Detection and Segmentation of Human Face

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Abstract: Detection and segmentation of faces from an image is a crucial problem that has gained importance, face detection and segmentation play the main role in the face recognition systems. There are many difficulties should be solved to make the face detection and segmentation algorithm successful. The face skin has special colors range as well as special textures that can be detected by using texture recognition algorithms which recognized skin from the background. In this paper we introduced a new method for face detection and segmentation based on face color, we uses the YCbCr color space as a method to segment image to many regions. Gray level co-occurrence matrix used to extract the important features represent the skin, and then Tamura texture used to remove all the non skin blobs which is recognized as skin by GLCM. The proposed algorithm tested with many images and it was successfully recognize the images with faces from images without faces. The proposed algorithm has high efficient in detected faces and segmented faces from the background. The accuracy of this algorithm more than 99% in detection faces and also segment its. The proposed algorithm forms a prerequisite for any practical verification system using face as the main attribute.

Keywords: segmentation, face detection, GLCM, skin color, Tamura.

I. INTRODUCTION

The face of a human being conveys a lot of information about identity and emotional state of the person. Face detection in a complex scene and its segmentation from the background forms a prerequisite for any practical verification system using face as the main attribute. So, robust detection and segmentation forms the first step in building a fool proof system.

In the few decades the human face detection and segmentation emerge as an active research. There are many applications for this field such as face identification system, face tracking, video surveillance and security control system, and human computer interface. The preprocessing for all these applications is the face segmentation. There are many factors faces the process of face detection and segmentation such as the variation of face expression, skin color and may be the present and absent of some objects such as the mustache and glasses in addition to the variation of illuminate, face direction, color background, and distance between camera and subject [9]. Face detection is the process of finding faces in image and when detection the faces then it should be determine the face location and its content. Face detection is the interest step in the process of automatic analysis and face recognizing.

Image segmentation is the crucial problem in image analysis and image understanding. The face segmentation is an essential step of face recognition system since most face classification techniques tend to only work with face images. Therefore face segmentation has to correctly extract only face part of given large image [1].

The corner stone of face detection and segmentation is the human skin color which is used as effectively feature for face detection. Although skin color differs among individuals, several studies have shown that the major difference exists in the intensity rather than the chrominance. Several color spaces have been used to label skin pixels including RGB, NRGB (normalized RGB), HSV, YCrCb, CIE-XYZ, CIE- LUV.

Face detection approaches can be classified into features based approaches and image based approaches.
there are many researchers' works in this field, some of them are:

H. C. Vijay Lakshmi and S. PatilKulakarni, presented an Algorithm based on color space, they combine HSI and YCbCr along with Canny and Prewitt edge detection techniques. This technique improve an approaches suggested by other researchers [4].

K. Satheesh, I. Laurence Aroquiaraj, proposed algorithm called Hit and Missed Transformed (HMT) for face segmentation based on Mathematical Morphological Operator. The HMT determined the features for gray image to use it as a base of face segment [7].

El Abbadi, N.K., and A.H. Miry, Suggested new method to segment the skin lesions based on histogram thresholding. The input image filtered to remove most of segmentation problems such as variety in color, shapes, size, and other. Mathematical morphology used to enhance the image [2].

II. METHODS AND MATERIALS

In this proposal, the input image is colored image which transformed to (YCbCr) space color image by using the following relation:

$$\begin{bmatrix} y \\ C_b \\ C_r \end{bmatrix} = \begin{bmatrix} 16 \\ 128 \\ 128 \end{bmatrix} + \begin{bmatrix} 0.299 & 0.587 & 0.114 \\ -0.168 & -0.331 & 0.5 \\ 0.5 & -0.418 & -0.081 \end{bmatrix} \times \begin{bmatrix} red \\ green \\ blue \end{bmatrix}$$

The important factor in this process is the (Cr) component, which plays the main role in the face segmentation process; **Fig. 1** shows the transformed process of image
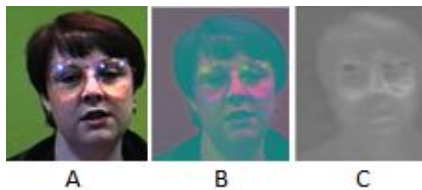
Fig. 1: transformed image. A. color image. B. YCbCr image. C. Cr image

Binary image is created from the Cr component; this is done by comparing each pixel value in the image with threshold (Cr mean). This step regards as the skin detector according to the mean of Cr component, each pixel value greater than threshold (mean) was classified as skin and converted to white color (with value equal to one), otherwise the pixel classified as background and converted to black color (with value equal to zero).

$$Threshold = \frac{1}{w \, x \, h} \sum_{i=0}^{w-1} \sum_{j=0}^{h-1} Cr \, (i,j)$$

Where w, and h are the width and height of the image, and (i, j) is the pixel coordinate. The result of this step showed in Fig. 2.
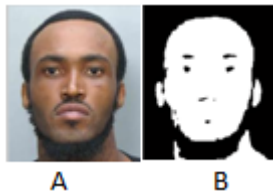

Fig. 2: creating binary image. A. color image. B. facial binary image.

