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Design and Implementation of Skin Segmentation System in Various Light Conditions

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ABSTRACT

Image processing and its applications in terms of skin segmentation are gaining importance in these days due to wide use it in virtually every field. Detection and tracking of human faces are important for gesture recognition and human computer interaction. In this paper, a RGB and HSV based skin segmentation technique is being presented. We frequently tested RGB, HSV color models for skin segmentation. These color models with thresholds, help to remove non skin like pixels from an image. In different lighting conditions it becomes paramount importance to switch to different Color spaces than the traditional RGB (Red-Green-Blue) model to achieve greater efficiency in pixel detection rate. We have analyzed and tested various color models like RGB, HSV, YCbCr, HIS, nRGB and lighting conditions has been kept to as most vary as it can be. Under various lighting conditions and noise, a list of experiments has been performed to detect human skin. The experiment result shows that, the algorithm gives hopeful results. At last, we concluded this paper and proposed future work.

Keywords-Pixel Classifications, skin segmentation, Color Space, Image Processing. Gesture Recognitions.

I. INTRODUCTION

Skin color segmentation plays an important role in computer vision, face detection and human related systems. Much work has been reported in literature regarding skin color detection using Gaussian mixture model. The Gaussian mixture model has certain limitations regarding the assumptions like pixels in each component are mesokurtic, having negative range and it doesn't adequately represent the variance of the skin distribution under illumination conditions. Skin Segmentation is gaining importance today due to its wide use over Image Processing and its applications in virtually every field of computer science, electronics as well. Detecting and tracking face and hands are important for gesture recognition and human computer interaction. The goal of face detection is to locate all regions that contain a face.

This study has a simple face detection procedure which has two major steps, first to segment skin region from an image, and second, to decide these regions contain human face or not. Our procedure is based on skin color segmentation and human face features (knowledge-based approach). In this study, we used RGB, YCbCr, HSV, HSV, HIS, and nRGB color models for skin color segmentation. These color models with thresholds, help to remove non skin like pixels from an image. We tested each skin region, that skin region is actually represents a human face or not, by using human face features based on knowledge of geometrical properties of human face. The experiment result shows that, the algorithm gives hopeful results.Face detection is the problem of determining whether a sub-window of an image contains a face. Several applications, such as face processing (i.e. face, expression, and gesture recognition), computer human interaction, human crowd surveillance, biometric, video surveillance, artificial intelligence and content-based image retrieval. All of these applications, stated above, require face detection, which can be simply viewed as a preprocessing step, for obtaining the „object". In other words, many of the techniques are proposed for these applications assume that, the location of the face is pre-identified and available for the next step. First problem is come in the way of face detection, is chosen proper color model for skin color segmentation. There are several color models and each has specific work field and strength. We used four color models for skin color segmentation; these are RGB, YCbCr, HSV, and LAB color models. After skin like pixels detection, we convert this segmented image into binary form. This binary image contains skin regions, but we don't know that, where is human face in segmented image. Next step of face detection after segmentation is based on knowledge of human face. Work of next step is to remove non-human face skin area from segmented image, by using Knowledge-based methods or human face features.

In terms of skin detection, color is a useful parameter of information. The skin detection plays a major in image processing in terms of detecting meaningful skin color [2]. [3], skin color detection may avoid exhaustive search for faces in an entire image. In this step, we describe that how non skin color is rejected from an Image so that the image may contains only skin like areas, which will be our skin color segmented image for further processing. From different type of color models, in HSV color model, Hue (H) is not reliable for the discrimination task when the saturation is low, Also in YCbCr color model, the distribution of skin areas is consistent across different races in the Cb and Cr color spaces, the RGB color model is lighting sensitive so Therefore, when we use different color models under uncontrolled conditions, and we get consequently result for skin color detection. The accuracy of skin detection depends on both the color model and the method of skin pixels classification or detection. Hence, the challenge problem is how to select color models that are suitable for skin pixel classifications under different varying conditions. In this thesis, there is various color models are used for skin color segmentation or detection of skin pixels. These are RGB, YCbCr, and HSV and color models. The combination of these color models overcomes all varying lighting conditions and changes in illumination, and it gives better result than individual color model result.

