International Journal of Computer Applications (0975 – 8887)
Volume 34– No.2, November 201

An Innovative Face Detection based on Skin Color Segmentation

Kamarul Hawari Bin Ghazali
Faculty of Electrical & Electronics Engineering
University Malaysia Pahang, Pekan, 26600, Malaysia

Jie Ma
Faculty of Electrical & Electronics Engineering
University Malaysia Pahang, Pekan, 26600, Malaysia

Rui Xiao
Faculty of Electrical & Electronics Engineering
University Malaysia Pahang, Pekan, 26600, Malaysia

ABSTRACT
It is very challenging to recognize a face from an image due to the wide variety of face and the uncertain of face position. The research on detecting human faces in color image and in video sequence has been attracted with more and more people. In this paper, we propose a novel face detection framework that achieves better detection rates. The new face detection algorithms based on skin color model in YCgCr chrominance space and HSV color space. Firstly, we build a skin Gaussian model in Cg-Cr color space, and then some constraints are used to get candidates of face. Secondly, a calculation of correlation coefficient is performed between the given template and the candidates. Experimental results demonstrate that our system has achieved high detection rates and low false positives over a wide range of facial variations in color, position and varying lighting conditions..

General Terms
Face Detection, Image Processing

Keywords
skin detection, YCgCr color space, HSV color space Gaussian Model, skin color model, template matching, morphological operation, skin color segmentation.

1. INTRODUCTION
The current evolution of semiconductor technology has accelerated the development of video and image processing. Human life is enhanced by all kind of application of vision based processing. Nowadays, face detection has been the issues of an extensive research. As human being can do it effortlessly, in computer vision terms this task is not easy. Skin color can be considered as a good feature for detecting human face. Color allows fast processing and is highly robust to geometric variations of face pattern [1]. So, an innovative face detection method using skin color model was proposed.

Skin color has proven to be a useful and robust cue for face detection, localization and tracking in [2-4]. Some color spaces have been submitted in literature for face detection applications, for instance RGB, normalized RGB, HSV, and YCbCr. This kind of approach seem to be simpler and easier to implement, however they lack the robustness against illuminations, color bias of image acquisition device and other factors. To overcome this drawback, the color balance algorithm has been suggested. Considering the YCbCr color space, a human skin color model can be considered practically independent on the luminance and concentrate in a small region of the Cb-Cr plane. YCgCr color space also has the above advantage and even the clustering effect of it's better than that of YCbCr color space. So in this paper skin model built in YCgCr color space..

2. COLOR SPACE
2.1 YCgCr Color Space
YCgCr color space was derived from YCbCr color space. In the YCbCr color space, Y is the luminance component and Cb and Cr are the blue-difference and red-difference chroma components [5]. Considering the YCbCr color space, a human skin color model can be considered practically independent on the luminance and concentrate in a small region of the Cb-Cr plane. YCgCr color space also has the above advantage that is non-sensitive to the luminance [6].

The YCgCr color space is a variation of YCbCr color space that uses the color difference (G-Y) instead of (B-Y). YCgCr components can be derived from the following matrix expression:

$$\begin{bmatrix} Y \\ Cg \\ Cr \end{bmatrix} = \begin{bmatrix} 16 \\ 128 \\ 128 \end{bmatrix} + \begin{bmatrix} 65.481 & 128.553 & 24.966 \\ -81.085 & 112 & -30.915 \\ 112 & -93.786 & -18.214 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

We found that a 2D projection of YCgCr skin color into Cg-Cr subspace, in which the skin color clustering effect of Cg-Cr color space is better than Cb-Cr color space in Figure 1.

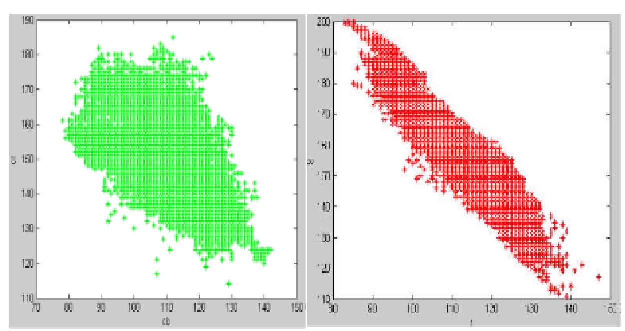


Fig 1: Skin color distribution in Cb-Cr(left) color space and Cg-Cr(right) color space

2.2 HVS Color Space
HSV color space represents colors in terms of Hue, Saturation and Intensity of the Value. It is also known as HSB (Hue, Saturation, and Brightness) or HIS (Hue, Saturation, Intensity).