The next step is to separate the image blobs in the color filtered binary image into individual regions.

Edges will be detected on binary image to divided image into separated segments achieved by applying the mask filter showed in **Fig. 3** on the entire image, it scanning the image from left to right and top to down, the pixel correspond to the center of mask will be one when the result of multiplication of pixels values in the image by the corresponding values of the mask will be equal to (1, 2, or 3), otherwise will be zero, **Fig. 4** showed the image after edge detection..

$$\begin{vmatrix} 0 & 0 & 0 \\ 0 & 1 & 1 \\ 0 & 2 & 0 \end{vmatrix}$$

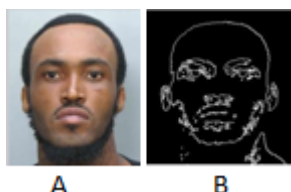Fig. 3: edge detection mask

Fig. 4: A. color image. B. edged image.

Each region segmented from this process will be labeled, starting from 1 which assign to first segment to the number of segments (regions) in the image.

Gray level co-occurrence matrix (GLCM) used to remove all the regions which are not part of face. This achieved by four steps:

First: converting the origin image to grayscale image.

Second: each labeled segment in the binary image separated as separated image by leaving this labeled region white, and converting all the other regions to black. In this step the result is number of images equal to number of labeled segments.

Third: mapping each white region in the each image resulted from second step with the corresponding gray color (extracted from gray image). The result is image with gray color for specific region and black background.

Forth: applying the GLCM for each segment to extract the important features, from the extracted feature we decide which of the segment regards as not skin (not face), and then remove from the image by converting it to black color. The suggested GLCM relations for this work are.

$$Correlation = \sum_{i=0}^{G-1} \sum_{j=0}^{G-1} \frac{\{i \, x \, j\} x \, P(i,j) - \{ \mu_x \; * \; \mu_y \}}{\sigma_x \; * \; \sigma_y}$$

$$Inverse \quad Difference \quad Moment \quad (IDM) \quad = \sum_{i=0}^{G-1} \sum_{j=0}^{G-1} \frac{1}{1 + (i-j)^2} \; P(i,j)$$

$$Angular \; Second \; Moment \; (ASM) = \sum_{i=0}^{G-1} \sum_{j=0}^{G-1} \{P(i,j)\}^2$$

$$Contrast = \sum_{n=0}^{G-1} n^2 \quad \{ \quad \sum_{i=0}^{G} \sum_{j=0}^{G} P(i,j) \quad \} \quad , |i-j| = n$$

The GLCM did not remove all the non skin regions from image, actually leave some small regions in the image regards it as part of face. For that to increase the segmentation efficiency we suggested using Tamura algorithm.

One of the Tamura textures is the coarseness which is the degree of coarseness of the image. Coarseness can be calculated on colored image. The resulting images from the GLCM operations will be mapped with color image (original image) to return the corresponding color region. Coarseness can be determined by dividing the image to non-overlapping blocks. The following process will be applied to image when the block size (2x2, 4x4, 8x8, 16x16, 32x32, and 64x64).

The mean for each block will be determined by the following relation

$$A_k \; (x,y) \; = \; \frac{1}{2^{2k}} \sum_{i=-2^{k-1}}^{2^{k-1}-1} \sum_{j=-2^{k-1}}^{2^{k-1}-1} f(x+i, y+j)$$

Where k = 1~ 5 and f (x+i, y+j) is the gray level value of (x+i, y+j). When k = 1 , a 2x2 block is selected to calculate the average pixel value A_1 (x, y) of this block. When k = 2, a 4x4 block is used to calculate the average pixel value A_2 (x, y) of the block, and so on.

