Global Journal of Computer Science and Technology
Graphics & Vision
Volume 13 Issue 4 Version 1.0 Year 2013
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 0975-4172 & Print ISSN: 0975-4350

Human Face Detection in Color Images with Complex Background using Triangular Approach

By Md. Hafizur Rahman & Jinia Afrin
International University of Business Agriculture and Technology, Bangladesh

Abstract - Face detection is very important nowadays because of increasing demand of security in society. It has become inseparable part of machine vision, biometric researches, pattern recognition and video surveillance. In this paper, we propose to detect face from image with varying lighting condition and complex background. This method relies on a two step process. First, we detect human skin regions. The detection of facial features from image is on the basis of pixel measurement. This is done by the conversion of RGB image into the YCbCr color space using proposed algorithm in order to observe the human face regions. This operation needs for the change of color image into gray scale image and also the removal of non face object. Then we construct eye and mouth maps in order to work on the triangle relationship between them. The result works well on wide range of facial variation in color, position, scale and orientation with photo collection including both indoors and outdoors.

Keywords : face detection; color space transformation; skin detection; eye map; mouth map; triangular approach.

GJCST-F Classification: I.4.8

HUMAN FACE DETECTION IN COLOR IMAGES WITH COMPLEX BACKGROUND USING TRIANGULAR APPROACH

Strictly as per the compliance and regulations of:

Human Face Detection in Color Images with Complex Background using Triangular Approach

Md. Hafizur Rahman [α] & Jinia Afrin [σ]

Abstract - Face detection is very important nowadays because of increasing demand of security in society. It has become inseparable part of machine vision, biometric researches, pattern recognition and video surveillance. In this paper, we propose to detect face from image with varying lighting condition and complex background. This method relies on a two step process. First, we detect human skin regions. The detection of facial features from image is on the basis of pixel measurement. This is done by the conversion of RGB image into the YCbCr color space using proposed algorithm in order to observe the human face regions. This operation needs for the change of color image into gray scale image and also the removal of non face object. Then we construct eye and mouth maps in order to work on the triangle relationship between them. The result works well on wide range of facial variation in color, position, scale and orientation with photo collection including both indoors and outdoors.

Keywords : face detection; color space transformation; skin detection; eye map; mouth map; triangular approach.

I. Introduction

Face detection plays a very important role in human computer interaction field. It represents the first step in fully automatic face recognition, facial features detection, and expression recognition. Human face detection and recognition are confronted with difficulties in computer vision and pattern recognition because of the many variations in the human face when there are changes in poses, facial expression and illumination conditions and when there are occlusions.

Many researches on face detection have been processing within this decade. Several popular approaches for detecting faces in still images are discussed here. In [1], an edge-detection-based approach to face detection was described, where edges needed to be labeled and matched to a face model in order to verify correct detections. This was accomplished by labeling edges as the left side, hairline, or right side of a front view face and matched these edges against a face model by using the golden ratio 3 for an ideal face.

Author α : Lecturer, Dept. of EEE, International University of Business Agriculture and Technology, Bangladesh.
E-mail : niham_kuet@yahoo.com
Author σ : B.Sc. In CSE, Khulna University, Bangladesh.

In [2], a neural network-based upright frontal face detection system was presented. A retinally connected neural network examined small windows of an image, and decided whether each window contains a face. In [3], an algorithm was described for object recognition that explicitly modeled and estimated the posterior probability function, P (object|image). A functional form of the posterior probability function was chosen that captures the joint statistics of local appearance and position on the object as well as the statistics of local appearance in the visual world at large. In [4] a method for detecting human faces in color images was presented that first determines the skin-color regions and then determined faces within those regions. A chroma chart was prepared to distinguish skin regions from nonskin regions. In [5], a robust and effective face identification system using triangle-based segmentation process was presented to extract face in various kinds of face images. In [6], a novel frontal face detection based on mixed Gaussian color model technique was developed and implemented using face images with different pose, illumination conditions. In [7], a two- step face detection technique was proposed. The first step used a conventional skin detection method to extract regions of potential faces from the image database. In the second step faces were detected among the candidate regions by filtering out false positives from the skin color detection module. In [8], a novel face detection algorithms based on combining skin color model, edge information and features of human eyes in color image was described. In [9], an efficient face recognition system based on Haar wavelet and Block Independent Component Analysis (BICA) algorithm was presented. In [10], a new approach was proposed for face detection based on skin color detection. It utilized the methodology of GMM to construct several skin color models for different kinds of skin colors.

