color space

According to literature, there are a number of color spaces used to model an input image, among them we are considering only three of them (HSV, RGB and YCbCr). In this step, we use the HSV (Hue saturation value) color space model to consider the luminance effects. Now we should familiar with some MATLAB commands [18], so that the implementation details will be much easier to understand. Here we use 'rgb2hsv' command to convert our rgb image into its corresponding HSV color space. After that we need to extract each of these three (H, S and V) components, which will provide necessary information for skin color. Then we use only two (H & S) components to be satisfied against the following equation. Moreover we can say that a pixel whose H and V components satisfied the following equation will be treated as a pixel in the candidate skin color region. Hence after executing this module we will get an image containing only the candidate skin color region. In figure 6a. We have shown the image in HSV color space and in figure 6b. All the skin color regions are extracted.

$$0 <= H <= 0.25; 0.15 <= S <= 0.9 \quad \text{-------------(3)}$$



(a) **(b)**

Figure 6. (a) Image in HSV color space and (b) Extracted skin color region from the image

C. The output image is then transformed into RGB color and produce a binary image based on the values of R, G & B

After getting the candidate face regions, we transformed these regions into RGB color space. Now we have to extract all three (R, G and B) components by simply assigning the value of three channels into three variables. If these R, G and B values of a pixel satisfied the following equations, then we consider it as a skin. Hence it will produce a binary image as its output, because a pixel can have either 0 or 1 depending on the above conditions. If all the three components of a pixel satisfy the conditions it will become white otherwise black as shown in the following figure.

$$\begin{aligned}&(R,G,B) \text{ is classified as skin if:}\\&R>95 \text{ and } G>40 \text{ and } B>20 \text{ and}\\&max\{R,G,B\}-min\{R,G,B\}>15 \text{ and}\\&|R-G|>15 \text{ and } R>G \text{ and } R>B\end{aligned}$$
--------------------(4)

Figure 7. Binary image whose pixel information satisfies all the above equation.

D. Fill the holes created inside all the regions

Now a candidate face region may contain some black spots, which may create problem in further processing. To remove these black spots we use 'imfill' MATLAB command as shown in figure 8.

Figure 8. Image after removing black spots.

E. Do morphological operation to remove the areas, which are too small to be a face region

This step is the most important as well as the most effective module in the whole face detection process. As stated earlier, our algorithm a skin color based face detection technique, and by executing all the previous modules we get all the skin color regions as our candidate face region. Hence, in the absence of this current module, we will also be able to locate face region, if the image is passport size photo containing only the face region of a single person. But, if there are some other skin color regions other than face, it will fail and locate all of them as a face region. But if we do some morphological operation, like here we consider the number of pixel in a candidate face region as our parameter to examine whether a candidate face region if a face or not. For example, a face region contains a larger number of pixels than the hand, foot etc, provided that there is not so much exposure of the body part or so much skin color region which are carrying larger number of pixels than the face region. Here we use 'bwareaopen', which removes from a binary image all connected components (objects) that have fewer than P pixels, producing another binary image as shown in figure 9.

Figure 9. Binary image showing all the skin color region boundary

F. Count the number of connected component

In case of single face image the number of connected component is one provided that we should consider some limitations. In MATLAB 'regionprops' is used to measure the number of connected component.

G. Draw bounding box around each of these connected components that corresponds to a face region

After getting all the connected components we need to plot a boundary around each of this region. In MATLAB 'bwboundaries' command is used to get the image boundary. In the following figure we have shown that a rectangle boundary is plotted around the face region.

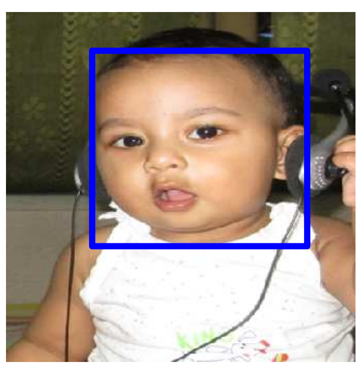


Figure 10. Detected face region

IV. EXPERIMENTAL RESULTS

We have implemented our proposed algorithm in MATLAB taking 30 test images that are given as input from a camera output interface. The tests images have two types of data both single face images and multiple face images. Hence the efficiency varied for each of these types (95% for single face images and 80% for multiple face images). Thus this combined approach is much more advantageous than HSV algorithm which cannot detect all faces from a multiple face image. The execution time is nearly 10 seconds. The main advantage of this algorithm is that it is independent on face pose; faces with tilted poses can also be correctly detected.

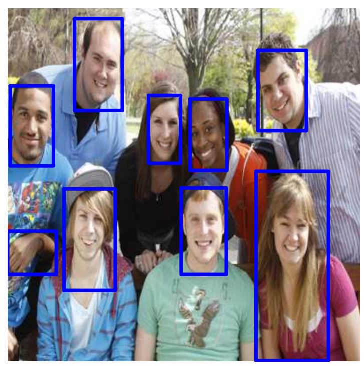
(a)

(b)

(a)

(b)

(a) **(b)**



(a) **(b)**

Figure 11. (a) Original image considering either single or multi face image. (b) Detected face regions

V. Conclusion and Future Scope

In this paper we have describe a face detection technique based on both skin color and the number of pixels in a region. There are some limitations present in this proposed approach like if two persons are very close to each other, it will be treated as a single face region, and also if there is so much exposure of the body part then also it will be detected as face region. Also our algorithm works very well on frontal view faces. So in future we need to solve these problems by using template matching or neural network based techniques.

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