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Hand Region Detection using CbCr Color Space and Otsu's Method

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ABSTRACT

Hand Segmentation is the most important steps for hand gesture recognition. If the correctly detect the hand, the hand gesture recognition accuracy will increase. In our research, we used two different threshold-based segmentation methods to detect the hand in various background conditions (simplex and complex) and various illumination conditions and compare the accuracy. The main objective of this paper is to investigate the best threshold values of CbCr threshold-based method on the performance of hand segmentation process. The proposed system used the CbCr color threshold based method with various threshold values and otsu's method for skin color hand segmentation.

KEYWORDS: *Hand Segmentation; CbCr Threshold based method; Otsu's Threshold based method, Thresholding.*

1. INTRODUCTION

Image segmentation is the basic step and also difficult problems in computer vision and image processing. Segmentation is the portioning the foreground and background regions. There are many hands segmentation techniques such as threshold-based, edge-based, region-based, pixel-based, model-based, ANN-based, watershed-based, and clustering-based and many other segmentation methods. Among these techniques, threshold-based method is simple and easy to implement. In threshold-based method, the researchers need to have prior knowledge about the threshold values and also need to choose the best threshold values to correctly segment the meaningful regions.

The motivation of our research is to find out the best threshold values of YCbCr colour space for human skin detection. According to the previous literature, YCbCr colour space is the best suitable colour space for human skin detection. But, the colour spaces and threshold values are not fixing because different taking image devices, skin tone, illumination changing, blurring condition due to the movement object, shadow and many other conditions.

In our experiment, we analyse the various threshold values about YCbCr threshold based method and Otsu's threshold based method. According to the state of art research, YCbCr color space is the most suitable for human skin color segmentation than other color space because YCbCr colour space has good characteristics such as colour independent each colour components, good colour clustering and simple to calculate.

2. RELATED WORKS

Makkar et al (2014) analysis images using improved otsu's thresholding method.[1].Chaves-Gonzales et al (2009) study ten different color space models (RGB, CMY, YIQ, YUV,XYZ, HSV, YDbDr, YPbPr, YCbCr, YIQ) to detect the skin for face recognition system[2]. Jalilian et al [2013] implemented face and shape segmentation using statistical skin detection for sign language recognition. In this paper contains five main steps such as RGB to YCbCr, Compute Skin and Non-Skin model, used Bayes rule to release skin probability image and used average mask and global thresholding to generate the binary image. Finally, this system performs morphological operations to remove the noise. [8]

Shaik et al [3] implemented YCbYCr colour thresholds based approach. In this paper, the authors applied the threshold values between 150 & 200 for chrominance component Cr and the chrominance components Cb are between 100 & 200. But, the threshold value is not suitable to detect the hand in NUS hand pose dataset I.

McBride et al (2019) proposed skin segmentation/ detection algorithms to recognize the hand gesture of the hand gesture recognition system. The authors used YCbCr skin thresholding based algorithm, RGB-H-CrCb skin thresholding based algorithm and KNN skin classification algorithm. In this proposed study, the author used chrominance component Cb and Cr values between 80 & 120 and 133 & 173. The authors tested the segmented results on the three different particular images and compare these three different algorithms. But, these threshold values for CbCr are not suitable to segment the hand in NUS Hand Pose datasets I [4].

Rahmat and his partners (2016) proposed skin colour segmentation by combining three different colour spaces such as Normalized RGB, HSV and YCbCr colour space. The skin colour detection accuracy is more robust than the single colour spaces. The recognition accuracy was obtained 91.05% on two different datasets (ECU and HGR) [5].

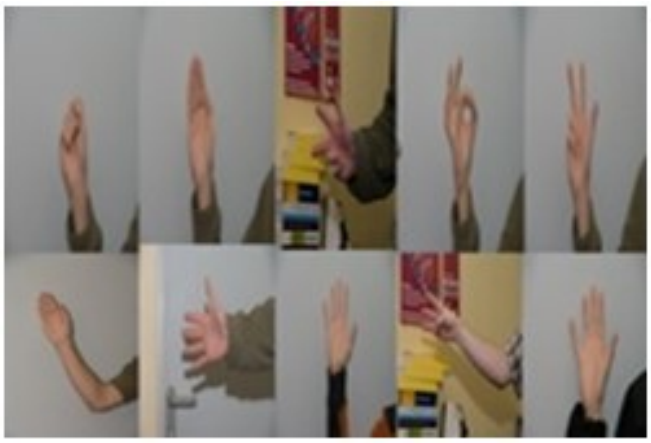
Qiu-yu et al (2015) proposed hand gesture segmentation method based on YCbCr color space and K-means Clustering. In this paper, the authors analysis three different color space such as RGB, YCbCr and HSV. Among these three color space YCbCr color space have better clustering range than RGB color space and HSV color space. So, YCbCr color space is the best color model for skin segmentation [9].

3. Datasets

In our experiment, we used three different datasets: HGR1 andHGR2A and HRG2B. These datasets contains simplest and complex background conditions. All images in these three datasets are number signs and character signs.

