DOI: 10.21917/ijivp.2013.0090

HIGH ACCURATE LOW COMPLEX FACE DETECTION BASED ON KL TRANSFORM AND YCBCR GAUSSIAN MODEL

Epuru Nithish Kumar[1], Gaddam Manoj Kumar[2], Gunda Venkatesh[3], Tanguturi Sai Jaswanth[4] and R. Menaka[5]

Department of Electronics and Communication Engineering, VIT University, India

E-mail: [1]epuru.nithishkumar2010@vit.ac.in, [2]g.manojkumar.2010@gmail.com, [3]venkateshg0114@gmail.com, [4]tanguturi.vvmsaijaswanth2010@vit.ac.in and [5]menaka.r@vit.ac.in

Abstract

This paper presents a skin color model for face detection based on YCbCr Gauss model and KL transform. The simple gauss model and the region model of the skin color are designed in both KL color space and YCbCr space according to clustering. Skin regions are segmented using optimal threshold value obtained from adaptive algorithm. The segmentation results are then used to eliminate likely skin region in the gauss-likelihood image. Different morphological processes are then used to eliminate noise from binary image. In order to locate the face, the obtained regions are grouped out with simple detection algorithms. The proposed algorithm works well for complex background and many faces.

Keywords:

KL Transform, Gauss Model, Statistical Model, Morphological Processing

1. INTRODUCTION

With the enhancement of awareness of people's safety there is a high requirement to confirm personal identity. Biometric technology or face detection techniques can be employed to confirm personal identity. Using biometric technology to identify personal identity has acquired high expectations, but face recognition has been accepted as the most important type of bio authentication as taking an image of a face is easy than that of fingerprints or iris. Template matching, Neural network techniques and skin color detection [3], [6] are different face detection techniques.

Template matching stores some faces as standard templates and then uses some algorithms to calculate the given region of likelihood or relevance of the region with standard template , so that it can judge whether the given region is a human face or not. Template matching involves high computational complexity and high processing time.

Neural networks rely on statistical analysis and machine learning techniques to construct a neural network that is highly robust and accurate. Although the neural network is theoretically feasible, it requires extensive training samples and the relative velocity is slow.

Skin color detection uses the color information of the digital image to segregate the possible face candidate areas and then judge upon each candidate area to determine whether it is face or not. Detection velocity is fast and it can do real time detection. The algorithm works well though the faces in the image are tilted and rotated. The missed rate is very low. However this algorithm also takes into account the background color that is similar to face color and eliminates the effect of it on the face detection.

2. SKIN COLOUR MODEL

Regional model which uses KL transform [5], [1] is simple and easier to understand but difficult to calculate the threshold value. Gaussian model [5], [6], [4] gives a better distribution of skin color model but its speed is slower than regional model. The original image has RGB components which are linearly dependent. This makes it difficult to calculate the threshold value for segmentation. The KL transform takes the job to convert these three linearly dependent components to three linearly independent components. Now the skin color of human face is reassigned to three components which contain the human face information of skin color.

Resemblance of the skin region is a major problem if Gaussian model based on YCbCr [5], [6], [4] is alone implemented.

To overcome all the short comings and get more satisfactory results we use both Regional model and Gaussian model together to remove resemblance of skin color and to calculate the threshold easily. The final image is then obtained by applying dot product of results obtained from both models.

2.1 REGIONAL MODEL

RGB coordinates are converted to KL coordinates using following matrix,

$$\begin{pmatrix} K_1 \\ K_2 \\ K_3 \end{pmatrix} = \begin{pmatrix} 0.666 & 0.547 & 0.507 \\ -0.709 & 0.255 & 0.657 \\ 0.230 & -0.797 & 0.558 \end{pmatrix} \begin{pmatrix} R \\ G \\ B \end{pmatrix} \tag{1}$$

The range of skin color is:

$$110.2 < K_1 < 376.3,\ -61.3 < K_2 < 32.9,\ -18.8 < K_3 < 19.5 \tag{2}$$

2.2 GAUSSIAN MODEL

In this model RGB values of each pixel are converted to YCbCr space. Skin color pixel in the Cb-Cr space has better clustering and is consistent with two dimensional Gaussian distribution, so statistical analysis of skin color is done in Cb-Cr space. A mathematical model is formulated to get the probability of skin color as output. The unknown parameters [m, C] are calculated using following equations,

$$\overline{C}_r = \frac{1}{N}\sum_{i=1}^{N} C_{ri} \tag{3}$$

$$\overline{C}_b = \frac{1}{N}\sum_{i=1}^{N} C_{bi}. \tag{4}$$

x is color vector of each pixel, whose first component is C_r and second component is C_b. m and C are mean and variance, where,

$$m = (C_r, C_b)^T \quad (5)$$

$$C = E[(x\text{-}m)(x - m)^T \quad (6)$$

P is similarity. Each value of P is normalized that is in the range [0, 1]. Similarity is calculated as,

$$P(Cr, Cb) = \exp[-0.5(x - m)^T C^{-1}(x - m)] \quad (7)$$

The resulting image is divided into regions based on the image size. Adaptive threshold algorithm is applied on each region. In Adaptive threshold algorithm, mean is taken as threshold and the image is segmented. For the resulting image mean is again taken as threshold and the image is segmented. This process is repeated until the difference between two successive thresholds is negligible.