Hue refers to color type, such as red, blue, or yellow. Saturation refers to the vibrancy or purity of the color. Value component refers to the brightness of the color. Fig. 2 shows a good representation of HSV components, where the hue is depicted as a three-dimensional conical formation of the color wheel. The saturation is represented by the distance from the center of a circular cross-section of the cone, and the value is the distance from the pointed end of the cone. [7]

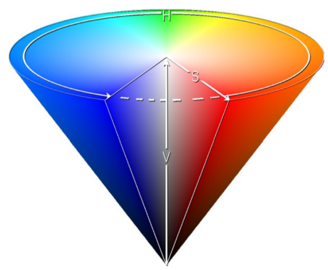


Fig 2: Conical representation of the HSV Color Space

The intuitiveness of the color space components and explicit discrimination between luminance and chrominance properties made these color spaces popular in the works on skin color segmentation. Several good properties if Hue color space were submitted in [8]: it is invariant to highlights at white light sources, and also, for matte surfaces, to ambient light and surface orientation relative to the light source. The transformation between HSV and RGB is defined by the following expressions:

$$\begin{cases} H = arccos\dfrac{\frac{1}{2}((R-G)+(R-B))}{\sqrt{((R-G)^2+(R-B)(G-B)}} \\ S = 1 - 3\dfrac{\min(R,G,B)}{R+G+B} \\ V = \dfrac{1}{3}(R+G+B) \end{cases}$$

3. SKIN COLOR SPACE

3.1 Lighting Compensation

The skin color is often affected light in image, which leads to deviate from the real color of skin. We use a lighting compensation algorithm which named Gray World Theory (GWT) [9] to do color correction in color images. The GWT method can be described as follows. The R, G and B are the amount of stimulus of red green and blue respectively in the recorded scenery. $R_{average}$, $G_{average}$ and $B_{average}$ are the average of the each color channel. The results can be shown Figure 3.

$$\begin{cases} R' = R * \left[\dfrac{K}{R_{average}}\right] \\ G' = G * \left[\dfrac{K}{G_{average}}\right] \\ B' = B * \left[\dfrac{K}{B_{average}}\right] \\ K = \dfrac{(R_{average} + G_{average} + B_{average})}{3} \end{cases}$$

Fig 3: Original image and the result of color balance

3.2 Gaussian Skin-Color Model

In order to segment human skin regions from non-skin region based on color, we need a reliable skin color model that is adaptable to people of different skin colors and to different lighting conditions. The color distribution of skin colors of different people was found to be clustered in a small area of the chromatic color space. Although skin colors of different people appear to vary over a wide range, they differ much less in color than in brightness. In other words, skin colors of different people are very close, but they differ mainly in intensities [10]. The color histogram revealed that the distribution of skin-color of different people is clustered in the chromatic color space and a skin color distribution can be represented by a Gaussian model (see Figure 3). In our work, each colorful image is concerted into Cg-Cb color space, we can get $X=(Cg, Cb)^T$; $m_x=E(X)$; $c_x= E[(X-m_x)(X-m_x)^T]$. Where m_x is it's mean, and c_x is the covariance matrix of x.

