Multi-face detection based on improved YCbCr color space

Li E
College of Mechanical and Electrical Engineering, Shandong Management University, No. 3500, Dingxiang Road, Changqing District, Jinan City, Shandong Province, China
1358727189@qq.com

Abstract. Face recognition has become a popular means of recognition. It is required in image retrieval, video monitoring, entrance and exit control of military bases or other sensitive areas and other occasions. Face recognition has three key steps: face detection, feature extraction and feature matching. Face detection plays an important role in face recognition. Skin color segmentation is an important part of face detection. The traditional skin color modeling rules of YCbCr color space still have some defects, so we made some improvements. We changed the parameters of the conversion matrix used in the conversion from RGB space to YCbCr color space, so that the chosen skin color region is closer to the face skin color region. By this way, the system can detect the face most accurately.

1. Introduction
In recent years, with the rapid development of science and technology, image acquisition equipment has been constantly updated, and color data sources are becoming more and more popular. A large number of scientific studies by researchers have shown that the skin tone of different parts of the body is uniform, and there is no difference in skin tone between different RACES. The reason why the skin looks different is caused by different brightness. Therefore, when in a natural color space, the face image chromaticity and brightness information separated separately, it will be a good way to achieve color segmentation.

Among all facial features, the advantages of applying skin color for face segmentation are obvious: first, skin color segmentation is not affected by image size, and the image quality generally does not affect skin color segmentation [1]. Secondly, skin color is not sensitive to human posture and facial expression. When the face is partially blocked or some details in the face image are lost, the accuracy of face detection using skin color segmentation will not be affected. Precisely because skin color has such advantages, it will have a great advantage over gray image, that is, it can exclude the area that looks like human face in gray image but is not skin color at all in color image [2]. Therefore, it can improve the accuracy of face detection and reduce the false detection rate, so that face detection can be more flexible to adapt to face image detection with complex background.

In this paper, the advantage of skin color is utilized in the multi-face detection. Firstly, skin color is used to segment the candidate's face area and exclude most complex backgrounds, which not only improves the speed of face detection, but also makes the detection accuracy free from the influence of background area.

2. YCbCr color space
YCbCr color space is a relatively common color space. In YCbCr color space, Y component is pixel brightness, CbCr is chromaticity component, Cb is blue component, Cr is red component, so brightness
and chromaticity are separated from each other in this color space [3]. YCbCr color space is converted from RGB color space, and the conversion formula is as follows:

\[
egin{bmatrix}
Y \\
Cb \\
Cr \\
1
\end{bmatrix}
= \begin{bmatrix}
0.2990 & 0.5870 & 0.1140 & 0 \\
-0.1687 & -0.3313 & 0.5000 & 0.5 \\
0.5000 & -0.1487 & -0.0813 & 0.5 \\
1 & 0 & 0 & 1
\end{bmatrix}
\begin{bmatrix}
R \\
G \\
B \\
1
\end{bmatrix}
\] (1)

Since brightness and chromaticity are separated in YCbCr color space, skin color can form better clustering in this color space, and at the same time, the influence of brightness change can be reduced [4]. In addition, YCbCr color space can be obtained by simple linear transformation of RGB color space, and the conversion speed is relatively fast.

3. YChCr color space skin color extraction

After statistical analysis of more than 2.2 million skin color pixels of 200 different color face images, the skin color curve of YChCr is shown as follows:

Figure 1. Three-dimensional distribution of skin color on Y-cb-cr

Figure 2. The two-dimensional distribution of skin color on cb-cr

According to the statistical analysis of the cb-cr subspace, the following results can be obtained:

\[
\begin{align*}
Cr & \leq 1.4966 \times Cb + 96.67 \\
Cr & \geq -0.3947 \times Cb + 183.33 \\
Cr & \leq -5.0989 \times Cb + 884.316 \\
Cr & \leq -0.59 \times Cb + 270.54
\end{align*}
\] (2-5)

Therefore, the rules for skin color modeling in the YChCr color space are as follows:

Rule: \( C : \text{type}(2) \lor \text{type}(3) \lor \text{type}(4) \lor \text{type}(5) \)

where, The symbol \( \lor \) represents logic or.