In HGR1 contains 899 images for 25 gestures. The data collected from 12 individuals' person and sizes of images are from 174*131 up to 640*480. The background and lighting condition are uncontrolled. In HGR2A contains 85 images with gray and uncontrolled environment for 13 gestures. The data collected from 3 people. The sizes of images in these dataset are 4672*3104 pixels. The lighting conditions are uniform and flash. In HGR2B dataset contains 574 images for 32 gestures. These data are collected from 18 individuals with controlled environment (green tone). The lighting conditions are uniform and flash. The images dimensions are 4672*3104 pixels.

a. Hand Gesture Recognition (HGR1) dataset



b. Hand Gesture Recognition (HGR2A) dataset

c. Hand Gesture Recognition (HGR2B) dataset

Fig 1: Some Sample Hand Gesture Images from three different datasets

4. Results and Discussion

4.2 Pre-processing

Three different dataset are used in our experiment. All images are RGB color space in these three datasets. There are number (0-9) signs and character (A-Z) signs. All of these images in three different datasets are resized to 256X256 images. Finally, the resize images are converted into YCbCr color space images for YCbCr color threshold based method and gray scale image for Otsu's threshold based method. RGB to YCbCr color space can be converted by using the following eq1.

$$\begin{bmatrix} Y \\ Cb \\ Cr \end{bmatrix} = \begin{bmatrix} 16 \\ 128 \\ 128 \end{bmatrix} + \frac{1}{256} * \begin{bmatrix} 65.738 & 129.057 & 25.064 \\ -37.945 & -74.494 & 112.439 \\ 112.439 & -94.154 & -18.285 \end{bmatrix} * \begin{bmatrix} R \\ G \\ B \end{bmatrix} \quad (1)$$

4.2 Hand Region Detection

Skin color detection is a useful technique to find the hands in images or videos. Skin color allows fast processing and also good features for detection the human face and hand. Color has proved to be useful for face and gesture detection, localization and tracking. There are many color space models: RGB, CMY, YUV, YIQ, YPbPr, YCbCr, YDbDr, YCgCr, HSV, CIE-XYZ and many others. Among them, YCbCr color space is the most suitable for human-skin detection.

In our experiment, we analyze YCbCr color threshold base method with adaptive threshold values and Otsu's threshold based method. These methods will be tested on three different (HGR1, HGR2A and HGR2B) datasets mentioned above. The various threshold values of YCbCr as shown in Table1.

4.2.1 YCbCr Threshold Based Method

In YCbCr color space, Y is the luminance component and Cb, Cr is the chrominance component. According to state of art research, the best threshold values are tested. The calculation process of YCbCr is very simple. YCbCr skin colour based segmentation is explained in [3][4][5][6][7]. The background and hand can be segmented with the threshold values (T) as shown in the following eq2,

$$I(row, col) = \begin{cases} 0; \ if\big(I(i,j) < T < I(i,j)\big) \\ 1; \ otherwise \end{cases} \quad eq(2)$$

Where,
0=black and 1=white

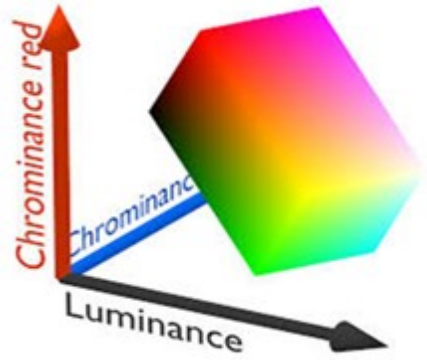


Figure 2: The YCbCr Colour Space Model

4.2.2. Otsu's Threshold Based Method

In image processing, otsu's method is commonly used to segment the images, foreground and background with automatic image thresholding values. In otsu's threshold based method, firstly convert original RGB image into gray scale image. And then produce the binary black and white images according to the pre-defined threshold values. The main advantage of otsu's threshold based method are quite fast and simplest calculation process.

The comparison accuracy resultIs that are tested on three different datasets with between two different methods describes in Table 1. The original image hand extraction result images and ground truth images in HRG1, HGR2A and HGR2B datasets is shown in Fig. 3, Fig.4 and Fig.5.