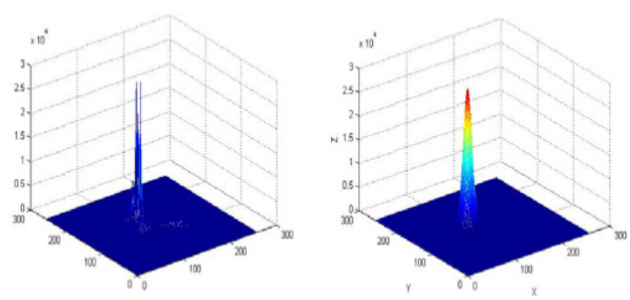


Fig 4: Skin-color distribution and Gaussian distribution in Cg-Cr space

We can now obtain the likelihood of skin for any pixel of an image; the likelihood of skin for this pixel can then be computed as follows:

$$P(X) = EXP\ [-0.5(X - m_x)^T {c_x}^{-1}(X - m_x)]$$

According to this Gaussian skin-color model, a color image can transform into a gray scale image. After that, using appropriate threshold, the gray scale images can then be further transformed into a binary image showing skin regions and non-skin regions. In Figure 5 show the picture after skin detection.

Fig 5: The original image and after Gaussian detection

4. DETAIL OF NOVEL FRAMEWORK

The framework of the paper proposed can be divided into 5 phases, namely, Color balance, color space convert, skin detection, Morphological operation, template matching. The flow chart of the framework is given in figure 6. Some of phases already discussed in foregoing paragraphs. In this paper, one novel combination of color space were proposed to detect skin color, according to experiments they can improve the performance of skin color detection. The rest work will focus on the rest phases.

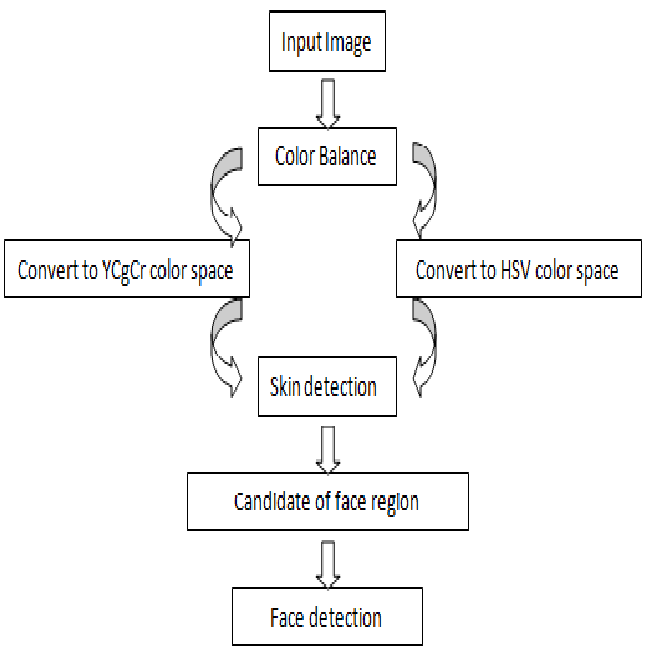


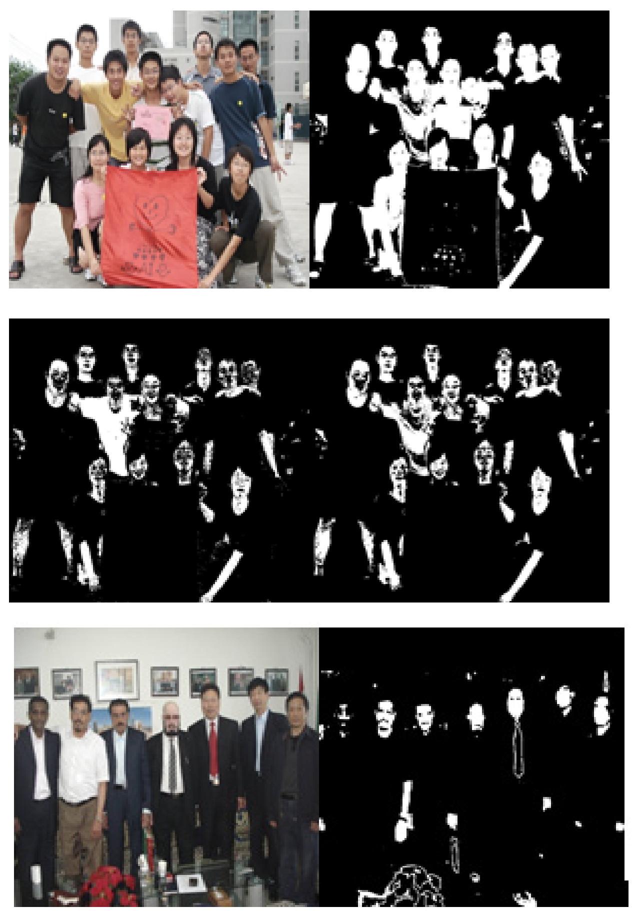
Fig 6: The framework of skin-color based face detection

