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Simple Method of Human Skin Detection using HSV and YCbCr Color Spaces

Muh. Arif Rahman[1], I Ketut Edy Purnama[2] and Mauridhi Hery Purnomo[3]
[1]Department of Computer Science, Universitas Brawijaya, Malang, Indonesia
(Tel : +62-34-157-7911; E-mail: arif.rahman12[at]mhs.ee.its.ac.id)
[2]Department of Electrical Engineering , Institut Teknologi 10 November Surabaya Indonesia
(Tel : +62-31-594-7302; E-mail: ketut[at]ee.its.ac.id)
[3]Department of Electrical Engineering , Institut Teknologi 10 November Surabaya Indonesia
(Tel : +62-31-594-7302; E-mail: hery[at]ee.its.ac.id)

Abstract—**Human skin detection is an important preliminary stage to improve the performance of other areas of object detection or recognition such as human face detection, hand gesture recognition, and pornography contents detection. Popular methods in this area are processing a single image pixel in HSV or YCbCr color spaces. The limitation of these approaches is they cannot address the wide range of the skin color distribution. This paper proposes a new approach by combining two model of skin color for each pixel into a vector contains color elements of H, S, Cb, and Cr. A set of experiments prove that the method produces an True Positif Rate (TPR) of 93.89% and False Positif Rate (FPR) of 10.75% . This result is significantly higher comparing those produced by single color models**

Keywords: human skin detection, RGB, HSV, YcbCr

I. INTRODUCTION

Human skin colors occupy a certain range in color space. Many attempts have been done to build exact methods to model the skin color range. Due to the existence of various skin characteristic such as the usage of different cameras, illumination, individual human characteristic, building the models are difficult[1]. In fact, the models are required in preliminary stage to improve the performance of other areas of object detection or recognition such as human face detection[2][3], hand gesture recognition[4], and pornography contents detection[5].

Human skin detections are becoming challenging research as there are no single ranges of skin pixel value in color spaces. Human skin colors occupy different ranges according their age, ethnic, and illumination [6]. The frequently used color models in this research area are HSV[7], YCbCr[8], YUV[9], and YIQ[10]. Here, each pixel is evaluated to determine whether it is skin color or not.

Skin color detection can be classified into three categories: explicit range method, nonparametric method, and parametric method. The explicit range method determines the class of pixels (skin or non-skin) according to the predetermined color range. This approach is frequently used for its simplicity and fast computation [6]. However, proper skin range and efficient rule must be determined to obtain good results [7]. Because people from different area has different skin color. To handling this problem different color space has been proposed[11].

Non parametric methods have a limitation as it variance of single color model cannot address all kind of skin color distribution[8]. Methods that use a single color model require the determination of proper color model and also color ranges that produce the highest accuracy [12]. The methods have limitations due to the occurrence of noises and non-skin pixels. Thus, to obtain better results, a number of methods treat pixel regions instead of a single pixel skin [11].

The improvements of human skin detection based on color pixel are done by combining several human skin models. Here, each pixel is evaluated using a number of color spaces [14]. For instance, Khaled [15] applies three color model HSV, YUV, and YIQ. He claims that his approach produces better result compare to those achieved by using a single color model.

Considering the facts mentioned above, the development of human skin detections seem to offer unexplored opportunities that may deserve the attention of scientist. Therefore, in this work, we propose a combination of YCbCr and HSV color model to detect human skin. Focus of the research is obtaining a proper variance value of color pixel to increase the accuracy. To increase speed of computation, we proposed block instead of single based based detection The remaining parts of this paper are organized as follows: Section 2 will discuss on skin color model; Section 3 will detail the proposed algorithm; and the results will be explained in Section 4

II. SKIN COLOR MODEL

Color is used to identify objects on images. Several color spaces have been proposed for digital image processing. Choosing a proper color space is highly required to obtain satisfactory results in object detection.

A. RGB

RGB is a color space that has color elements (channels) of *Red* (R), *Green* (G), and *Blue* (B); each of them has value in interval [0, 255]. Human skin detections based on RGB color space cannot produce good result as the existence of strong relationship among channels [6].

Range of human skin color in RGB is defined as follow:

$$R > 95 \text{ and } G < 40 \text{ and } B > 40 \text{ and } \\ (\max(R,G,B) - \min(R,G,B)) > 15 \text{ and } \\ |R - G| > 15 \text{ and } R > G \text{ and } R > B \quad (1)$$

B. *HSV*

HSV is a color space that has color elements of *Hue* (H) that describes the color change from red to green, *Saturation* (S) that describes the color change from red to pink, and *Value* (V) that also named as *intensity* or *lightness* that represents the color change from black to white. Comparing to RGB, HSV could produce better results for human skin detection [16].