Later, based on each k value, the average gray level value difference between each pixel and its neighboring pixels (in horizontal and vertical directions) can be derived as follows [10]:

$$E_{k,h}(x, y) = |A_k(x + 2^{k-1}, y) - A_k(x - 2^{k-1}, y)|$$

$$E_{k,v}(x, y) = |A_k(x, y + 2^{k-1}) - A_k(x, y - 2^{k-1})|$$

Where (h, v) represent the horizontal and vertical directions.

Finally, after we determined $E_{k,h}(x, y)$, and $E_{k,v}(x, y)$ for k = 1~ 5, the maximum value E and the corresponding k are used to represent the coarseness of the pixel (x, y), denoted as $F_{coarse}(x, y)$:

$$F_{coarse}(x, y) = \max \{E_{k,i}(x, y), \ i = h \text{ and } v, k = 1,2,3,4,5 \}$$

III.   RESULTS

The proposed algorithm tested with many images, some of them showed in **Fig. 5, Fig. 6, Fig. 7, Fig. 8, Fig. 9, and Fig. 10.** When we applied the proposed algorithm on each image the final image result will be either image with face (and black background) when there is face in the input image or black image when there is no face in the input image as in **Fig. 8, Fig. 9**, and **Fig. 10**. In each figure we showed the image in various stage starting from the color image (input image), YCbCr image, Cr component image, binary image, and face image (the final result).
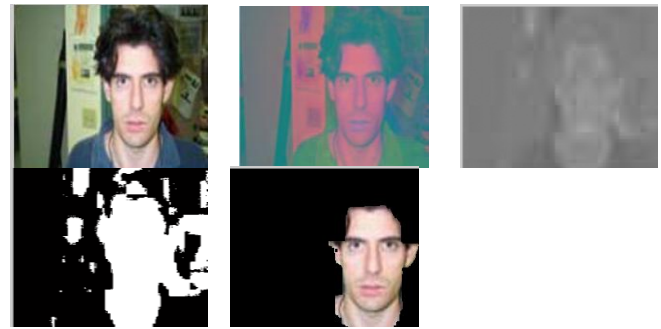

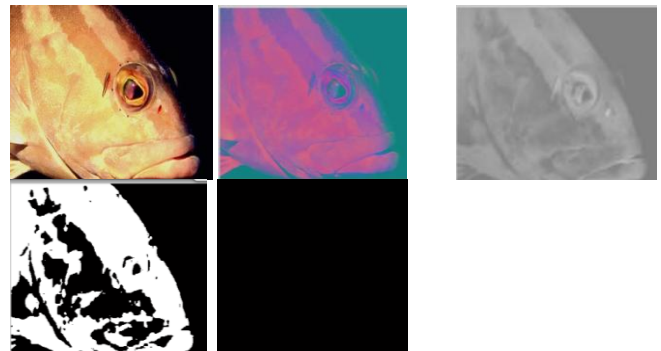Fig. 7: example (3) for face detect

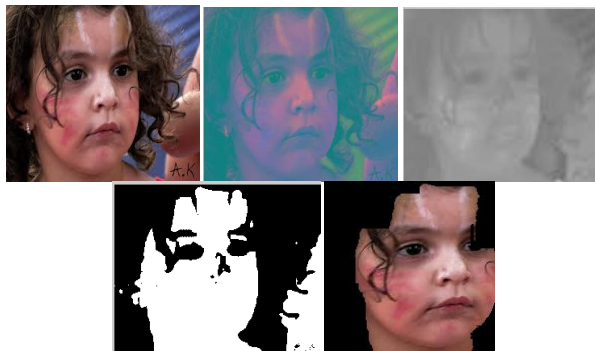Fig. 8: example (4) for face detect
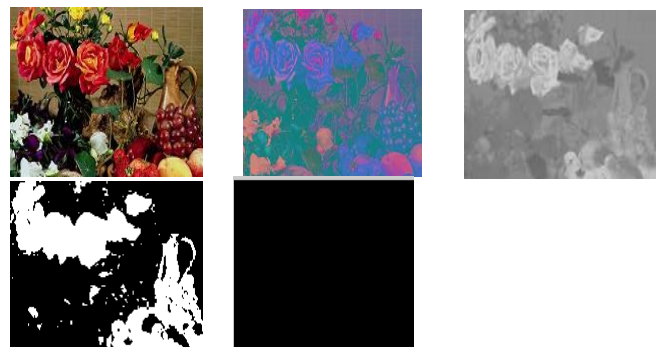