4.1 Skin Detection

After the image doing color balance operation, then one copy is converted into YCgCr color space; another one is converted into HSV color space. In the YCgCr color space, we use Gaussian Skin-Color Model to get a black-white image named BW1. We can get another black-white image named BW2 using such constraints:

$$\begin{cases} Y > 80; \\ 100 < Cg < 130; \\ 135 < Cr < 175; \\ 0.05 < H < 0.9412; \end{cases}$$

According experiments, we found such constraints can divide skin and non-skin clearly. Finally we can get BW3 by doing and operation between BW1 and BW2. The candidate of face region will be selected from BW3. From under Figure (from up left to down right is original image BW1, BW2 and BW3), the Gaussian skin-color model can extract the pixels of skin very well, but some background with similar color also been selected. As the top picture shown, the pink color and yellow color clothes were selected by the Gaussian skin-color model. However, the pink color clothe is not selected in other algorithm using constraints. In low picture, dark yellow trousers can erase by the Gaussian skin-color, but still be in the other detection algorithm. After logical operation, many interferential elements can be erased. So it is self-evident that this approach of skin detection can improve the robustness and accuracy in face detection.



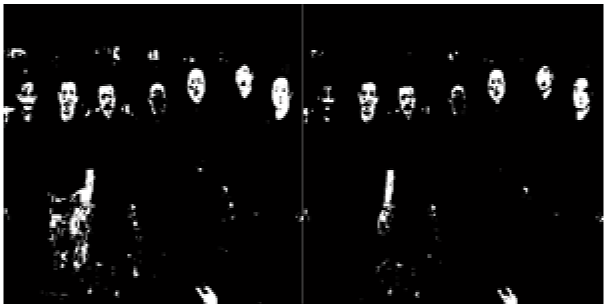


Fig 7: The result of skin detection mentioned in this paper

4.2 Morphological operation

The aim of Morphological operation is to transform the signals into simpler ones by removing irrelevant information. So morphological operation can reserve essential shape feature and eliminate irrelevancies. Firstly, erosion function is used to get rid of some small pieces, compared with face area, which is unwanted fragment. After that step, dilation operation will help to recover face area. This procedure can be done several times to get good result. The Figure 8, show the effect of Morphological operation.

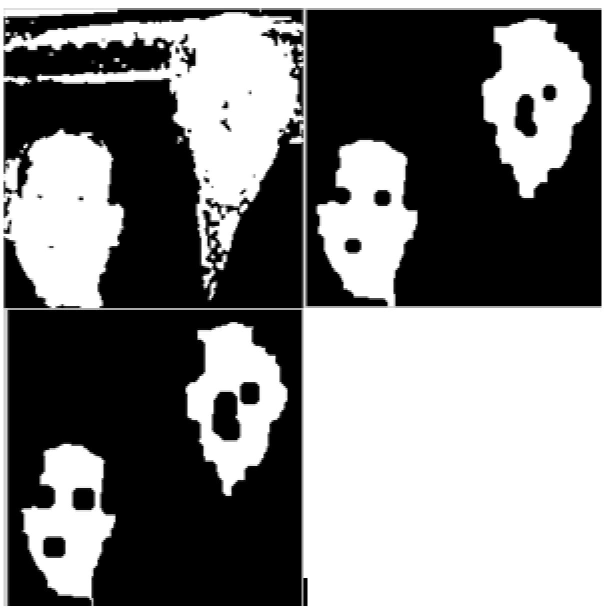


Fig 8: The effect of morphological operation

4.3 Template matching and estimation of face

The target of using template matching is to select face segment from skin segments. First, we select a skin segment which has hole in his region and then close the holes in the region. The template face will be resized and rotated in the same coordinate as the skin segment image. At last, the cross-correlation value between the selected skin segment and the template face will be computed [11]. By empirically determined, from our experiments, the threshold value for classifying a segment as a face is 0.6. If the resulting autocorrelation value is greater than the threshold, the skin segment will be classified as face area. After template matching operation, a number of criteria will be used to estimate face:

