COMPARATIVE ANALYSIS OF SKIN COLOR BASED MODELS FOR FACE DETECTION

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ABSTRACT

Human face detection plays an important role in many applications such as face recognition , human computer interface, biometrics, area of energy conservation, video surveillance and face image database management. The selection of accurate color model is the first need of the face detection. In this paper, a study on the various color models for face detection i.e. RGB, YCbCr, HSV and CIELAB are included. This paper compares different color models based on the detection rate of skin regions. The results shows that YCbCr as compared to other color models yields the best output even in varying lightening conditions.

KEYWORDS

Skin color model & face detection.

1. INTRODUCTION

Detecting human faces automatically is becoming a very important task in many applications, such as content-based indexing video retrieval systems or security access control systems like the distributed audio visual archives network system [1]. Face detection is the first step in any automated system that solves problems such as facial expression recognition, face tracking and face recognition [2]. Up to now much work has been done on detecting and locating faces in color images and the methods like neural network based [3], level set methodology [4], chrominance based [5], ada boost based [6], skin color based [7] studied by many researchers. Among many face detection algorithms skin color model has been widely used because of simple performance, convenient use and high detection rate.

1.1 Face Detection

Face detection is a visual task which can be done by humans without any effort but in computer vision this task is very difficult. Given a single image, detect and localize the number of faces regardless of pose, illumination and expression. Face detection is used for self-serviced immigration clearance, for person verification, security, image search and research is being done in the area of energy conservation etc. The goal of face detection is to identify and locate all of the human faces regardless of their positions, scales, orientations, poses and light conditions and

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this is a challenging problem because human faces are highly non-rigid with a high degree of variability of in size, shape, color and texture. A simple face detection block diagram is shown in fig.1:-

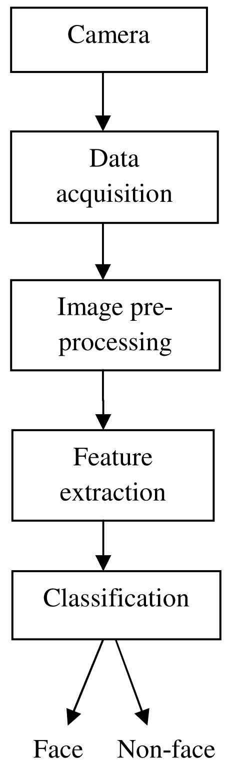


Figure 1. Basic block diagram of face detection

1.2 Challenges in Face Detection

Detection and recognition of faces are challenging because face has a wide variability in poses, shapes, sizes and texture. The problems or challenges in face detection are listed as follows [8]:-

- Illumination
- Facial Pose
- Facial Expression
- Age Span
- Motion
- Occlusion
- Image orientation
- Image condition
- Background Complexity
- Environment Changes
- Noise
- Textural differences among Faces

These are the most general problems that occur during face detection. We can remove most of the drawbacks by increasing the efficiency and by applying the loops to get better results.

2. SKIN COLOR BASED ALGORITHM

Color is a useful piece of information for skin detection. It is the first most common approach for detecting meaningful skin color [9], as it avoids many exhaustive searches for faces in an entire image. Human skin colours are distinguished from different ethnic through the intensity of the skin colour not the chromatic features [10].According to the Hyun-Chul, Ju-Yeon You and Sung-Il Chien, skin color algorithm can be used under the various illumination conditions [11] and according to Yogesh Tayal , Ruchika Lamba and Subhransu Padhee, color image is segmented into skin and non-skin region for different color spaces and the skin color algorithm can be applied on a wide variety of the images under different lighting conditions and with different backgrounds [12]. Many researches have been done using the color models. In this paper four basic color models i.e. RGB, HSV, YCbCr and CIELAB are reviewed.

2.1. RGB Color Model

RGB Colors are specified in terms of three primary colors i.e. Red (R), Green (G), and Blue (B). In RGB color space, a normalized color histogram is used to detect the pixels of skin color of an image and can be further normalized for changes in intensity on dividing by luminance. This localizes and detects the face [10].

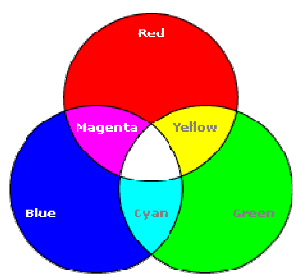


Figure 2. RGB color model

It is the basic color model and all other color models are derived from it. RGB color model is light sensitive. In comparison with other color models such as YCbCr or HSI it has a major drawback that it cannot separate clearly the mere color (Chroma) and the intensity of a pixel, so it is difficult to distinguish skin colored regions [2]. These factors contribute to the less favorable of RGB. It is widely used color space for processing and storing digital images because of the fact that chrominance and luminance components are mixed in RGB; it is not widely used in Skin detection algorithms [13].