Most of the aforementioned methods limit themselves to dealing with human faces in these approaches. (1) They cannot detect a face which is smaller than 50×50 pixels. (2) They cannot detect multiple faces (more than 3 faces) in complex backgrounds. (3) They cannot handle the defocus and noise problems. (4) They cannot conquer the problem of partial occlusion of mouth or wearing sunglasses.

Although there are some researches that can solve two or three problems as pointed out above, there is still no system that can solve all the aforementioned problems. So, we propose a face detection algorithm which is able to handle a wide range of variations in static color images, based on a lighting compensation technique and a nonlinear color transformation. The main reason in comparison with the aforementioned methods for choosing this approach is that it is simple to implement, and the face detection rate is satisfactory. Another benefit is that time consumed for running this algorithm is relatively short, comparing with other methods such as neural network-based face detector. The final reason for choosing this algorithm is that there is no need to train the system as face classifier. Face detectors based on neural network or its extension concepts are necessary to train the system for several hours, or even several days to obtain an accurate result. Although it only need to train the system once to obtain the trained data, if the trained data lose or be damaged, this time consuming training process must need to carry out again. The proposed face detection system locates multiple faces oriented in complicated background automatically. Furthermore, it can handle different sizes, dissimilar lighting conditions, varying pose and expression, noise and defocus problems and the problem of partial occlusion of mouth and sunglasses.

II. Methodology

Our proposed algorithm architecture is described in Figure 1.

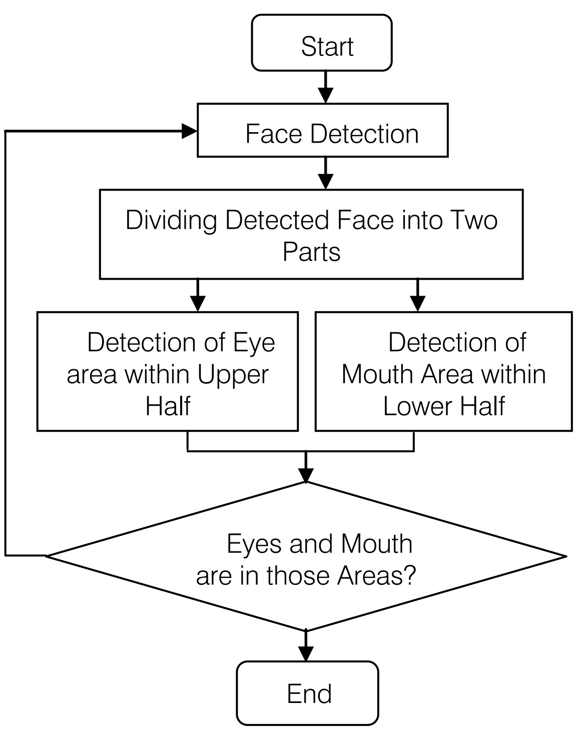

Figure 1 : Algorithm architecture of proposed method

a) Lighting Compensation

The problem of elimination of non-standard illumination is one of the most complicated problems in the area of computer vision, due to the complex illuminated environment in the real world. In face detection and gender recognition problems, non-standard illumination effects become severe. The accuracy on detecting skin color in complex background is difficult to increase. It is because the appearance of skin-tone color depends on lighting condition. In the past, many researches assume that chrominance is independent to luminance. However, in practice, skin tone color is nonlinearly dependent on luminance. The technique of lighting compensation uses top 5% of luma (nonlinear gamma-corrected luminance) as reference white and re-adjusts the chrominance value in each pixel if the value of luma is too high or too low. The main usage of this technique is to remove yellow bias color. According to [11], the lighting compensation (LC) algorithm is very efficient in enhancing and restoring the natural colors into the images which are taken in darker and varying lighting conditions. Therefore, lighting compensation has been used in their skin and face detection algorithms, and they stated that this algorithm is indispensable for robust skin-tone color detection.

The LC algorithm can be defined as followings:

$$S_c = \frac{C_{std}}{C_{avg}} \tag{1}$$

$$C_{avg} = \frac{\sum_{i=1}^{m}(C_i)_{C_i>0}}{\sum_{i=1}^{m}(1)_{C_i>0}} \tag{2}$$

$$C_{std} = \frac{\sum_{i=1}^{m}[max\,(R_i,G_i,B_i)+min\,(R_i,G_i,B_i)]}{2*n} \tag{3}$$

$$n = m = \sum_{i=1}^{m}(1)_{(R_i=G_i=B_i=0)} \tag{4}$$

Where, S_c stands for the scale factor for one specific channel of R, G or B. The C_{std} and C_{avg} separately stand for the standard mean gray value of the specific channel and the mean value non-black pixels in the same channel. Here m stands for the number of pixels in the image, n stands for the number of non-black pixels in the image. By calculating the average of the maximum and minimum channel percentage, an adaptive mean gray value of the whole image is gained. Fig. 2 illustrates some examples of images and the result images after applying the LC algorithm.

