Skin Detection Algorithm Using RGB, YcbCr, and HSV Color Space.

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***Abstract*— It has been proven that skin detection is useful for facial detection and tracking [7].The application for colour stabilization of image material can indeed benefit from automatic skin detection in photographs. Skin pixels may differ with light; measuring the values for which the majority of skin pixels fall within the skin clour space is also a difficult task. As a result, over the past few years, numerous methods for skin color mapping and identification are already being proposed and a few papers are published with a comparison of different skin detection methods. They are all highly specific, but this paper presents a technique for the identification of human skin tone regions with a threshold-based combination of RGB (Red, Green, Blue), YCbCr (Luminance, Chrominance) and HSV color models (Hue, Saturation, Value)**

Keyword: Skin detection, Tracking, RGB, HSV, YCBCR

1. INTRODUCTION

Skin color includes relatively condensed details in the color images of human faces. A process of skin colour recognition used in lots of image processing application, like car number plate scanning, hand moment tracking, video editing, and facial identification [1]. In order to eliminate non-skin color pixels, the main job of skin colour analysis is to create noise philtres so that existing skin color pixels fall within a defined colour space. Color space is the definition of a coordinate system where only a given variable determines each colour. For the creation of digital images, different colour spaces are used [2]. A process for detecting the face based on RGB, HSV, YCrCb and are proposed in [2]. In their process, skin color areas are removed which remove non-skin color regions. The main considerations for the determination of the threshold range are following [2]:

1) The effect of light on the world.
2) Features such as age, gender and components of the body.
3) Variation with respect to different types of skin tone.
4) Other variables, like motion blur, background colors.

Recognization of skin determined by variables such as Illumination, Intensity, Visibility, Lighting as well as Exposure, Recognition is usually optimised by considering the formulations of the above factors listed in their optima range [2]

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2.Color space

Color Space is a conceptual structure demonstrating the knowledge of colour as 4 distinct components of color. For various uses, such as graphic design, image recognition, etc., different colour spaces (models) may be used. Broadcast television, object recognition. For skin detection, different colour spaces are needed. These are, Rgb Dependent Colour Model (Rbg, Rbg Normalized), Hue Centered Color Space (HSI,HSV, and HSL), Color Space Luminance (YCBCr),[9]. For skin colour evaluation and further classification, Color Space Choice is the main approach. One or two colour spaces threshold value is given for the recognition of skin pixels in input images. A process for texture analysis and implementation also specifies the selection of the correct approach to colour space. We use the colour spaces below to detect skin pixels.

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2.1 Red, Green, Blue (RGB) color model

RGB colour space is commonly used for digital images to be collected and represented and is normally the default colour space. Any other colour space is derived from a linear or non-linear RGB transformation [2]. The colour space used by computers and graphics cards is the RGB colour space[2]. It involves three elements, the primary colour being red, green and blue, as shown in Fig. A. By combining the three colours, any colour can be obtained. The basic colors. Any colour can be generated on the basis about how often each base colour is used Inversely, as seen in equation 1, a single colour can be broken down into its red, blue and green components. You may use these values to find identical coloured pixels in the picture [9]. Describes the colour detection of the skin based on the RGB colour field. The standardised RGB is a representation easily extracted from the RGB. RGB values via a simple procedure for standardization[3].

$$\mathrm{R} = \frac{R}{R+G+B} \qquad \textit{(eq. 1)}$$

$$\mathrm{G} = \frac{G}{R+G+B} \qquad \textit{(eq. 2)}$$

$$\mathrm{B} = \frac{B}{R+G+B} \qquad \textit{(eq. 3)}$$

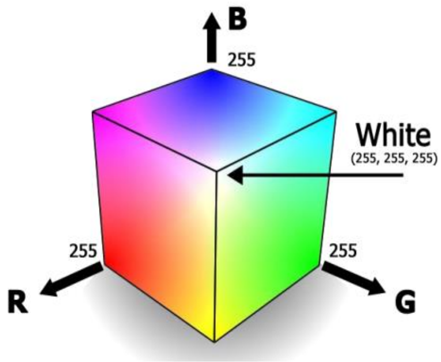


Fig A. RGB Color Model. [2]