The transformation of RGB elements into HSV is defined in the following equations:

$$H = \begin{cases} H_i & \text{if } B \le G \\ 360 - H_i & \text{if } B > G \end{cases} \quad (2)$$

$$H_i = arc\cos\left(\frac{\frac{1}{2(R-G)+(R-B)}}{[(R-G)^2 + (R-B)(G-B)]^{\frac{1}{2}}} \right) \quad (3)$$

$$S = \frac{\max(R,G,B) - \min(R,G,B)}{255} \quad (4)$$

$$V = \frac{\max(R,G,B)}{255} \quad (5)$$

Range of human skin color in HSV is defined as follow [17]:

$$0^o \le H \le 25 \text{ and } 335^0 \le H \le 360^0 \\ 0.2 \le S \le 0.6 \\ V \ge 40 \quad (6)$$

C. *YCbCr*

YcbCr is a perception color space that has two elements: *luminance* (Y) that states the light intensity and *chrominance* (Cb and Cr) that the blue-difference and red-difference chroma components [18]. The transformation of RGB elements into YcbCr is defined in the following equations:

$$Y = 0.299R + 0.587G + 0.114B \\ Cb = B - Y \\ Cr = R - Y \quad (7)$$

The determination human skin color in YCbCr is defined as follows:

$$77 \le Cb \le 127 \quad \text{and} \quad 133 \le Cr \le 173 \quad (8)$$

III. Proposes Method

There are two stages in the proposed method: learning stage and testing stage. The learning stage is performed by scanning skin color from several images that contain face, hand, and foot. The testing data are obtained from private collection and the internet. Several examples of training and testing data are provide in Fig. 1 and Fig. 2

.Figure 1. example of training data

Figure 2. Testing Data

Fifty images with varied sized are used as the training data and ten images are used as the testing data. Several images in the testing data have background that is almost similar with skin color. Steps in the training stage are performed to produce average vector and covariance matric of skin color.

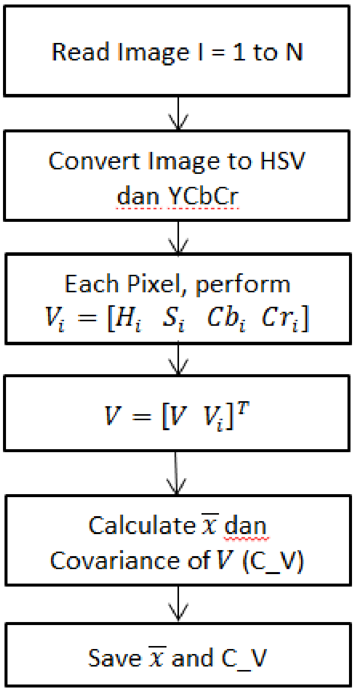


Figure 3. Training Stage

In this training step. Color model of each image are in RGB. Every pixel of image is convert to HSV and YCbCr color model to perform vector $V_i = [H\ S\ Cb\ Cr]$. The element color of H and Y is luminance and be ignored. Each vector Vi is arranged to form matrik V which have size Nx4. N is number of pixel from all images. The result of training stage are mean ($\bar{x}$) and matrix covariance (Λ) of V. To find threshold T, compute mahalanobis distance D of every pixel in training image.

$$D = \sqrt{(y - \bar{x})^T \Lambda^{-1} (y - \bar{x})} \qquad (9)$$

Then compute standart deviation τ. Threshod $T = 0.5\tau$

In this testing stage read image one by one. For every image convert RGB value into HSV and YCbCr color model. In every image, read every pixel and perform as a vector $y = [H\ S\ \ Cb\ Cr]$. Divide image into block size 5x5 and and calculate mahalobis distance D every corner and center pixel as follow:

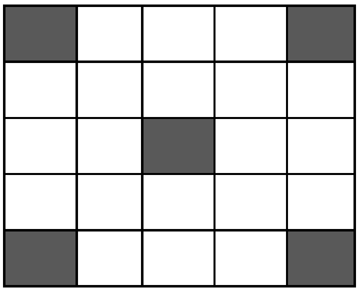


Figure 4. Testing Stage

The corner and center pixel of a block is (1,1), (1,5), (3,3), (5,1) and (5,5). If those pixel have D < Threshold then the block is skin. If none of those pixel have D < Threshold then the block is not skin. If any of five pixel which have D > Threshold then every pixel in the block will be evaluated to find this pixel as skin or not skin. Testing stage is shown in figure 4.