Global Journal of Computer Science and Technology (F) Volume XIII Issue IV Version I Year 2013

Figure 2 : Image before and after lighting compensation

Skin detection is the process of finding skin-colored pixels and regions in an image or a video. This process is typically used as a preprocessing step to find regions that potentially have human faces and limbs in images. Several computer vision approaches have been developed for skin detection.

The apparent difference in skin color perceived is mainly due to the darkness or fairness of the skin, characterized by the difference in the brightness of the color, which is governed by Y but not Cb and Cr in YCbCr color space. Y, luminance component is brightness component, whereas Cb and Cr are chrominance components, which correspond to color components. In the color detection process, each pixel is classified as either skin or non-skin based on its color components.

b) Color Space Transformation

The approach on this report will use mainly the color- based algorithm with the technique of color space transformation from RGB (red, green and blue) to YCbCr (luminance, chrominance blue and red). The reason to adopt YCbCr color space is because it is perceptually uniform and widely use in video compression standard such as MPEG and JPEG. To convert an image from RGB to YCbCr we compute the following equations.

$$Y = 0.299R + 0.587G + 0.114B \qquad (5)$$

$$Cb = -0.169R - 0.331G + 0.500B + 128 \qquad (6)$$

$$Cr = 0.500R - 0.419G - 0.082B + 128 \qquad (7)$$

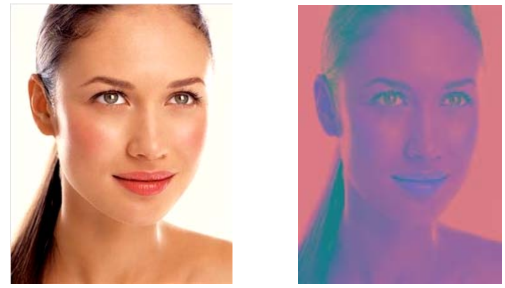

Figure 3 : Color space transformation from RGB to YCbCr

c) Face Detection

In the skin color detection process, each pixel was classified as skin or non-skin based on its color components. The detection window for skin color was determined based on the mean and standard deviation of Cb and Cr component, obtained using 85 training faces in 10 input images. The Cb and Cr components of 85 faces are plotted in the color space in Fig 4.

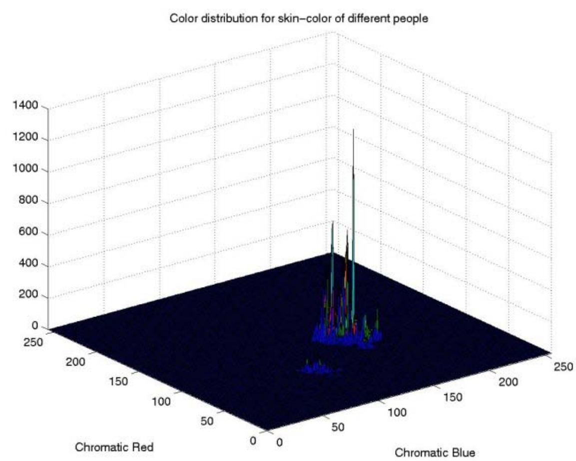

Figure 4 : Skin pixels in YCbCr color space

As noted above, skin color of individuals will fall in a small area of color space. This threshold can be done very simply on a component or on a combination of several components.

$$90 < Y < 180, \; 90 < Cr < 130, \; 80 < Cb < 150$$

Input image is then converted to binary image. To remove small areas that have been obtained in previous stage, geometric operations, using the available filters, will be done on this area. These processes (Dilation, Erosion, and Hole filling) remove many of unacceptable areas from the face area. The final output after segmentation of skin area for example is shown in Fig 5. Fig. 6 shows detected face in color image.

Figure 5 : (a) Original image, (b) Skin area segmentation

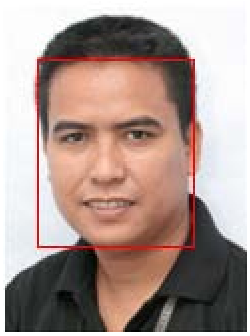

Figure 6 : Face detection example in color image

After detection of face region, face area is separated into two equal parts assuming that upper part contains eyes and lower part contains mouth. Fig. 7 shows how detected face area is divided into two equal parts.

