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Facial Skin Color Segmentation Using Otsu Thresholding Algorithm

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Abstract - The development of technology and information is currently very fast. One of the fields of technology and information that is experiencing development is the field of digital image processing. There are many technologies today that utilize digital images such as facial recognition, object detection and many others. Skin is one of the largest components of the human body. Currently, technology in the identification of skin color is widely used in recognizing the human race. In this study, skin color detection uses the YCbCr color space, which in this study only uses the range of Cb and Cr values, and ignores the Y value. Where Y is the lighting in the image. So if not changed, the image will contain light effects that can change the characteristics of skin color. However, problems were found because the detected images were not segmented properly, such as clothes and hair from the tested images were still detected as skin. Therefore, the HCbCr color space method is proposed where the Hue value will represent the color of visible light. While the Otsu Thresholding method will separate the background from the object in the digital image.

Keywords - color HCbCr, color YCbCr, Otsu Thresholding

1. INTRODUCTION

The growth of technology and information today is very rapid [1]. These developments can be used to help human work and become one of the entertainments of various groups of young and old. One of the fields of technology and information that is experiencing development is the field of digital image processing. Image processing is a technology that can be used as a solution to problems related to image processing to be applied in the future. Digital image processing itself can later be used and utilized in the field of human life [2].

Skin is one of the largest components of the human body. Human skin itself has a function to protect the body from heat, chemicals, infections and as a sense of touch [3]. In addition, human skin also has different colors so that it makes its own character for each individual [4]. Leather can be used as a good source of starting data because it requires a short processing time and is resistant to various geometries of skin patterns or textures, for example, the transformation of image resolution and the efficiency of using special equipment.

Image segmentation is an image processing process that aims to separate the object area from the background area so that the object is easily detected [5]. Segmenting the skin image means separating the image that includes skin and non-skin objects such as image background, hair and eyes. Basically the purpose of skin segmentation is also used in face detection and recognition systems. There is a problem with skin detection which makes it not so perfect. Because there are many problems that will affect the skin segmentation process such as the influence of lighting, background, the influence of camera characteristics, ethnicity, and others [6].

In a study on skin color detection using the YCbCr color space, in this study only the range of Cb and Cr values was used, and ignored the Y value [7]. Where Y is the lighting in the image. So that if it is not changed, the image will contain light effects that can change the characteristics of skin color. However, problems were found because the detected images were not segmented properly, such as clothes and hair from the tested images which were still detected as skin. From a study in segmenting the skin area using the chromatic color space to eliminate lighting with a normalization process and determining the likelihood value will be a pixel from the skin. The results of skin segmentation show that errors that occur in the process of segmenting the skin area occur because there are areas that have similarities to possible skin values, such as the color of the clothes worn or the background color. Meanwhile, in other studies, the stage of testing the skin segmentation process with the YCbCr color transformation method obtained good image binarization results in detecting skin, but there were still detection errors such as hair detected as skin [8]. From these studies, there are still weaknesses in detecting skin and non-skin. Because in the YCbCr color space the value of Y is ignored, where Y is the lighting in an image itself. Therefore, the YCbCr color space method is proposed where the Hue value will represent the color of visible light [9]. While the Otsu Thresholding method will separate the background from the object in the digital image [10].

2. RESEARCH METHOD

2.1. Otsu Thresholding

Thresholding process is one of the image segmentation which in the process is based on the difference in gray level of an image [11]. The purpose of the thresholding process is to get a binary image where the image is black and white, so that it knows the object area and the background area [12]. The otsu method aims to group by threshold value. The threshold itself will separate the intensity so that the optimal threshold value is obtained [13].