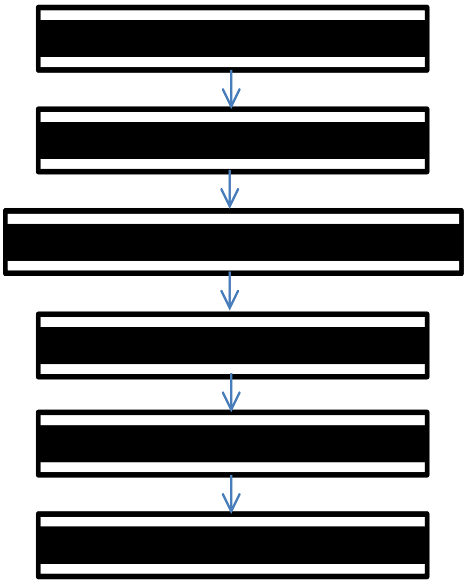
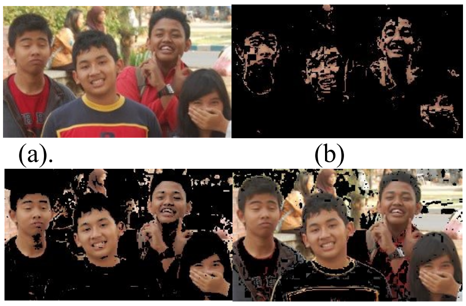


Figure 5. Testing Stage

IV. COMPUTATION RESULT

An example of result of the testing stage is given in Fig. 6. Pixels that are detected as non-human skin are drawn as black.



(a). (b)

(c). (d)

Figure 6. Original Image and Skin Detection various τ

Fig 5. (a) Testing Image. (b) Detection result with Threshold of 0.2τ. (c) Detection result with Threshold of 0.5τ. (d) Detection result with Threshold of $0.9\,\tau$. The determination of proper threshold values is very important to obtain good results.

The performance of the proposed method is measured by using True Positive Rate (TPR), False Positif Rate (FPR). The complete result is given in Table 1

Table 1. Computational Result TPR, FPR with Threshold of 0.5T

Image	TPR	FPR
1	96.1	7.0
2	96.6	3.1
3	93.9	7.8
4	95.7	2.4
5	95.4	23.1
6	93.9	7.6
7	95.7	5.6
8	88.0	19.3
9	88.5	23.1
10	95.2	8.4
Average	**93.9**	**10.7**

The True Positif Rate (TPR) states the percentage of skin color is also detected as skin color, whereas the False Positif Rate mean the percentage of skin color is detected as non skin color. The better method is try to increase TPR and decrease FPR. In table 1. the average value of TPR is 93.9% and FPR ias 10.7% that could be considered as a good result.

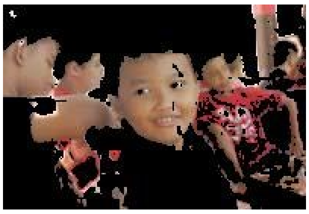
The performance comparison of the proposed method with other methods that use only a single color model is provided in Table 3. Here, the proposed method produces significantly higher TPR and smaller FPR.

Table 2. The performance comparison of the proposed method with other methods

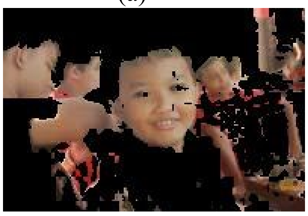
Method	TPR	FPR
RGB	89.52	40.80
HSV	86.96	27.24
YCbCr	91.01	39.70
Proposed	93.89	10.75

From the table 2 is found that the proposed method show better result than other method. And Figure 7 show image filtering skin detection using proposed method and other method. As seen on those images there are pixels which is not a skin but detected as skin.

(a)

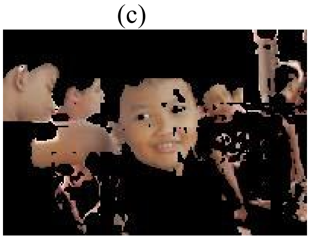


(b)



(c)

(d)



(e)

Figure 7. (a) Original Image, (b) filtering RGB, (c) Filtering HSV, (d) Filtering YCbCr and (e) Filtering Proposed Method

CONCLUSION

This paper provides simple method by combining YCbCr and HSV color to detect human skin color from image. Mahalanobis distance method is used to assign weight of every pixel on image. Based on the value skin can be classified. The experimental results show that this algorithm produces significantly higher TPR and at the same time has smaller FPR than other methods that use only a single color model.

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