Then dot product is applied for the results from KL and Gaussian models to eliminate the background color which is similar to skin color.

2.3 SEPERATE FACE AND NON-FACE REGIONS

Morphological process [2] which is used to remove noises uses open operation on binary image obtained from dot product. Open operation can remove isolated dots, eliminate small objects, smooth borders of large objects.

a. Noise rules:

   If the target area occupies less than 2% of the total image then we consider that region as a noise.

b. Rules of occupation ratio:

   If the intensity of the target area is less than 45 % we will remove the region.

c. Aspect ratio:

   If aspect ratio of bounding rectangle does not belong to the range (0.9 to 1.7), we will remove the region.

2.4 BLOCK DIAGRAM

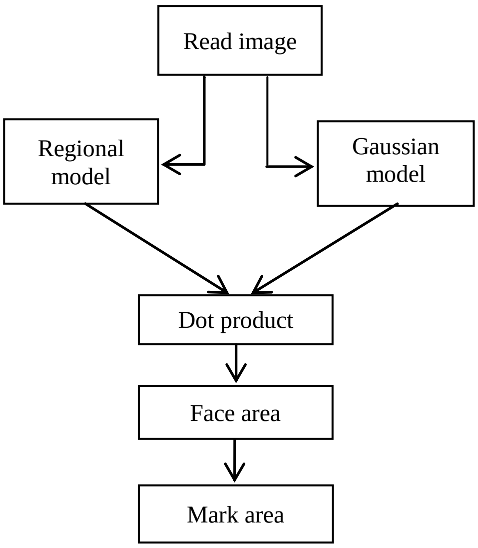

Fig.1.Block Diagram

3. RESULTS

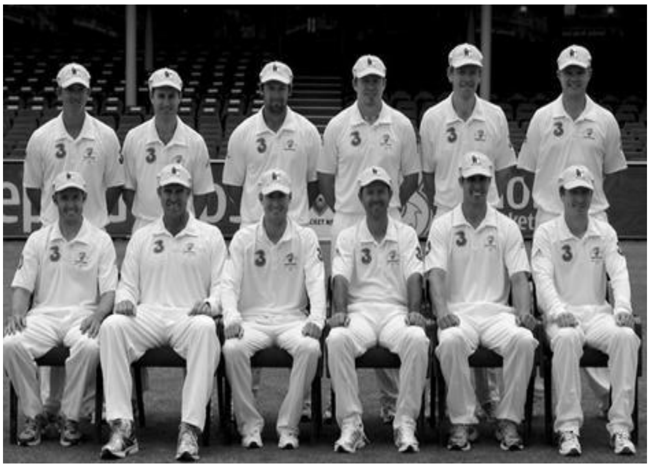

Fig.2. Original Image

Fig.3. Morphological image

Fig.4. Face marked image

$$m = (0.5147, 0.4841)^T$$

The Fig.2 shows the original image, Fig.3 is obtained after applying morphological processing to the binary image resulted from the dot product. In Fig.4 boundaries are marked, taking in to account occupation ratio, aspect ratio and noise rules.

Fig.5. Original image

Fig.6. Morphological image

Fig.7. Face marked image

$$m = (0.5425, 0.4745)^T$$

The Fig.5 shows the original image, Fig.6 is obtained after applying morphological processing to the binary image resulted from the dot product. In Fig.7 boundaries are marked, taking in to account occupation ratio, aspect ratio and noise rules.

4. CONCLUSION

The algorithm provides an effective and high detective rate as both Regional model and Gaussian models are combined.

When the background is simple, accuracy is more and when back ground is complex like if shirt color is similar to skin color or if hands are exposed to greater extent, detection rate is lowered.

Even in case of complex back ground and low lightning conditions results are satisfactory. This algorithm works fine with tilted faces, rotated faces and images with low lightning conditions.

REFERENCES

[1] Gao Jian-po, Wang Yu-jian, Yang Hao and Wu Zhen-yang, “An Elliptical Model Based on KL Transform for Skin Color Detection”, *Journal of Electronics and Information Technology*, Vol. 29, No. 7, pp. 1739 – 1743, 2007.

[2] Rafael C Gonzalez and Richard E. Woods, “*Digital Image Processing*”, Third Edition, Prentice Hall, 2007.

[3] Kunqing Wu, Lianfen Huang, Hezhi Lin and Xiangping Kong, ”Face Detection Based on YCbCr Gaussian model and KL Transform”, *IEEE International Symposium on Computer Science and Society*, pp. 100 – 103, 2011.

[4] Cui Xu and Ran Li, “Face Detection Based on YCbCr Gaussian Model”, *Softword Guide*, Vol. 8, pp. 179 - 181, 2009.

[5] Wen-Hsiang Lai and Chang-Tsun Li, “Skin Colour-based Face Detection in Colour Images”, *Proceedings of the IEEE International Conference on Video and Signal Based Surveillance* , pp. 56, 2006.

[6] Jinting Wang and Min Yang, “Self-adaptive Skin Color Detection Based on YCbCr Color Space”, *Computer System and Application*, pp. 99 – 102, 2007.