The following stages in the Otsu method are as follows:

a. Image conversion process to grayscale image

$$L(x,y) = \frac{(R(x,y)+G(x,y)+B(x,y))}{3} \quad (1)$$

b. Calculating the gray level distribution of an image

$$P_i = \frac{ni}{N} \quad (2)$$

Keterangan :

ni = jumlah piksel dengan tingkat keabuan i

N = jumlah semua piksel pada citra

c. Menghitung pembagian piksel kedalam dua kelas berbeda

ω_0 = Pr Pr (C_0) = $\sum_{i=1}^{k} Pi = \omega(k)$ (3)

ω_1 = Pr Pr (C_1) = $\sum_{i=k+1}^{L} Pi$ = 1- $\omega(k)$ (4)

2.3. Research Object

The data used in this study are facial images of various ages, genders, and ethnicities. The data used are 1000 images from the database available at www.kaggle.com. The images obtained have variations in skin color, expressions, and complex backgrounds. This makes it a challenge for the research to be carried out.

Figure 1. Face Image Database

2.4. Method

In this study, image segmentation was carried out to obtain the skin area, which has several stages. First, the process begins with the acquisition of facial images as input images. Then the image color changes from the RGB color space to Grayscale to get the initial image in the form of a gray image [14]. Then in the next stage it is binary using Otsu Thresholding to separate the object from the background. [15] Furthermore, processing is carried out using the HCbCr color space method in which this color space uses a combination of the HSV and YCbCr color spaces which have been used as skin detection methods in previous studies. After obtaining the segmented image, it is then repaired using morphological techniques.

From all the steps that have been carried out, the program will produce an output in the form of a skin image and those that do not include skin will be changed to 0 or black. Then the image evaluation stage is carried out with MSE and PSNR in order to get performance results in using the proposed method [16].

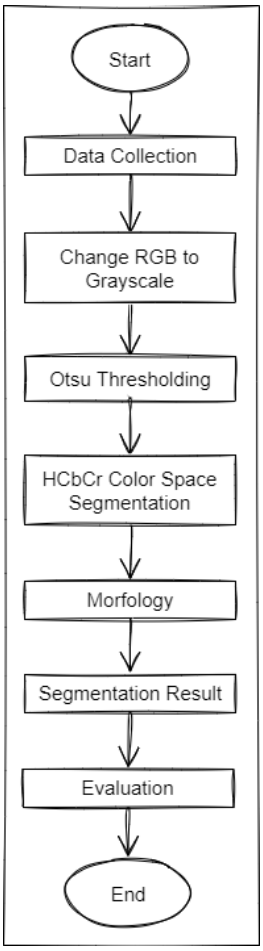

Figure 2. Research Flow

3. RESULTS AND DISCUSSION

The color space in the testing of this research is done by comparing the proposed color space, namely HCbCr with another color space, namely RGB. In addition, tests were also carried out with the Otsu threshold value of 0.1 to 0.9 and the use of morphology in both methods.

3.1. Image Segmentation Results Using Otsu Thresholding and HCbCr Methods

The results of the tests carried out using the HCbCr color space, the first is using the automatic thresholding otsu method with the graythres function and adding imfill and opening morphological methods. Second, using the Otsu thresholding method with a threshold value of 0.1 to 0.9 and adding imfill and opening morphology.

(a) (b) (c)

Figure 3. Comparison of the result of image segmentation (a) using Otsu, (b) using Otsu T = 0.1, (c) using Otsu T = 0.5

The picture above shows a comparison of the results of image segmentation using the Otsu Thresholding method and the HCbCr color space with different Otsu Threshold values. Image (a) using the Otsu value automatically displays a visual image that no longer has a background. Non-skin colors like hair, eyebrows, lips and eyes are also well segmented. In image (b) with a value of Otsu T = 0.1, it produces a fairly good image, but there are parts that are not skin that have not been segmented. While the image (c) with an Otsu value of T=0.5 displays only the skin, but there are some areas of the skin that are also segmented, this makes the pixels in the image decrease a lot compared to the automatic value.

It has been known that several image segmentation results from the Otsu Thresholding and HCbCr methods have been identified. Therefore, to determine the performance of the Otsu and HCbCr methods, the MSE and PSNR values were calculated. The following is a table of MSE and PSNR values tested on 10 RGB images using Otsu Thresholding and HCbCr.

