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Real-time human skin color detection using OTSU thresholding

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ABSTRACT

Skin color is a robust cue in human skin detection. In the development of Human-Computer Interface (HCI) applications, information that is relative to skin color is extensively utilized. Human skin color shows resemblance with non-skin materials like wood, wall paint etc. So an accurate human-computer interaction system is required to be designed which can distinguish between them. Although several methods have been proposed, skin color detection still remains a challenge mainly due to problems such as illumination conditions, camera characteristics, and ethnicity.

Keywords: *Skin color detection, Color space, Computer vision, Thresholding, Skin color model.*

1. INTRODUCTION

Color information is an important source of information during the human visual perception activities. Skin color is relatively concentrated & relative stabilization of region in the color image, and it is not to influence by size, shape and so on. In recent years, skin color detection has become a hot topic between domestic and foreign researchers and the great process has been made in this field. Nowadays, skin color detection has many applications in tasks like detecting and tracking human gestures and faces and retrieving people in databases and internet, even diagnosing diseases. It also plays an important role in a wide range of image processing applications ranging from face detection, face tracking, gesture analysis, and content-based image retrieval systems and to various human-computer interaction domains. Recently skin detection methodologies based on skin color information as a cue has gained much attention as skin color provides computationally effective yet, robust information's against rotations, scaling and partial occlusions.

Skin color identification becomes very tough task under the inconsistent visible spectrum of light with an obscure background as the image is receptive to various factors like ethnicity, illumination, imaging device characteristics, human physical characteristics and other factors [2].

While designing skin color detection algorithm there are two important features that have to keep in mind. They are color space selection and skin color model. Various color spaces that are available in the visible spectrum are RGB, HSV, YCbCr, CIELAB, CIEXYZ etc. Skin color models can be mainly classified into three types. They are explicitly defined, parametric methods and non-parametric methods. Skin-color detection in the visible spectrum can be a very challenging task as the skin color in an image is sensitive to various factors such as:

1) There is color constancy problem that means indoor, outdoor, shadows; highlight produces a change in the skin color of images. So it is a very important problem which seriously affects the performance of skin detection task.
2) Skin color also varies from person to person belonging to different ethnic groups and from persons across different regions.
3) The skin color distribution for the same person differs from one camera to another depending on the camera sensor characteristics.
4) Individual characteristics such as age, sex, and body parts also affect the skin color appearance.
5) Different factors such as subject appearances (makeup, hair style, and glasses), background colors, shadows, and motion also influence skin color appearance [3].

A. Color spaces

Color is a significant source of information for a wide range of research areas such as segmentation, image analysis, classification and object recognition. However, some of the original colors in an image might not be appropriate for analysis and the colors must be adjusted. Adjusting the colors can be done by transferring colors from space to another while preserving the image's original details and natural look at the same time. Selecting proper color space is crucial for skin color detection.

Different color spaces are available for the skin detection. They are RGB based color space (RGB, normalized RGB), Hue based color space (HSI, HSV, HSL), Luminance based color space (YCbCr, YIQ, YUV) and perceptually uniform color space(CIEXYZ, CIELAB, and CIELUV).

RGB color space is the default color space for the most available image formats. Any other color space can be obtained from a linear or non-linear transformation from RGB. The color space transformation is assumed to decrease the overlap between the skin and non-skin pixels thereby aiding skin pixel classification and to provide robust parameters against various illumination conditions. IT has been observed that skin colors differ more in intensity than in chrominance. Hence, it has been a common practice to drop the luminance component for skin classification. Several color spaces have been proposed and used for skin detection [2].

RGB corresponds to fundamental color space and mostly used to portray digital images since most of the imaging devices like camera provide information as RGB. It is also recognized as the primary color of light as RGB stands for R- Red, G- Green, and B- Blue. The RGB color space is the color space used by computers, graphics cards, and monitors or LCD [3].