4. The deficiency of skin color modeling space in YChCr

The above established skin color model in YChCr color space can be found through analysis:

It is a linear transformation from RGB color space to YChCr color space. Moreover, in YChCr color space, brightness and chromaticity are separated, which has great advantages, and it is simple and convenient to establish skin color model in YChCr color space. It can be found by further research that there are still some defects. The accuracy is not high to extract skin color region in YChCr color space [5], and the miss rate is not very satisfactory. Therefore, further improvement is needed in this space to obtain higher detection rate and lower omission rate. In this paper, an improved method of skin color modeling in YChCr color space was proposed to improve the accuracy of skin color extraction [6].

5. Improved color modeling space

First, we make a feature analysis of the color of a person's skin. The reason why we choose to use skin color for face area detection is that for a face, the study of skin color has certain advantages, that is, for a
face image, facial expression and other details have little influence on it. Moreover, skin tone is well separated from other backgrounds in most images. Studies have shown that, for different RACES, the skin tone of human faces is basically the same [7]. The reason why human faces show different skin colors, such as black, white and yellow, has a lot to do with the brightness information of skin color. If the brightness of face images of different RACES is removed, all face skin tones will show certain clustering. Therefore, if the brightness component of face image is removed by certain method, the face image we want to study will be obtained.

Secondly, the improved YCbCr color space is put forward according to. In this paper, the YCbCr color space is improved, mainly to analyze the difference between YCbCr color space and RGB color space. YCbCr color space can distinguish the brightness and chromaticity information in the image. Moreover, the process of differentiation can be obtained by simple linear transformation of RGB color space [8].

It can be obtained through research that in the RGB color space, the values of R, G and B can be calculated respectively, and for our face image, the size of the three values has the following relationship: R>G>B, for the three components, the greater the value of the component, the greater the influence on the face color distribution. Therefore, this paper proposes a new YCbCr color space method for detecting facial features of skin color, which can replace the original YCbCr color space, effectively improve some disadvantages of the original space, and obtain higher detection rate and lower detection rate of omission.

5.1. Improved YCbCr color space

According to the previous introduction, the formula for the conversion from RGB space to YCbCr color space is as follows [9]:

\[
\begin{align*}
Y &= 16 \cdot \frac{y}{16} + 128 \cdot \frac{G}{256} + 24.966 \cdot \frac{B}{256} \\
Cb &= 128 \cdot \frac{-37.797}{128} + 112 \cdot \frac{-74.203}{128} + 112 \cdot \frac{-214}{128} \\
Cr &= 128 \cdot \frac{-103.867}{128} + 112 \cdot \frac{-129.058}{128} + 112 \cdot \frac{-101.406}{128}
\end{align*}
\]

Where, Y represents the brightness of the image, and Cb and Cr represent the blue and red components of the image respectively.

The following three expressions can be further obtained from the above formula:

\[
\begin{align*}
Y &= x \cdot R + y \cdot B + z \cdot G \\
Cb &= \frac{1}{2(1 - y) \cdot (B - Y)} \\
Cr &= \frac{1}{2(1 - x) \cdot (R - Y)}
\end{align*}
\]

In the above equation, x and y satisfy the following relation: \(x + y + z = 1\). So we can evaluate the fourth component:

\[
Cg = \frac{1}{2(1 - z) \cdot (G - Y)}
\]

In combination with the agreement of \(BT.601 in ITU - R\), This article makes \(x = 0.299, y = 0.114\). And we can calculate that \(z = 0.578\).