Most existing skin segmentation techniques involve the classification of individual image pixels into skin and non-skin categories on the basis of pixel color. The rationale behind this approach is that the human skin has very consistent colors which are distinct from the colors of many other objects. In the past few years, a number of comparative studies of skin color pixel classification have been reported. Jones and Rehg [4] created the first large skin database—the Compaq database—and used the Bayesian classifier with the histogram technique for skin detection. Brand and Mason [5] compared three different techniques on the Compaq database: thresholding the red/green ratio, color space mapping with 1D indicator, and RGB skin probability map. Terrillon et al. [6] compared Gaussian and Gaussian mixture models across nine chrominance spaces on a set of 110 images of30 Asian and Caucasian people. Shin et al. [7] compared skin segmentation in eight color spaces. In their study, skin samples were taken from the AR and the University of Oulo face databases and non-skin samples were taken from the University of Washington image database.

The format of the remaining paper is: section 2, defines and explains the skin color models and different classifications of skin colors that has been employed and discusses during the implementations in brief and other detection approaches. Section 3 deliberates the framework design and discusses our detailed design of the implemented system. Section 4 discusses conclusion and future work of the research problem.

II. BACKGROUND AND MOTIVATION

A Skin Color Models

A human skin color model is used to decide if a color is a skin or non-skin color. Major requirements of a skin color model are listed below:

- *Very low false rejection rate at low false detection rate*. Skin color detection is first step in skin segmentation; therefore it is imperative that almost all skin colors are detected while keeping the false detection rate low. False detections can be handled later when more *a priori* knowledge about the object of interest (ie. face, hand) is available.
- *Detection of different skin color types*. There are many skin color types, ranging from whitish and yellowish to blackish and brownish, which must be all classified in one class, skin color.
- • *Handling of ambiguity between skin and non-skin colors*. There are many objects in the environment that have the same color as skin. In these instances, even a human observer cannot determine if a particular color is from a skin or non-skin region without taking into account contextual information. An effective skin color model should address this ambiguity between skin and non-skin colors.
- *Robustness to variation in lighting conditions.* Skin color can appear markedly different under different lighting. It is impractical to construct a skin color model that works under all possible lighting conditions. However, a good skin color model should exhibit some sort of robustness to variations in lighting conditions. In our work, we aim to create a skin color model for typical office lighting and daylight conditions.

A human skin color model requires a color classification algorithm and a color space in which colors of all objects are represented.
In order to segment human skin regions from non-skin regions, a reliable skin model is needed that is adaptable to different colors and light conditions [?]. The color spaces that are frequently used in studies are HIS, HSV,, TSL and YUV. In this paper, we choose the color space as the space of skin detection.

B. Classifications of skin color:

Good skin color pixel classification should provide coverage of all different skin types (blackish, yellowish, brownish, whitish, etc.) and cater for as many different lighting conditions as possible. This section describes the color spaces and the classification algorithms that will be investigated in this study. [9].

- Color Representations

In the past, different color spaces have been used in skin segmentation. In some cases, color classification is done using only pixel chrominance because it is expected that skin segmentation may become more robust to lighting variations if pixel luminance is discarded. In this paper, we investigate how the choice of color space and the use of chrominance channels affect skin segmentation. We should note that there exist numerous color spaces but many of them share similar characteristics. Hence, in this study, we focus on four representative color spaces which are commonly used in the image processing field [10]:

- RGB: Colors are specified in terms of the three primary colors: red (R), green (G), and blue (B).
- HSV: Colors are specified in terms of hue (H), saturation (S), and intensity value (V) which are the three attributes that are perceived about color. The transformation between HSV and RGB is nonlinear. Other similar color spaces are HIS, HLS, and HCI.
- YCbCr: Colors are specified in terms of luminance (the Y channel) and chrominance (Cb and Cr channels). The transformation between YCbCr and RGB is linear. Other similar color spaces include YIQ and YUV.
- CIE-Lab: Designed to approximate perceptually uniform color spaces (UCSs), the CIE-Lab color space is related to the RGB color space through a highly nonlinear transformation. Examples of similar color spaces are CIE-Luv and Farnsworth UCS.