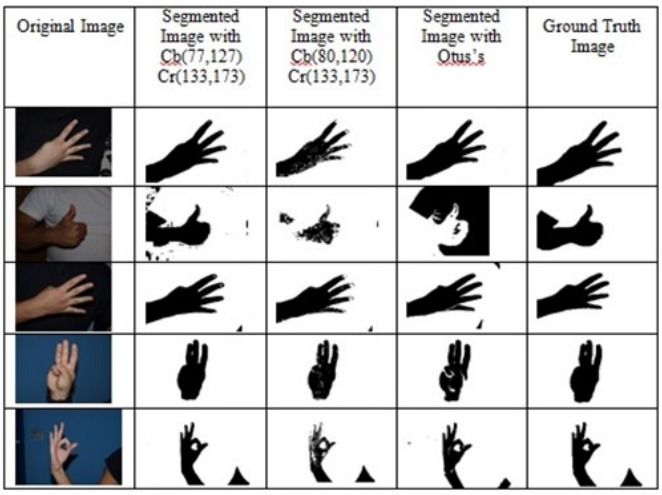


Figure 3: Hand Segmentation Result on HGR Dataset

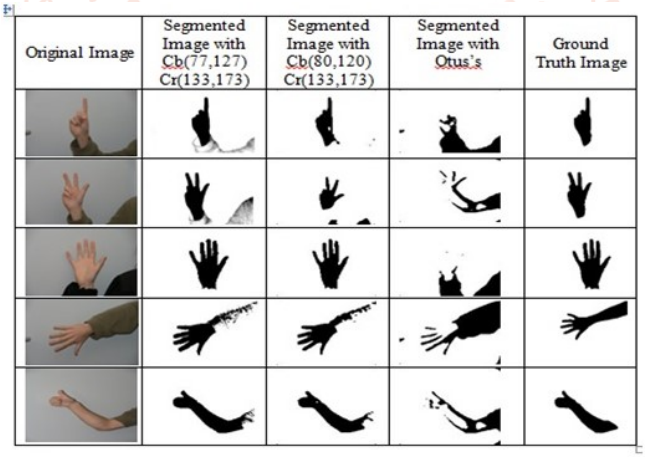


Figure 4: Hand Segmentation Result on HGR2A Dataset

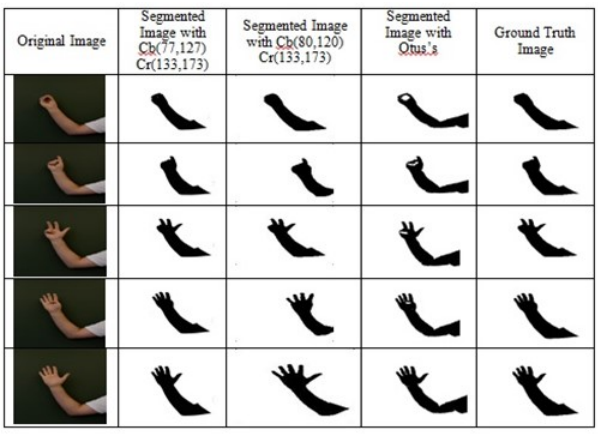


Figure 5: Hand Segmentation Result on HGR2B Dataset

Table.1. Different Threshold Values for Human Skin Segmentation

References	Thresholds Values of Colour Channel	Application Domain	Colour Space	Datasets
Shaik et al (2015) [3]	(100<Cb<150)&&(150<Cr<200)	Human Skin Colour Segmentation	CbCr	Internet Source
McBride et al (2019) [4]	(80<Cb<120)&&(133<Cr<173)	Human Skin Colour Segmentation	CbCr	Pratheepan Dataset
Rahmat et al (2004) [5]	Normalized R/Normalized G>1.185 & 0.2<S<0.6 & 0<H<25 or 335<H<360 (77<Cb<127)&&(133<Cr<173)	Human Skin Colour Segmentation	Combining Normalized RGB, HSV, CbCr	ECU, HGR Datasets
KuKharev et al (2004) [6]	(Y>80) && (85<Cb<135) &&(135<Cr<180)	Face Recognition	YCbCr	-
Chai et al (1999) [7]	(77<Cb<127)&&(133<Cr<173)	Face Segmentation	CbCr	-

The accuracy of this experiment can be calculated by the following equation.

$$\text{Specificity} = \frac{\text{TN}}{\text{TN} + \text{FP}}$$

$$\text{Recall} = \frac{\text{TP}}{\text{TP+FN}}$$

$$\text{Accuracy} = \frac{(\text{TP} + \text{TN})}{(\text{TP} + \text{TN} + \text{FP} + \text{FN})}$$

Where, TP is the number of pixel that is detected hand correctly; TN is the number of pixel that is detected background correctly, FP is the number of pixel that is detected hand as background and FN is the number of pixel that is detected background as skin. The segmentation performance accuracy results as shown in Table 2.

Table.2: Performance comparison on Three Different Datasets.

Datasets	Methods	Accuracy
HGR1	(77<Cb<127 && 133<Cr<173)	**98.54**
	(80<Cb<120 && 133<Cr<173)	98.16
	Otsu's Method	16.07
HGR2A	(77<Cb<127 && 133<Cr<173)	49.37
	(80<Cb<120 && 133<Cr<173)	58.55
	Otsu's Method	**61.47**
HGR2B	(77<Cb<127 && 133<Cr<173)	**98.55**
	(80<Cb<120 && 133<Cr<173)	96.91
	Otsu's Method	97.86

5. Conclusions

Accurate hand segmentation is the most important for sign language recognition. The system analyzed CbCr color threshold based method with various threshold values and Otsu's threshold based method. As a conclusion, the CbCr color threshold based method is good accuracy but the background contain like human skin color can degrade the performance. According to the experimental result, CbCr threshold based segmentation is good performance than Otsu's threshold method on HGR, HGR2B datasets. In the future, we will study hand segmentation with dynamic and very complex background for sign language recognition.

Declaration

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