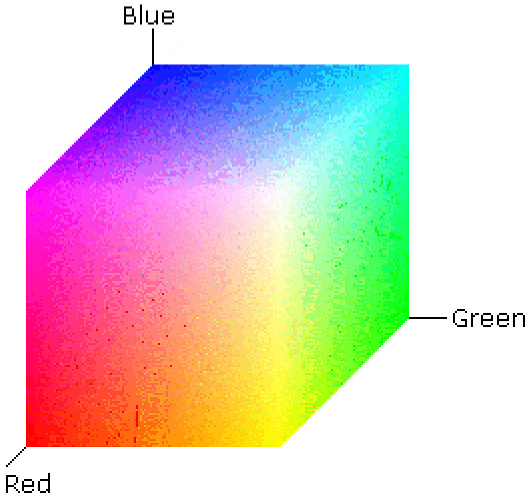

Fig.1. RGB Color space

In order to reduce the dependence on lightning, the RGB values are normalized by a simple normalization procedure as follows:

$$R = \frac{R}{R+G+B}$$

$$G = \frac{G}{R+G+B}$$

$$B = \frac{B}{R+G+B}$$

As the sum of the three normalized components is known as (r+g+b = 1), the third component does not hold any significant information and can be omitted, reducing the space dimensionality. The remaining components are often called "pure colors", for the dependence of r and g on the brightness of the source RGB color is diminished.

2) YCbCr (Luminance, Chrominance)

YCbCr is an encoded nonlinear RGB signal. Two difference chrominance values Cb & Cr formed by subtracting luminance from blue and red components. Because of separation of chrominance and luminance components, this color space is effective for skin color modeling. The transformation simplicity and explicit separation of luminance and chrominance components make this color space one of the most effective choices for skin detection [1]. The equation for RGB conversion to YCbCr is seen in equation (1).

$$Y = 0.299R + 0.587G + 0.114B$$

$$Cr = R - Y$$

$$Cb = B - Y$$

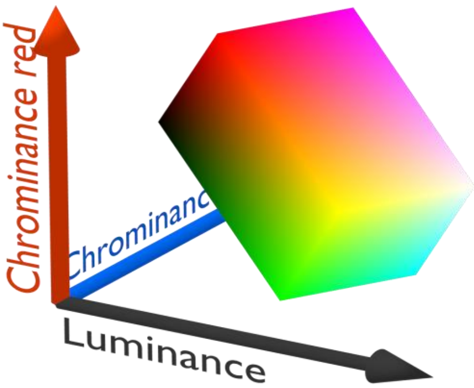

Fig.2. YCbCr Color Space

3) HSV (Hue Saturation Value)

Here Hue indicates the dominant color of an area; saturation calculates the colorfulness of an area in proportion to its brightness. The value indicates the color luminance. The separation between luminance and chrominance makes this color space popular in skin color detection. The transformation from RGB to HSV is invariant to high intensity at white lights, ambient light and surface orientations relative to the light source and hence can form a very good choice for skin detection methods.

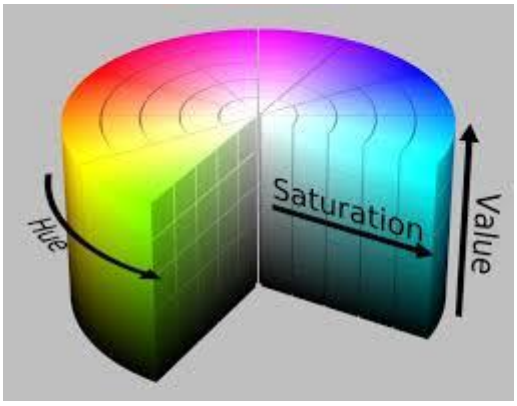

Fig.3. HSV Color Space

4) CIELAB

The LAB color space describes mathematically all perceivable colors in the three dimensions L for lightness and a and b for the color components green- red and blue-yellow. The terminology "Lab" originates from the Hunter 1948 color space. The lab color space exceeds the gamuts of the RGB and CMYK color models. One of the most important attributes of the Lab model is device independence. This means that the colors are defined independently of their nature of creation or the device they are displayed on.