2.2 YCbCr (Luminance, Chrominance) Color Model

YCbCr is a non-linear RGB condensed signal, commonly used for image compression work and by European television studios. As shown in the below fig. B color is expressed by luma built as a linear combination of RGB values [8]. YCbCr is commonly used in the digital video environment as a colour space. Since visualization makes it a lot easier to get out of any irrelevant details about colour, it is used in JPEG, MPEG1, MPEG2 and MPEG4 for video and image encoding. YCbCr colour space is made by the simplicity and simple separation of the luminance and chrominance components[5]. The luminance data is collected as a one factor (Y) in this system and the chrominance data is collected as two-color difference variables cb and cr. The discrepancy between the variable in blue and reference value is cb and cr is the difference between a reference value and the red variable It is possible to extract the YCbCr values from the RGB colour space according to eq. It's 4, eq. 6. [9][10][11] YCbCr uses space for skin detection.YCbCr uses skin detection space.

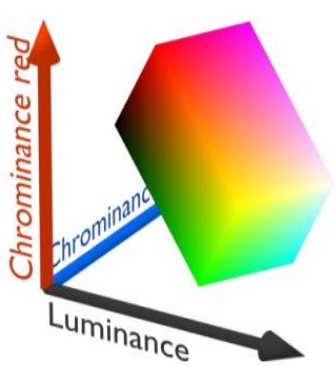


Fig B. YCbCr Color Model. [2]

$Y = 0.299R + 0.287G + 0.11B$ *(eq. 4)*

$Cr = R - Y$ *(eq. 5)*

$Cb = B - Y$ *(eq. 6)*

2.3 Hue Saturation Value (HSV) Color Model

In terms of how people view colour, HSV colour model is intuitive compare to the RGB colour space. The related colours range from Red, Yellow, Green, Cyan, Blue and Magenta to Red since the hue (H) ranges between 0 to 1.0. As saturation ranges between 0 to 1, the related colours varies from unsaturated to fully saturated. As value (V), or brightness, the value ranges between 0 to 1. The colour that are associated have become lighter All of them, as shown in Figure C [5], lie around a hexagon. The colour will have values such as 0.5, 0.5, 0.25 with RGB, and it will be 30°, ~3/4, and 0.5 with HSV. When the user interactively selects a colour, HSV is best utilised. Compared to using RGB [7], it is commonly much easier for the consumer to get to the desired colour. [15].

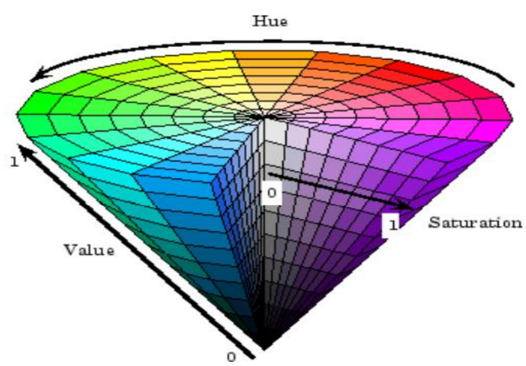


Fig C. HSV Color Model. [2]

$R' = R/255$; $G' = G/255$; $B' = B/255$ [17]

$Cmax = \max(R', G', B')$; $Cmin = \min(R', G', B')$ [17]

$\Delta = Cmax - Cmin$ *[17]*

Hue calculation [17]:

$$H = \begin{cases} 0^\circ & \Delta = 0 \\ 60^\circ \times \left(\frac{G'-B'}{\Delta} mod 6\right) & , C_{max} = R' \\ 60^\circ \times \left(\frac{B'-R'}{\Delta} + 2\right) & , C_{max} = G' \\ 60^\circ \times \left(\frac{R'-G'}{\Delta} + 4\right) & , C_{max} = B' \end{cases} \quad (eq.\ 7)$$