- The ration of height (H) and width (W) of the candidate of face is in a range between 0.5 and 3. i.e. $0.5<W/H<3$
- The area of candidate of face is defined A (A=H*W); the number of pixel in A is define N. the ration of A and N is in a range between 0.3 and 0.9. i.e. $0.3<N/A<0.9$

4.4 Experiment results

In this paper, the Matlab simulated experiments are performed to verify the effectiveness of the proposed framework. In order to verify the validity of our way, 200 images in the database are processed. Facial images in the experiment come mostly from digital still camera photos from life and collected stochastically from the internet. The examples of part experimental result show in Figure 9. Experimental results using the proposed method show that the new approach can detect face with high detection rate and low false acceptance rate. But false alarms and misses are still existing .The statistical data is shown in Table.1

Fig 9: part experimental result

Table 1 Statistical Data

Face Numbers In A Photo	1	2	3	4	More than 5	Total
Photo Numbers	20	20	20	20	20	100
Face Numbers	20	40	60	80	152	352
Hits	20	39	58	76	143	336
Wrong Selected	0	0	2	4	9	15
False Detection Rate	0%	0%	3.33 %	5%	5.92%	4.62%
Missed Rate	0%	2.5%	3.3%	5%	5.93%	4.55%
Precision Rate	100 %	97.5 %	96.7 %	95 %	94.07 %	95.45 %

5. CONCLUSIONS

We have presented an approach for face detection under varying illumination. This detection approach initially takes the color image and the color balance model to modify the RGB color space to YCgCr color space. The algorithm is implemented by combining Gaussian skin-color model, template matching and face verification. Experimental results show that the method mentioned in this paper can achieve high detection accuracy. In the future work, we will improve this algorithm combined with other face detection algorithm to achieve better performance and further reduce the false detecting rate in dealing with images with more complex background.

6. REFERENCES

[1] Vladimir Vezhnevets, Vassili Sazonov, and Alla Andreeva, ”A Survey on Pixel-Based Skin Color Detection Technique,” In Proceedings of the GraphiCon 2003(2003), pp.85-92.

[2] R-L Hsu, M. Abdel-Mottaleb, A.K. Jain, “Face detection in color images,” IEEE Transactions on Pattern Analysis and Machine Intelligence, May 2002. Vol. 24, 696-706.

[3] C. W. Lin, Y. J Chang, and Y. C. Chen, “Low complexity face-assisted video coding,” IEEE International Conference on Image Processing, Sept. 2000, Vol. 2, 207-210.

[4] S. Srisuk, W. Kurutach, “A new robust face detection in color images,” in Proceedings of the 5th IEEE Int. Conference on Automatic Face and Gesture Recognition (FGR’02), May 2002, 306-311.

[5] YCbCr. Retrieved September 17 2010 from http://en.wikipedia.org/wiki/YCbCr.

[6] Zhang zhengzhen, Shi Yuexiang, “Face detecting based on skin color clustering in a color space YCgCr,” Computer Engineering and Applications, PP 163-165, 2009,

[7] Jose M. Chaves-González ∗, Miguel A. Vega-Rodríguez, Juan A. Gómez-Pulido, Juan M. Sánchez-Pérez, “Detecting skin in face recognition systems: A colour spaces study,” in Digital Signal Processing 20(2010),PP 806-823.

[8] W.Skarbek and A. Koschan, “Colour image segmentation – a survey- Technical University of Berlin,” Technical Report 94-32,1994.

[9] Chiang J.Gray World Assumption [EB/OL] http://scienstanford.edu/class/psych221/projects/99/jchiang/intro2.html., 1999-03-27

[10] Jie Yang and Alex Waibel, "A Real-Time Face Tracker", CMU CS Technical Report.

[11] Henry Chang and Ulises Robles, Face Detection. Retrieved September 17 2010 from http://www-cs-students.stanford.edu/~robles/ee368/matching.html.