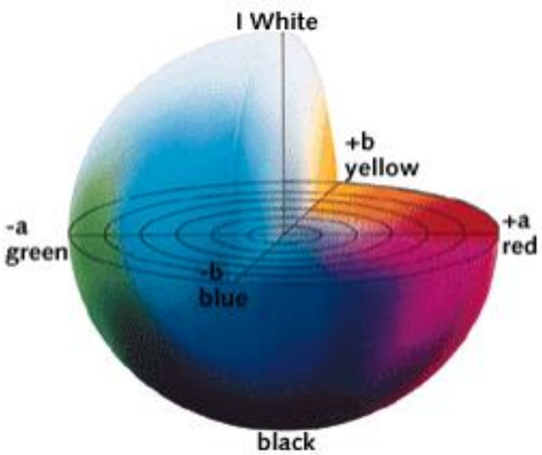

Fig.4. LAB color space

B. Skin color models

The final goal of skin color detection is to build a decision rule, that will discriminate between the skin and non skin pixels. This is usually accomplished by introducing a metric, which measures distance(in general sense) of the pixel color to skin tone. The type of this metric is defined by the skin color modeling method [8]. Skin color models are mainly classified into three categories. They are pixel based, region based and edge-based models. Pixel-based skin color models can be further classified into the following categories as shown in Fig.5.

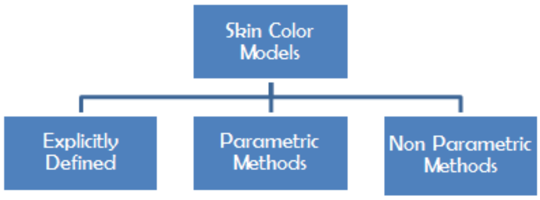

Fig.5. Skin Color Models

Additionally, parametric methods are segregated into two parts one is a Gaussian model and second is a mixture of Gaussians (MOG) model. Similarly, non-parametric methods are segregate as look up table and Baye's skin probability map model.

1) Explicitly defined skin color model.

Different individuals belonging to different ethnic groups, race, and region noticeably have different skin color tone. But under the influence of same lightning conditions, the skin color of different individuals falls in the small area of color space. So one of the straight forward approaches is to explicitly define the decision boundary of RGB color space is defined as :

R > 95 and G > 40 and B > 20 and

Max{R, G, B}-min {R, G, B} > 15 and

|R-G| > 15 and R > G and R > B

So the value of skin pixels falling in this range can be easily distinguished from non- skin pixels.
Similarly range used for HSV color space is
H = [0, 50], S = [0.20, 0.68] and V = [0.35, 1.0] and for YCbCr color space is Cb = [77 127] and Cr = [133 173].

2) Parametric skin color model.

Due to some shortcomings in non-parametric methods used in skin color classification, there is a need for more convenant skin models. These models must be able to simplify and incorporate with less training data hence fosters the evolution of parametric skin color distribution methods. Fig.5. represents various parametric methods used for skin color taxonomy. These methods are namely single Gaussian, a mixture of Gaussian and elliptical boundary model.

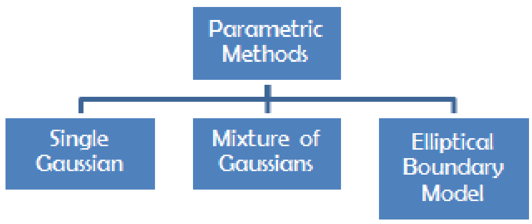

Fig..6. Parametric methods

3) Nonparametric methods

The main goal of non – parametric skin color modeling is to make an estimation of the skin color distribution through the training data set which is devoid of using explicit model for skin color segmentation. Thus results obtained through these methods sometimes attributed to the creation of Skin Probability Map (SPM). This skin probability map allocates a probability value to every point of isolated color space. The information carried out by these probability values is extracted in order to distinguish between skin and non- skin color pixels in complex images. Fig.6. shows the three basic and foremost methods which come under the non- parametric skin color taxonomy namely: standardized look-up table (LUT) method, Bayes classifier and self-organizing maps.

C. OTSU Thresholding

In computer vision and image processing, Otsu's method, named after Nobuyuki Otsu (Otsu Nobuyuki) is used to automatically perform clustering based image thresholding or the reduction of a grey level image to a binary image. The algorithm assumes that the image contains two classes of pixels following bi-modal histogram (foreground pixels and background pixels), it then calculates the optimum threshold separating the two classes so that their combined spread (intra ckass variance) is minimal, or equivalently (because the sum of pairwise squared distances is constant), so that their inter-class variance is maximal. Consequently, Otsu's method is roughly a one dimensional, a discrete analog of Fisher's Discriminant Analysis. Otsu's method is also directly related to Jenks optimization method.