Saturation calculation [17]:

$$S = \begin{cases} 0 & , C_{max} = 0 \\ \frac{\Delta}{C_{max}} & , C_{max} \neq 0 \end{cases} \quad (eq.\ 8)$$

Value calculation [17]:

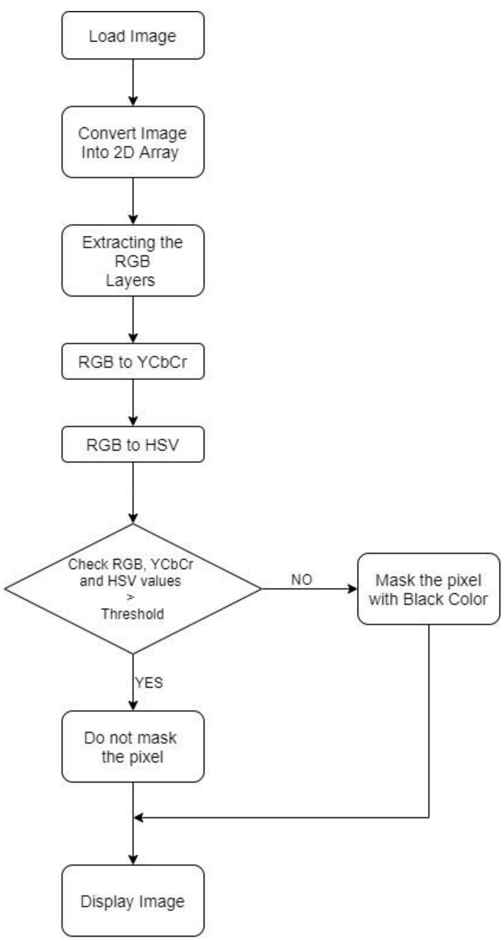
$V = Cmax$ *(eq. 9)*

3. Implemented Skin Detection Algorithm

The algorithm starts with loading the image and converting it into a 2D array[0]. Once the image has been converted into a 2D array space, the algorithm extracts the Red, Green, and Blue layers from the 2D array. In order to convert RGB to YCbCr, the algorithm uses the eq. 4, eq. 5, and eq. 6. Then the algorithm converts RGB to HSV by using eq. 7, eq. 8, eq 9. In the end, the algorithm checks each value that is produced by RGB, YCbCr, and HSV with below given two thresholds and produce two different images for each threshold. The flow of the algorithm can be seen from the flow chart given below (see *3.1 Flow chart of algorithm*)

Threshold 1 [2] :
$0.0 <= H <= 50.0$ and $0.23 <= S <= 0.68$ and $R > 95$ and $G > 40$ and $B > 20$ and $R > G$ and $R > B$ and $| R - G | > 15$ [2]

Threshold 2 [2] :
$R > 95$ and $G > 40$ and $B > 20$ and $R > G$ and $R > B$ and $| R - G | > 15$ and $Cr > 135$ and $Cb > 85$ and $Y > 80$ and $Cr <= (1.5862*Cb)+20$ and $Cr>=(0.3448*Cb)+76.2069$ and $Cr >= (-4.5652*Cb)+234.5652$ and $Cr <= (-1.15*Cb)+301.75$ and $Cr <= (-2.2857*Cb)+432.85$



3.1 Flow chart of algorithm [2]

4. Testing

4.1 Testing on "Other Test Images"

For testing purposes, we are comparing True Positive, True Negative, False Positive, False Negative, Precision, and Accuracy for eight different images. We have a total of two tables that shows the results produce by threshold 1 and threshold 2.