Fig. 5: example (1) for face detect

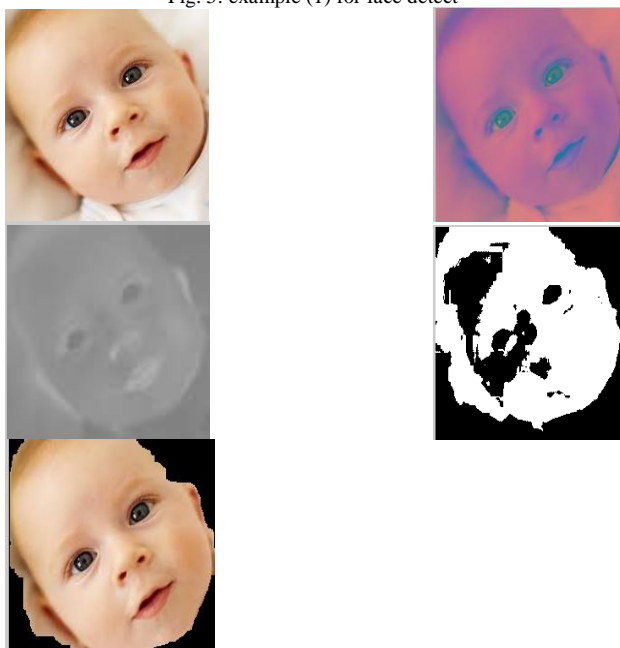Fig. 9: example (5) for face detect

Fig. 10: example (6) for face detect

Fig. 6: example (2) for face detect

- The algorithm also checked with more than one face in the image and works well as showed in **Fig. 11**.

Fig. 11: image with two faces

- To evaluate the performance, we determined the precision and recall as follow:

$$Precision = \frac{No.\,of\ relevant\ images\ retrieved}{Total\ no.\,of\ images\ retrieved} \times 100$$

$$Precision = \frac{100}{100} \times 100 = 100\%\ \text{for the proposed system}$$

$$Recall = \frac{No.\,of\ relevant\ images\ retrieved}{Total\ no.\,of\ relevant\ images\ in\ the\ database} \times 100$$

$$Recall = \frac{99}{100} \times 100 = 99\%\ \text{for the proposed system}$$

- The average execution time for detection and segment the face from the image was 2.4 sec.

IV.   DISCUSSION

The algorithm tested with many images, in all images included faces it successfully detect the face and segmented it, even when there is more than one face in image.

Facial images in the experiment come mostly from digital still camera photos from life and collected stochastically from the internet.

From the other side the algorithm return black image when there is no face in image. The precision was 100% while the recall equal 99%, and this is very good result, these results better than many algorithms used to detect and segment human face. Proposed algorithm compared with other algorithms and gives promised results as shown in **Table 1**.

V.   CONCLUSION

In this paper we suggested new method to detect and segment the face from an image. We suggested using the GLCM to detect the face or skin features in the image.

Also we used the Tamura to increase the segmentation efficiency, by removing the segments which is not skin and classified as skin in the GLCM.

The algorithm tested with many images and gives very good results.

We suggest expanding this work in the future to detect and segment all the human skin in the image regardless to which part of the human body belong.

In our study we applied many experimental limitations for each pixel or segment by detecting the feature rang of each face region that distinguishes it from other regions in the image. comparing proposed algorithm with other algorithms gives better results as in **Table 1**.

Table 1: comparing proposed algorithm with other algorithms

Algorithms	Efficiency
With Mixed Gaussian skin color model [6]	92.5%
Without Mixed Gaussian skin color model [6]	87.5%
Kamarul Hawari Bin Ghazali, Jie Ma, Rui Xiao [5].	95.45%
Yogesh Tayal et al. 2012	73.68%
Reema Ajmera, Namrata Saxena, 2013	84.61 %
HIS Color Space [3]	73.8 %
YCbCr Color Space [3]	84.61 %
RGB Color Space [3]	21.64 %
Hewa Majeed Zangana, Imad Fakhri Al Shaikhli, [3]	92.69
Proposed algorithm	99%

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BIOGRAPHY

Nidhal El Abbadi, received BSc in Chemical Engineering, BSc in computer science, MSc and PhD in computer science, worked in industry and many universities, he is general secretary of colleges of computing and informatics society in Iraq, Member of Editorial board of Journal of Computing and Applications, reviewer for a number of international journals, has many published papers and three published books (Programming with Pascal, C++ from beginning to OOP, Data structures in simple language), his research interests are in image processing, security, and steganography, He's Associate Professor in Computer Science in the University of Kufa – Najaf, IRAQ.