2. PROPOSED APPROACH

Distinct ethnic group peoples have distinct skin color and texture. These parameters can also be helpful in determining age, beauty, and race of human beings. In employing computer vision applications namely human-computer interaction system and hand gesture based system, skin color identification plays a crucial role. This is the first step in employing these systems. Broadly classifying skin color detection method comprises of two aspects namely: skin color representation and skin color model. Several methods of skin segmentation mentioned in the earlier section have some drawbacks [7]. In order to overcome the drawbacks of earlier methods, this type of skin color detection is used.

Algorithm

1: Acquisition of RGB image.

The primary step in this algorithm is to acquire an RGB image from the live video stream. The acquired image is normalized into M by N pixels.

2: Conversion to LAB color space.

The acquired image in RGB color space is converter into LAB color space. The chosen color space is LAB color space because it is the effective color space in case of OTSU thresholding.

3: Identifying the skin pixels.

Here the skin pixels are identified using OTSU thresholding technique. Otsu's thresholding method involves iterating through all the possible threshold values and calculating a measure of spread for the pixel levels on each side of the threshold, i.e the pixels either fall in foreground or background.

4: Apply morphological operations

The binary image that is obtained after thresholding will undergo morphological operations like erosion followed by dilation in order to provide noise and some imperfections**.**

5: Filtering

The median filter is used for the filtration purpose in order to remove the background noise. Median filters area class of nonlinear digital filters.

6: Draw the bounding rectangle

In order to show the output skin colored detected image, a bounding rectangle will be drawn on this area. Firstly draw the centroid point of this area in order to draw the bounding rectangle.

3. RESULTS

Fig.7. Input RGB image

Fig.8. L, a and b components

Fig.8. shows the L, a and b component of the input RGB image

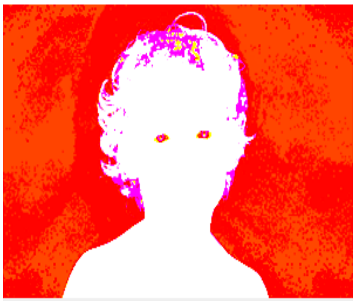

Fig.9. L*a*b converted image

Fig.9. shows the converted image of Lab color space

Fig.10. AB image and OTSU thresholded image

Fig.10. shows the AB image and the corresponding OTSU thresholded image

Fig.11. L*a*b Mask image and RGB mask image

Fig.11. shows the mask images of Lab and RGB color space

Fig.12. Masking skin

Fig.12. shows the skin masking

Fig.13. Skin color map

Fig.13. shows the skin color map

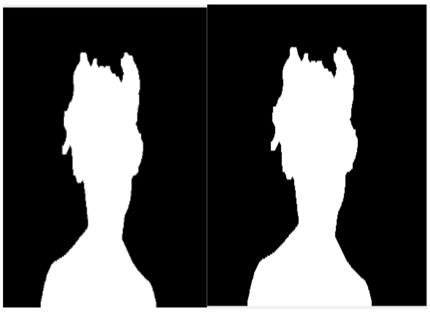

Fig.14. Eroded and dilated skin maps

Fig.14. shows the eroded and dilated skin maps

Fig.15. Median filtered skin map

Fig.15. shows the skin map after median filtering

Fig.16. Tracing of boundary

Fig.16. shows the boundary tracing

Fig.17. Final detected skin bounding box

Fig.17. shows the final detected skin bounding box using OTSU thresholding

4. CONCLUSION

Skin color detection is generally a preprocessing step in many applications like face detection and gesture tracking and many algorithms have been proposed for this task. This paper proposes a real-time human skin detection method based on skin color for the complex background using OTSU thresholding. WE have proposed a skin color detection algorithm using LAB color space. The experimental result has indicated that the approach in this paper has a preferable robustness and the skin color detection is improved significantly using OTSU thresholding technique. OTSU method is a better threshold selection method for general real-world images with regard to uniformity and shape measures.

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