Threshold 1

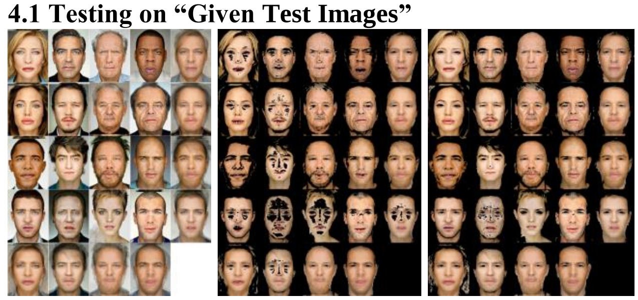
Img No.	Total Pixel	Skin Pixel Pred	Skin GT	Non-Skin Pixel Pred	Non-Skin GT	TP	FP	TN	FN	Pre.	Accu.
1	185760	81804	82792	103956	102968	68084	14708	89248	13720	83.22	84.69
2	327680	104017	80197	223663	247483	62308	17889	205774	41709	59.90	81.81
3	167000	34197	22609	132803	144391	17707	4902	127901	16490	51.77	87.19
4	239400	66726	83777	172674	155623	61367	22410	150264	5359	91.96	88.40
5	691200	102549	84002	588651	607198	56002	28000	560651	46547	54.60	89.21
6	307200	112387	101884	194813	205316	82072	19812	175001	30315	73.02	83.68
7	95172	12819	18748	82353	76424	9155	9593	72760	3664	71.41	86.07
8	273280	34389	21811	238891	251469	15996	5815	233076	18393	46.51	91.14

Threshold 2

Img No.	Total Pixel	Skin Pixel Pred	Skin GT	Non-Skin Pixel Pred	Non-Skin GT	TP	FP	TN	FN	Pre.	Accu.
1	185760	97560	82792	88200	102968	81909	883	87317	15651	83.95	91.09
2	327680	150730	80197	176950	247483	67960	12237	164713	82770	45.08	71.00
3	167000	52940	22609	114060	144391	19316	3293	110767	33624	36.48	77.89
4	239400	97327	83777	142073	155623	83389	388	141685	13938	85.67	94.01
5	691200	127905	84002	563295	607198	59332	24670	538625	68573	46.38	86.50
6	307200	115211	101884	191989	205316	82687	19197	172792	32524	71.77	83.16
7	95172	17538	18748	77634	76424	13106	5642	71992	4432	74.72	89.41
8	273280	49773	21811	223507	251469	17575	4236	219271	32198	35.31	86.66

The main key difference to observe between both tables is Precision values and Accuracy Values. In the Threshold 1 table, the overall values for Precision are higher than the Threshold 1 table and at the same time Threshold 2 has an overall higher value for Accuracy than the Threshold 2 table. It's because when Accuracy increase, it cost the quality of the result and that leads to a decrement in Precision.

4.1 Testing on "Given Test Images"



We can observe that the algorithm is able to identify skin areas from a given image but at the same time, it identifies some clothes, hair, teeth, eyes, eyebrows as skin. It's because that area has the same color tone as skin. So in that case algorithm fails to distinguish skin and non-skin areas of images. Apart from that, some time algorithm fails to identify some shadow areas of skin.

4.2 Testing Time Complexity on "Given Test Images"

Img No.	Total Pixel	RGB	YCbCr	HSV	Threshold 1	Threshold 2
Skin0	3197414	9.29	0.08	16.98	38.05	26.78
Skin1	1705600	8.82	0.02	8.89	19.73	12.97
Skin2	1023536	8.10	0.01	5.54	6.28	4.63
Skin3	512400	8.10	0.0095	2.74	5.30	3.54
Skin4	1848000	7.62	0.03	9.63	16.81	10.84
Skin5	27810653	8.58	0.76	145.89	230.08	193.95
Skin6	217000	1.16	0.0041	1.12	2.81	1.77

All time is in second

From the above table, it is easy to observe that when the size of the image is large (number of pixels is more) at that time it takes more time to produce the output

I. CONCLUSION

To wrap up, we see the algorithm that uses RGB, HSV, and YCbCr and then uses the two different thresholds to produce two different images. Although the algorithm identifies some non-skin objects as skin objects such as hair, teeth, eyebrow, and cloths. The future scope of this algorithm is to differentiate skin and non-skin objects more accurately.

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