Figure 7 : Dividing face area into two parts

d) Detection of Eye area within Upper Half

After we got all possible face candidates, we detect the existence of eyes in each possible face candidate by building two separate eye maps, one for chrominance component and one for luminance component. These two eye maps then combined into single eye map. For chrominance component, eye's surrounding is high value in Cb and low value in Cr based on observation. So chroma eye map is constructed by-

$$\text{EMC} = \frac{1}{3}\left\{(Cb)^2 + (255 - Cb)^2 + \frac{Cb}{Cr}\right\} \qquad (8)$$

Now we focus on luminance component. By grayscale morphological operators, the brighter and darker pixels in the luma component around eyes region can be emphasized. In other words, we can build luma eye map by using grayscale dilation and erosion with a ball structuring element. The equation of EyeMapL is-

$$\text{EML} = \frac{[Y(x,y) \oplus g(x,y)]}{[Y(x,y) \ominus g(x,y) + 1]} \qquad (9)$$

Where, $\oplus$ is dilation and is $\ominus$ erosion function.

After we created EMC and EML, we can combine them by AND (multiplication) operation, i.e.

$$\text{EyeMap} = (\text{EMC}) \text{ AND } (\text{EML}) \qquad (10)$$

Then we dilate, mask and set a threshold value on *EyeMap* for brighten both eyes and suppress other facial areas. The final result of eye map is shown in Fig. 6. The figure shows that there are still many brighten area in *EyeMap*. By using eroded non-skin area as a mask, most of the brighten area will be covered by black. The remaining brightens areas are therefore all inside the face. Then we set a threshold value to suppress other facial area because the eyes are usually the brightest in *EyeMap*. Finally we dilate the *EyeMap* to make both eyes clearly.

Figure 8 : Resultant eye map

e) Detection of Mouth area within Upper Half

Based on the observation, the color of mouth region contains stronger red component and weaker blue component. Hence, the value of Cr is greater than that of Cb in mouth region. Furthermore, mouth has relatively low response in the Cr/Cb and it is high response in Cr^2. So the Mouth Map can be constructed by-

$$\text{Mouth Map} = \text{Cr}^2 . (\text{Cr}^2 - \eta . (\text{Cr}/\text{Cb}))^2 \qquad (11)$$

$$\eta = 0.95 \times \frac{(1/N)\sum Cr^2}{(1/N)\sum(Cr/Cb)} \qquad (12)$$

Where, N represents the spatial size of the face-bounding box.

Fig. 9 shows the resultant mouth map. Similar to resultant eye map, we need to dilate, mask and set threshold value to obtain the final mouth map.

Figure 9 : Resultant mouth map

f) Eye/Mouth Geometry and Orientation of Triangle

After achieving the resultant *EyeMap* and *MouthMap* from all possible face candidates, we consider 3 points i, j and k which can make a triangle as shown in Fig.10. Here, i is the center of left eye block, k is the center of right eye block, j is the center of mouth block. There are 4 matching rules for such an isosceles triangle as stated below.

Let I, k be eye and j be mouth, we have

$$|D(i,j) - D(j,k)| < 0.25 \times max\big(D(i,j)\ D(j,k)\big) \quad (13)$$

$$|D(i,j) - D(i,k)| < 0.25 \times max\big(D(i,j)\ D(j,k)\big) \quad (14)$$

For x coordinate, i <j and k<j
For y coordinate, i<j< k

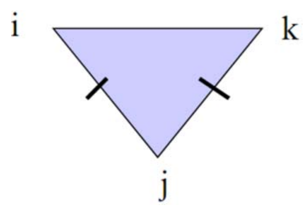

Figure 10 : Eye mouth triangle ikj

Where, D(i,j) denotes the Euclidean distance between the centers of block i (right eye) and block j (mouth), D(j,k) denotes the Euclidean distance between the centers of block k (left eye) and block j (mouth), D(i,k) represents the Euclidean distance between the centers of block i (right eye) and block k (left eye). If three points (i, j and k) satisfy the matching rules, then we think that they form an isosceles eye mouth triangle.

III. Experimental Results

In this section, a set of experimental results is demonstrated to verify the effectiveness of the proposed system. There are some single images and some grouped images that are used to verify the validity of our system. Some test images are taken using a digital camera, some from scanner, and some from videotape. The sizes of the test images range from 10 *10 to 640 *480 pixels. In these test images, human faces were presented in various environments. In this research, the minimum size of a face that could be detected is 5 * 5 pixels. Experimental results of single and grouped color images with simple/complex backgrounds are shown in Fig. 11. Also the verification of distinct position of faces is described in Fig. 12. Fig. 13 shows the detection results of face images with different expressions. By all the above experimental results we can consider that this proposed system works well.