Figure 1 depicts the skin pixel color classifications algorithms. In the past several algorithms have been proposed for skin color classifications.

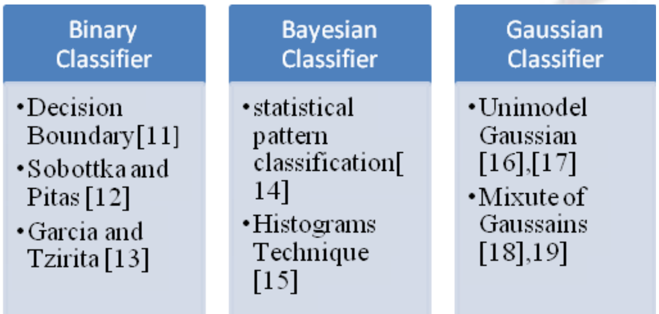

Figure 1. Skin Color Classification algorithms

III. Proposed Framework Design

Here we discuss the detailed system design including source of image and applied algorithm to segment the pixels of images. In the past different color spaces have been used in skin segmentation, in some cases, color classification is done by using only pixel chrominance because it was expected that skin segmentation may become more robust to lighting conditions if pixel luminance is discarded. The choice of the color space is important for many computer vision algorithms. No color space can be considered as universal because color can be interpreted and modeled in different ways.

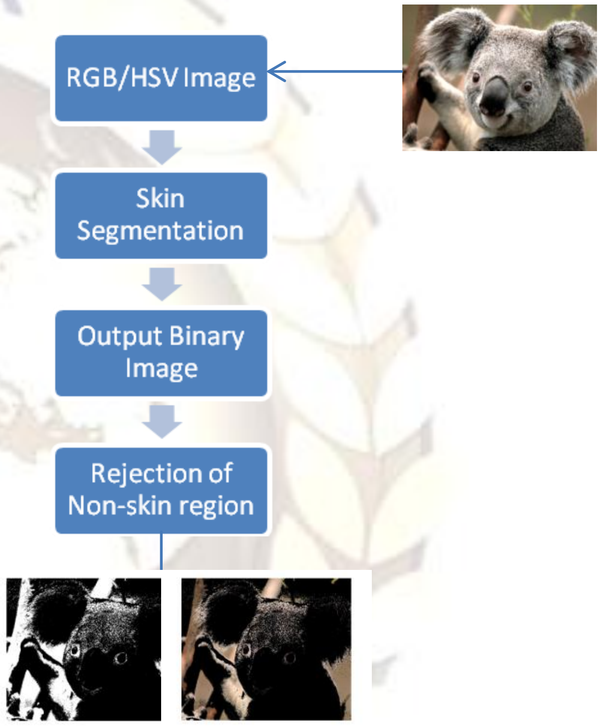

Figure 2: Skin Segmentation System

Implemented Algorithm: Below algorithm is being used when imagemap is returned:
Individual pixels are picked and analysed to fit in the test range. Newton's secant root method is applied to reach to an optimum range for the color space in consideration.