The improved new color space is shown below:
In this paper, 200 face images of different ages and genders are selected, in which skin color contains different body regions [10]. Convert R, G and B of each pixel in the skin area into YCgCr, and then project these pixels into cg-cr color space to get the following figure:

![Figure 3. Cg - Cr space](image)

As can be seen from the above figure, the brown area is the clustering area of skin color. In the image, if the pixels of Cg and Cr fall into the brown area, the system considers them to belong to the skin color area; otherwise, they do not belong to the skin color area [11]. The range of the brown area can be determined as follows, as shown below:

![Figure 4. Cg - Cr space](image)

As shown in the figure above, the brown region is within the region composed of four straight lines, which can be represented as follows:

\[
\begin{align*}
Cr &= -Cg + 260 \\
Cr &= -Cg + 280 \\
Cg &= 85 \\
Cg &= 135
\end{align*}
\]

That is \( Cr \in [-Cg + 260, -Cg + 280] \)
\( Cg \in [85, 135] \)

When the pixel value falls within the above range, it is considered to be skin color pixel; otherwise, it is non-skin color pixel.
6. The results of the experiments

6.1. The results of experiment 1 are as follows:

![Figure 5. The original image](image1.png)

![Figure 6. RGB converted to YCbCr image](image2.png)

![Figure 7. Y component](image3.png)

![Figure 8. Cb component](image4.png)

![Figure 9. Cr component](image5.png)

![Figure 10. YCbCr Skin extract](image6.png)

6.2. The results of experiment 2 are as follows:

![Figure 11. The original image](image7.png)

![Figure 12. RGB converted to YCbCr image](image8.png)

![Figure 13. Y component](image9.png)

![Figure 14. Cb component](image10.png)

![Figure 15. Cr component](image11.png)

![Figure 16. YCbCr skin extract](image12.png)
7. Summary
This article first introduces the YCbCr color space, and establishes a skin color model in YCbCr color space for skin color extraction. It also analyzes some shortcomings in the process of extraction. Then it puts forward some improvements as follows: It changes the parameters of the conversion matrix used in the conversion from RGB space to YCbCr color space, so that the chosen skin color region is closer to the face skin color region. By this way, the system can detect the face most accurately.

Acknowledgments
Here, I would like to express my special thanks to my families for their continued support for my work, creating a good working environment for me, solving my worries and enabling me to work and study with peace of mind. Here, I would like to express my deep gratitude, thank you.

References
[1] Tian xin 2001 Skin color model based on different color space J. Journal of Xi 'an University of Science and Technology.21(4) 369-371
[2] Yang G Z 1994 Human face detection in a complex background J. Pattern Recognition. 27(1)53-63
[3] Yang M-H, Ahuja N 2002 Detecting faces in images: a survey J. IEEE Transactions on Pattern analysis and Machine Intelligence.24(1)34-58
[4] Yanjiang Wang,Baozong Yuan Face detection from color images using an evolutionary approach J. Chinese Journal of Electronics.9(3)270-273
[5] Yang min, wang jin-ting 2006 Color space in color detection J. Fujian Computer.
[6] P.Kakumanu,S Makrogiannis,and N.Bourbakis 2007 A survey of skin-color modeling and detection methods J. Pattern Recognition.40 1106-1122
[7] Hsu R.L.,Abdel--Mottaleb M.,Join A 2002 Face detection in color images J. IEEE Transactions on Pattern Analysis and Machine Intelligence.24(5)696-706
[8] Cai J,Goshtasby A 1999 Detection human faces in color images J. Image and Vision.18(1)63-75.
[9] Yang J.,Lu W.1998 Waibel A..Skin color modeling and adaptation. Proceeding of the 3rdAsian Conference on Computer Vision.pp:687-694
[10] Zhu Q.,Cheng K.,Wu C.,Wu Y 2004 Adaptive learning of an accurate skin-color model. Proceeding of the 6th IEEE International Conference on Automatic Face and Gesture Recognition.pp:37-42
[11] Yang M.H..Abuja N 1999 Gaussian mixture model for human skin color and its application in image and video databases. The SPIE Conference on Storage and Retrieval for Image and Video Databases Proceedings.pp:458-466
[12] Zhang zhen-zhen, shi yue-xiang 2010 Color detection of YCrCb and YCbCr color space J. Computer Engineering and Application. (34)167-170