Figure 11 : Experimental results of single and grouped color images with simple/complex backgrounds

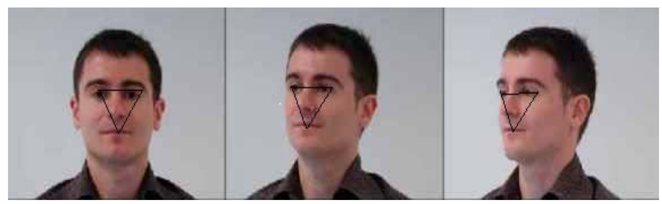

Figure 12 : Experimental results of face images with distinct positions

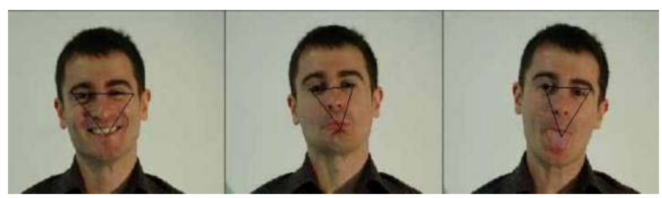

Figure 13 : Experimental results of face images with different expressions

IV. Conclusion

In this paper we propose to detect face from image with varying lighting condition and complex background. The face detection algorithm is based on YCbCr color method with lighting compensation technique and nonlinear color transformation. At first the skin region is detected from image, and then face candidates are found from grouping skin region. Then we construct eye and mouth maps in order to work on the triangle relationship between them. This proposed system works well on wide range of facial variation in color, position, scale and orientation with photo collection including both indoors and outdoors. The experimental results reveal that the proposed method is much better in terms of altered circumstance. In the future, we plan to use this face detection system as a preprocessing for solving face recognition problem.

References Références Referencias

1. Govindaraju, D. B. Sher, T. K. Srihari and S. N. Srihari, "Locating Human Faces in Newspaper Photograph", Computer Vision and Pattern Recognition, 1989. Proceeding IEEE Computer Society Conference on CVPR 89, 4-8 June, 1989 Page(s): 549 – 554.
2. H. A. Rowley, S.t Baluja, T. Kanade, "Neural Network-Based Face Detection", Computer Vision and Pattern Recognition, 1996. Proceeding IEEE Computer Society Conference on CVPR 96, 18-20 June 1996, Page(s): 203 – 208.
3. H. Schneiderman and T. Kanade, "Probabilistic Modeling of Local Appearance and Spatial Relationships for Object Recognition", Computer Vision and Pattern Recognition, 1998. Proceedings IEEE Computer Society Conference on CVPR., 1998, 23-25 June 1998 Page(s): 45-51.
4. J. Cai & A. Goshtasby, "Detecting Human Faces in Color Images", Proceedings International Workshop on Multi-Media Database Management systems, 1998, 5-17 Aug,1998 Page(s): 124 – 131.
5. C. Lin, Kuo-chin Fan, "Triangle- based approach to the detection of human face", Pattern Recognition 34 (2001). Page: 1271– 1284.
6. K. Nallaperumal, R. Subban, R. K. Selvakumar, A. Lenin Fred, C. Nelson KennadyBabu, S.S. Vinsley, "Human Face Detection in Color Images using Mixed Gaussian Color Models", International Journal of Imaging Science and Engineering (IJISE), 2010. GA, USA, ISSN, 1934-9955, vol. 2, no.1, January 2008.
7. Qianni Zhang, Ebroul Izquierdo, "Multi-feature Based Face Detection", 2010.
8. J. Qiang-rong, L. Hua-lan, "Robust human face detection in complicated color images", The 2nd IEEE International Conference on Information Management and Engineering (ICIME), 2010. Page(s): 218 – 221.
9. V. Vaidehi, A. Annis Fathima, T. Mary Treesa, M. Rajasekar, P. Balamurali, M. Girish Chandra, "An Efficient Face Detection and Recognition System "Proceedings of the International Multi Conference of Engineers and Computer Scientists 2011, Vol I, IMECS 2011, 16-18 March, 2011.
10. F. Alizadeh, S. Nalousi, C. Savari, "Face Detection in Color Images using Color Features of Skin", World Academy of Science, Engineering and Technology 76 2011.
11. Chen, P. and Grecos, C. (2005), "A Fast Skin Region Detector", ESC DIVISION RESEARCH 2005, Department of EEE, Loughborough University, pp. 35-38.

Global Journals Inc. (US) Guidelines Handbook 2013

www.GlobalJournals.org