Function HSV: parameters image map:
Begin
For each pixel {
If: compare: Imagemap (pixel, 1) and range (1)
{Binary output (pixel) equals 1 }
Else
{Binary output (pixel) equals 0}
End
End
Bwmorph: binary output
Median filter: binary output
Matrix multiplies:
Color output = (binary output). *(imagemap)

Show image
End function

Algorithm for obtaining imagemap:

case HSV:

$$M = \max(R, G, B)$$
$$m = \min(R, G, B)$$
$$C = M - m$$

$$H' = \begin{cases} \text{undefined}, & \text{if } C = 0 \\ \frac{G-B}{C} \bmod 6, & \text{if } M = R \\ \frac{B-R}{C} + 2, & \text{if } M = G \\ \frac{R-G}{C} + 4, & \text{if } M = B \end{cases}$$

$$H = 60^\circ \times H'$$

$$\alpha = \tfrac{1}{2}(2R - G - B)$$
$$\beta = \tfrac{\sqrt{3}}{2}(G - B)$$
$$H_2 = \text{atan2}(\beta, \alpha)$$
$$C_2 = \sqrt{\alpha^2 + \beta^2}$$
$$Y'_{601} = 0.30R + 0.59G + 0.11B$$

$$S_{HSV} = \begin{cases} 0, & \text{if } C = 0 \\ \frac{C}{V}, & \text{otherwise} \end{cases}$$

$$S_{HSL} = \begin{cases} 0, & \text{if } C = 0 \\ \frac{C}{1-|2L-1|}, & \text{otherwise} \end{cases}$$

$$V = M$$

imageMap=

for evry pixel in originalMatrix

imageMap(x,y,z)=addMatrix+ convertMatrix * originalMatrix(x,y,:)

Make a start:

RGB Segmentations:

Figure 3: Start function in MATLAB.

Figure 4: Black and White Image pixels with no light conditions and with light conditions.

Above figure depicts the black and white segmented image pixels with no lighting conditions and with light conditions.

Figure 5: Segmented Image pixels with no light and with light conditions.

Experimental Results:

Color Space	Conditions Checked for
RGB	R > 100, G > 50, B > 30 R>G, R>B
HSV	H:0.04-0.0882 S:0.11 – 0.68 V: 0.38 – 0.112

Table 1: Results for the RGB skin detection in various lighting conditions

S.NO.	Lighting Condition	% Value for each pixel after image quantization
1	Lighting Condition-1	37.34
2	Lighting Condition-2	28.19
3	Lighting Condition-3	29.70
4	Lighting Condition-4	28.07
5	Lighting Condition-5	24.89

#Small Skelton of Implemented Code

```
function [ bwout,out ] = skin_rgb( imageFile )
%UNTITLED2 Summary of this function goes here
%   Detailed explanation goes here

%bwmorph clean spur

RGB_img = imread(imageFile);                  %# Load an RGB image
[img1,map] = rgb2ind(RGB_img,65000);          %# Create your quantized image
red = reshape(map(img1+1,1),size(img1));  %# Red color plane for image
green  =  reshape(map(img1+1,2),size(img1));   %# Green color plane for image
blue = reshape(map(img1+1,3),size(img1));
red=red*255;
green=green*255;
blue=blue*255;
[row,column]=size(red);
in=RGB_img;
out=in;
```

Methodology Adopted:

Tools and Techniques:

MATLAB Code with minimum complexity for detecting a shape drawn by fingertip (Drawing a line with fingertip in real time using web cam) and if required code for hand segmentation.

Tools Used: MATLAB Software to code different coloring schemes

IV. CONCLUSION

An analysis of the pixel-wise skin segmentation approach that uses color pixel classification is presented, during the course of our research work; we implement and discuss skin pixel segmentations with the effect of various light conditions. Compared with the conventional methods of segmentation, we put three methods into this paper; the methods are adjudging the images with the light interference, enhancing the images and an improved algorithm of threshold segmentation. The method which combines otsu with histogram avoids the partition in the whole range of grayscale, thereby accelerates the speed of segmentation, which provides real-time guarantee for face detection system based on skin detection. Using these methods can handle various sizes of faces, different illumination conditions, diverse pose and changeable expression. In particular, the scheme significantly increases the execution speed of the face segmentation algorithm in the case of complex backgrounds. In the future, the proposed methods will be applied to face detection, face recognition and face tracking effectively.

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