2012 International Conference on Solid State Devices and Materials Science

An Innovative Face Detection Based on YCgCr Color Space

Kamarul Hawari Bin Ghazali, Jie Ma, Rui Xiao, Solly Aryza lubis

Faculty of Electrical & Electronics Engineering, UNIVERSITI MALAYSIA PAHANG, Pekan, 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 method that achieves better detection rates. The new face detection algorithms based on skin color model in YCgCr chrominance space. Firstly, we build a skin Gaussian model in Cg-Cr color space. 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.

© 2012 Published by Elsevier B.V. Selection and/or peer-review under responsibility of Garry Lee

1. Introduction

Face detection and tracking has been the topics of an extensive research for the several past decades. Many heuristic and pattern recognition based strategies have been proposed for achieving robust and accurate solution. Among feature-based face detection methods, the ones using skin color as a detection cue have gained strong popularity. Color allows fast processing and is highly robust to geometric variations of the face pattern. Also, the experience suggests that human skin has a characteristic color, which is easily recognized by humans. So trying to employ skin color modeling for face detection was an idea suggested both by task properties and common sense [1].

Skin color has proven to be a useful and robust cue for face detection, localization and tracking. Face detection techniques based on the use of color information have been proposed [2-4]. Several color spaces have been proposed, for instance RGB, normalized RGB, HSV, XYZ and YCbCr. In this paper we discuss pixel-based skin detection methods that classify each pixel as skin or non-skin individually. This kind of approach seem to be simpler and easier to implement,

The remainder of the paper is organized as follows: Section 2 describes the YCgCr color space briefly. In Section 3 we describe in detail the new method for face detection and present some results. Finally, conclusions and future work are in section V.

2. YCgCr Color Space

RGB image is converted to a luminance color space; it is often called 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. YCbCg color space and YCgCr color space also have the above advantage [6]. Y,Cb, Cr and Cg are defined as follow:

$$Y = kr*R + kg*G + kb*B;$$
$$Kr + kg + kb = 1;$$
$$Cb = B-Y;$$
$$Cr = R-Y;$$
$$Cg = G-Y;$$

(kr, kg and kb are weighting factors, according to ITU-R BT.601, kb = 0.114, kr = 0.299)

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

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

Considering the YCbCr color space, a human skin color model can be considered practically independent on the luminance and the skin color is converged in a small region of the Cb-Cr plane, and YCgCr color space also possesses this kind of virtue. Figure 1 represents the distribution of skin colors in Cb-Cr subspace and Cg-Cr subspace; we find that the skin color clustering effect of Cg-Cr subspace is better than that of Cb-Cr subspace. According to the features of RGB color components proportion: R>G>B in the skin regional, so Cg-Cr subspace can provide more accurate skin color information.
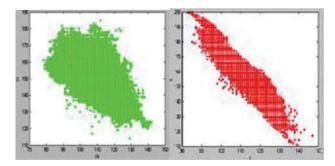

Figure 1 Skin color distribution in Cb-Cr(left) color space and Cg-Cr(right) color space

3. 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 [7]. 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 2). In our work, each colorful image is concerted into Cg-Cb color space, we can get X$= \left(Cg, Cb \right)^{T}$; $m_x =$E(X);

$C_x =$ E $[\left(X - m_x \right) \left(X - m_x \right)^{T}$]. Where m_x is it's mean, and c_x is the covariance matrix of x.
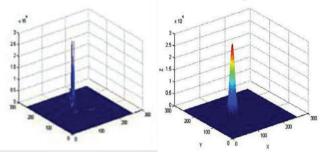

Figure 2 skin-color distribution and Gaussian distribution in Cg-Cr space

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:

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

Hence, this Gaussian skin-color model can transform a color image into a gray scale image. With appropriate threshold, the gray scale images can then be further transformed to a binary image showing skin regions and non-skin regions. In Figure 3 show the picture after skin detection.
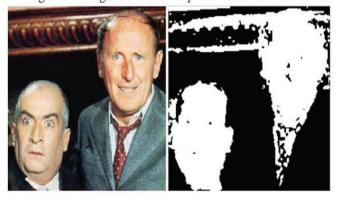

Figure 3 the original image and after skin detection

4. Detail of novel framework

The novel 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 4. Some of phases already discussed in foregoing paragraphs. The rest work will focus on the rest phases.
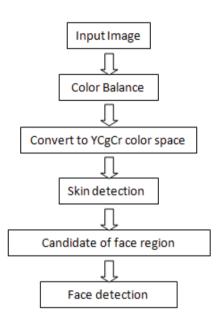
```
┌─────────────────┐
│   Input Image   │
└─────────────────┘
         ⇩
┌─────────────────┐
│  Color Balance  │
└─────────────────┘
         ⇩
┌──────────────────────────┐
│ Convert to YCgCr color space │
└──────────────────────────┘
         ⇩
┌─────────────────┐
│  Skin detection │
└─────────────────┘
         ⇩
┌──────────────────────────┐
│  Candidate of face region │
└──────────────────────────┘
         ⇩
┌─────────────────┐
│  Face detection │
└─────────────────┘
```

Figure 4 the framework of skin-color based face detection

4.1 Color Balance

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) [8] to do color correction in color images. The GWT method can be described as follows.

$$\begin{cases} R' = R * \left[\dfrac{K}{R_{average}} \right] \\[2mm] G' = G * \left[\dfrac{K}{G_{average}} \right] \\[2mm] B' = B * \left[\dfrac{K}{B_{average}} \right] \\[2mm] K = \dfrac{(R_{average} + G_{average} + B_{average})}{3} \end{cases}$$

Where R, G and B are the amount of stimulus of red, green and blue respectively in the recorded scenery. And $R_{average}$, $R_{average}$ and $R_{average}$ are the average of the each color channel. The results can be shown Figure 5.

Figure5. Original image and the result of color balance

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. We use erosion and dilation operators to eliminate unwanted fragment. The Figure 5, show the effect of Morphological operation.

Figure 5 the effect of morphological operation

4.3 Template matching

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 [9]. 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.

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 6. 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
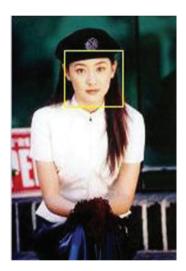
Figure 6 experimental result

TABLE I.　　Statistical Data

Face number in a photo	Photo number	Face number	hits	misses	precision
1	20	20	20	0	100%
2	20	40	38	2	95%
3	20	60	56	4	93.3%
4	20	80	73	7	91.25%
More than 5	20	152	138	14	90.8%
Total	100	352	325	27	92.32%

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.

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

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

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