Table 1. MSE and PSNR results Otsu Thresholding (automatic) and HCbCr methods

Nama File	MSE	PSNR
00000	0,491	51,250
00001	0,138	56,771
00002	0,443	51,697
00003	0,435	51,776
00004	0,550	50,758
00005	0,211	54,930
00006	0,477	51,383
00007	0,186	55,469
00008	0,166	55,972
00009	0,584	50,502

In the table above, the calculation of MSE and PSNR from the Otsu thresholding method is carried out with automatic values and segmentation of the HCbCr color space. The image with the best results is image 00001 which has the smallest MSE value and the largest PSNR value.

3.2. Image Segmentation Results Using Otsu Thresholding and HCbCr Methods

In this test using the otsu thresholding method and the RGB color space, two tests were carried out, the first using the automatic otsu thresholding method with the graythres function and adding imfill and opening morphological methods. Second, using the Otsu

thresholding method with a threshold value of 0.1 to 0.9 and adding imfill and opening morphology.

(a) (b)

(c) (d)

Figure 4. Comparison between the original image (a & c) and RGB color segmentation image (b & d)

The picture above is a comparison between image (a) and image (c) which is the original image with image (b) and (d) is the image resulting from RGB color space segmentation. From the image segmentation, it can be seen that the method can produce good skin segmentation, but there are still non-skin objects such as hair that have not been segmented.

Table 2. MSE and PSNR results with Otsu Thresholding (automatic) and RGB methods

NAMA FILE	MSE	PSNR
00000	0,476	51,385
00001	0,215	54,847
00002	0,446	51,668
00003	0,427	51,856
00004	0,505	51,132
00005	0,210	54,945
00006	0,313	53,209
00007	0,182	55,556
00008	0,097	58,282
00009	0,400	52,144

The table above shows the results of the MSE and PSNR calculations from the Otsu thresholding method with automatic threshold values and RGB color space segmentation. The

image with the best results is the 00008 image which has the smallest MSE value and the largest PSNR value.

3.3. Comparison of Test Results

From the tests that have been carried out with both methods which include the image segmentation results, the MSE and PSNR values, and the runtime or time required by the system to run the program. The results have been compared as follows:

(a) (b)

Figure 5. Result of Segmentation

The picture above is the result of segmentation using different color space methods. Picture (a) is the result of the HCbCr method and picture (b) is the result of the RGB method. Based on the test results of the two methods, the results obtained visually indicate that both methods produce the same good image segmentation results.

The next stage is to calculate the average MSE and PSNR values from each test method to determine the quality of the resulting image and also the running time required to run the program. Below is table 3.3 which shows the average MSE and PSNR values of 1000 segmented images using the Otsu Thresholding method and the HCbCr color space with the Otsu Thresholding method and the RGB color space.

Table 3. Runtime results, Average MSE and PSNR values

No.	Method	MSE	PSNR	Run Time
1.	metode Otsu Thresholding (otomatis) & HCbCr	0,306	53,880	851,030 s
2.	metode Otsu Thresholding (t=0.1) & HCbCr	0,330	53,809	643,576 s
3.	metode Otsu Thresholding (t=0.2) & HCbCr	0,331	53,721	531,338 s
4.	metode Otsu Thresholding (t=0.3) & HCbCr	0,328	53,690	572,082 s
5.	metode Otsu Thresholding (t=0.4) & HCbCr	0,321	53,676	517,568 s
6.	metode Otsu Thresholding (t=0.5) & HCbCr	0,323	53,532	537,193 s
7.	metode Otsu Thresholding (t=0.6) & HCbCr	0,352	53,019	467,115 s
8.	metode Otsu Thresholding (t=0.7) &	0,399	52,377	469,941 s