Input image RGB image

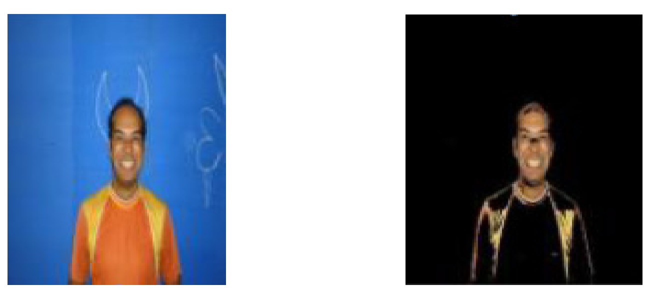
Figure 3. RGB image

2.2. HSV Color Model

HSV Colors are specified in terms of Hue (H), Saturation (S) and Intensity value (V) which are the three attributes. Those are perceived about color. Hue refers to the color of red, blue and yellow having the range of 0 to 360. Saturation means purity of the color and takes the value from 0 to 100% whereas Value refers to the brightness of color and provides the achromatic idea of the color [14]. From this color space, H and S will provide the necessary information about the skin color. The skin color pixel should satisfy the following condition:-

$$0 <= H <= 0.25$$
$$0.15 <= S <= 0.9$$

The transformation between HSV and RGB is non-linear [12]. In HSV color model Hue (H) is not reliable for the discrimination task when the saturation is low. But where color description is consider, HSV color model is preferred over RGB model according to Yogesh Tayal [13], colors similarly is described that how human eye tends to perceive color and also describe color using more familiar comparisons such as vibrancy, color and brightness.



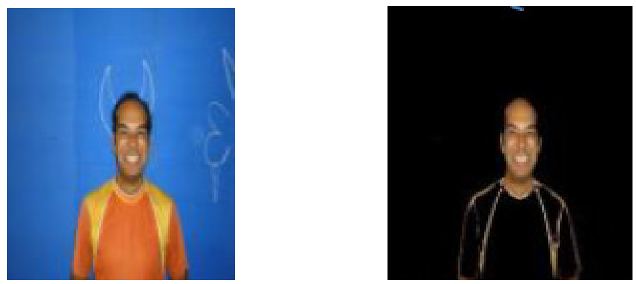
Input image HSV image

Figure 4. HSV image

2.3. YCbCr Color Model

YCbCr Color model is specified in terms of luminance(Y channel) and chrominance (Cb and Cr channels). It segments the image into a luminous component and chrominance components [12]. In YCbCr color model, the distribution of the skin areas is consistent across different races in the Cb and Cr color spaces [15]. As RGB color model is light sensitive so to improve the performance of skin color clustering, YCbCr color model is used. Its chrominance components are almost independent of luminance and there is non-linear relationship between chrominance

(Cb, Cr) and luminance(Y) of the skin color in the high and low luminance region [2]. Range of Y lies between 16-235 where 16 for black and 235 for white whereas Cb & Cr are scaled in the range of 16-240 [14]. The main advantage of YCCr color model is that influence of luminosity can be removed during processing of an image. Different plots for Y, Cb and Cr values for face and non-face pixels were plotted using the reference images and studied to find the range of Y, Cb and Cr values for the face pixels.



Input image YCbCr image

Figure 5. YCbCr image

2.4. CIELAB Color Model

In 1976, the CIE (international commission on illumination) recommended the CIEL*a*b* or CIELAB, color scale for use. It provides a standard, approximately uniform color scale which could be used by everyone so that the color values can be easily compared. This color model is designed to approximate perceptually uniform Color spaces (UCSs). It is related to the RGB color space through a highly nonlinear transformation. Examples of similar color spaces are CIE-Luv and Farnsworth UCS [12]. It has three axes in it two are color axes and the third is lightness.

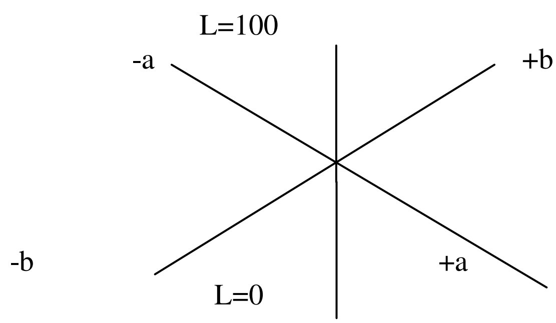
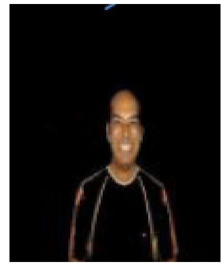


Figure 6. CIELAB Color Model

Where L indicates lightness, +a and –a indicates amount of green and red color respectively, +b and –b indicates amount of yellow and blue color respectively.
Here maximum value of L is 100 which represent a perfect reflecting diffuser (white color) and the minimum value for L is 0 which represents black color. Axes a and b do not have any specific numerical value.



Input image CIEL*a*b image

Figure 7. CIELAB image

3. RESULTS AND COMPARISON

The results after survey on these four color models are shown below in tabular format:-

Table 1. Comparison of four Color Models

Type of color model	**Detection rate %**	**False detection %**
RGB	65	35
HSV	70	30
CIELAB	89	11
YCbCr	90	10

The table compares face detection rate of the four color models i.e. RGB, HSV, CIELAB and YCbCr. Detection rate of RGB color model is only 65% that means it can only detect 65% of the faces correctly. Detection rate of HSV color model is 70%, CIELAB color model is 89% and detection rate of YCbCr color model is 90%. Out of these four color model YCbCr has highest detection rate and lowest false detection rate.

To increase the speed, accuracy of the system and to overcome on false face detection rate these four color models can be combined to get better result, after combining all these models we can get correct detection rate which can be up to 92%.

4. CONCLUSION

Four different color models in face detection have been studied and compared namely, RGB, YCbCr, HSV and CIELAB. The paper concludes that out of these four color models YCbCr yields a better results and performance under varying lightening conditions and changes in illumination.

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