	HCbCr			
9.	metode Otsu Thresholding (t=0.8) & HCbCr	0,440	51,897	472,058 s
10.	metode Otsu Thresholding (t=0.9) & HCbCr	0,457	51,710	459,828 s
11.	metode Otsu Thresholding (otomatis) & RGB	0,270	54,371	6593,407 s
12.	metode Otsu Thresholding (t=0.1) & RGB	0,362	53,079	7400,541 s
13.	metode Otsu Thresholding (t=0.2) & RGB	0,357	53,154	6614,977 s
14.	metode Otsu Thresholding (t=0.3) & RGB	0,335	53,464	6855,745 s
15.	metode Otsu Thresholding (t=0.4) & RGB	0,294	54,058	6524,039 s
16.	metode Otsu Thresholding (t=0.5) & RGB	0,284	54,110	7150,153 s
17.	metode Otsu Thresholding (t=0.6) & RGB	0,317	53,485	6510,976 s
18.	metode Otsu Thresholding (t=0.7) & RGB	0,376	52,640	6582,092 s
19.	metode Otsu Thresholding (t=0.8) & RGB	0,429	52,006	6363,206 s
20.	metode Otsu Thresholding (t=0.9) & RGB	0,454	51,739	6758,687 s

3.4. Discussion

The average table shows that the smallest MSE value is owned by the automatic otsu thresholding method and the RGB color space which is 0.270 and also has the largest average PSNR value of 54.371 . Which means that the smallest average MSE value indicates the automatic otsu thresholding method and the RGB color space has better segmentation results. Meanwhile, in the Otsu Thresholding and HCbCr methods, the smallest MSE value is generated by Otsu Threshold automatically with the MSE value of 0.306 and the PSNR of 53,880.

The otsu thresholding and RGB methods have weaknesses in terms of a very long average run time, the average runtime required by the otsu thresholding method and the RGB color space for 1000 images is 6735.382 seconds or about 6 seconds for each picture. Runtime is the time it takes the method to run the program. While the average time required for the Otsu Threshold and HCbCr methods is 552.173 seconds or for each image it only takes 0.5 seconds.

What makes the otsu thresholding method and the HCbCr color space able to run the program well is because the otsu thresholding method and the HCbCr color space use a multi-stage algorithm, starting from separating the foreground and background picture using otsu thresholding, then looking for pixels that have the potential to be skin pixels using otsu thresholding. Hue value of HSV color space and CbCr value of YCbCr color space. This ensures that the segmentation results obtained are truly skin and reduce the possibility that non-skin is also defined as skin. Morphology is used to reduce the noise contained in the segmentation results. The HCbCr color space is used because the hue color space defines the actual colors, such as red, violet and yellow, which can represent skin color, such as a threshold in facial images. And the second is because to determine the object area, the focus is on the greatest light intensity, so that if in an area there is almost the same light intensity (too bright or too dark), it will be difficult to automate objects in the image.

The Otsu Thresholding method and RGB color space have also shown quite good segmentation results and also produce a small MSE value. On the other hand, this method takes longer than the otsu thresholding method and the HCbCr warna color space. The MSE and PSNR results obtained can also have the result that the MSE value is small because there are more segmented pixels than the initial image. Because the expected segmentation is the

image of the skin and the percentage of facial skin compared to the background image, of course the background is bigger.

4. CONCLUSION

Based on the research that has been done to determine the results of facial skin image segmentation using the Otsu Thresholding algorithm and the HCbCr color space, the following conclusions can be drawn:

1. The Otsu Thresholding algorithm and the HCbCr color space are capable of segmenting facial skin images. The best average MSE from the HCbCr method is 0.306 and the PSNR is 53,880 in the automatic Otsu Thresholding method.
2. The Otsu Thresholding algorithm and the HCbCr color space have advantages over the Otsu Thresholding and RGB methods, namely in terms of run time or time to run programs that show faster results with an average of 552.173 seconds while the Otsu Thresholding and RGB methods require an average runtime of 6735 ,382 seconds.

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