Face Detection Using Generic Eye Template Matching

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***Abstract*-Face identification and detection has become very popular, interesting and wide field of current research area. As there are several algorithms for face detection exist but none of the algorithms globally detect all sorts of human faces among the different colors and intensities in a given picture. In this paper, a novel method for face detection technique has been described. Here, the centers of both the eyes are detected using generic eye template matching method. After detecting the center of both the eyes, the corresponding face bounding box is determined. The experimental results have shown that the proposed algorithm is able to accomplish successfully proper detection and to mark the exact face and eye region in the given image.**

***Keywords:Face detection; eye detection; generic eye template; face bounding box; features point extraction*.**

I. INTRODUCTION

Human face detection is important and very general approach in the field of image processing. But, because of its limitations in the database centric performance evaluation, face detection is still an emerging topic of enhancing the face detection in the given image. There are many applications of face detection[1], eye detection, and face recognition such as automatic face recognition, video surveillance [2], criminal investigation, human-computer communication, large-scale face image [3] retrieval systems, etc. In spite of these applications, many different aspects of human face detection are also noticed. Some well defined algorithms have also been developed to eliminate different constraints of face detection viz., active testing face detection [4], facial expression recognition [5], feature based face recognition [6], facial caricature generation [7], etc. But in each of the above mentioned cases, the facial database is used very specifically for producing the appropriate output. Also, the researchers in this field are using a particular color model for obtaining the optimal result. Thus, the main challenges encountered in face detection is to cope up with a wide variations in human face image such as size, orientation, expression, ethnicity and skin color [3, 8, 9]; external factors such as occlusion, complex backgrounds [10-12], different lighting conditions and the quality of the images are also playing a significant role in the overall problem. For this reason, accurate eye and face detection of any input images [1, 13] is posing a great challenge.

Thus, many eye and face detection algorithms can be seen in the literature survey. Most of the eye detection algorithms may be classified into three types: The first approach [14, 15] locates eyes using cross-correlation between the eye templates of the images. The second approach [16, 17] uses the principle component analysis [18] to locate the eyes. And, the third approach [19, 20, 21] uses deformable templates to detect the eyes. However, the first and the second approaches require the normalization of the image face in its size and orientation but the variations in size and orientation of the image face are not very small. And, the third approach has the drawback that the initial position of the eye template has to be set manually, to the position of the eyes.

Lin and Wu [22] proposed a novel facial feature detection algorithm. The algorithm computes a cost for each pixel inside the face region using generic feature templates and selects pixels having the maximum costs as facial feature points.

This paper assumes that the user will co-operate with the system, and thus, the detection module will deal only with the frontal faces. But, the method has also been applied for detecting faces other than frontal ones. The method assumes the image to be an intensity-based image, i.e.; the image lies from head to shoulder with a plain background and the irises of both eyes appears clearly in the image.

This paper emphasizes mainly on eye detection because the face detection is totally dependent on the exact location of the eye which in turn increases the face detection accuracy rate. In eye detection module, there exists four parts-Extraction of face region, crop the portion of left and right eyes, and detection of the probable eye region, and generic eye template matching. A new concept known as generic eye template matching has been introduced which is the most interesting part of this paper.

II. PROPOSED ALGORITHM

The proposed method can be described in the following steps:

Step-1: First convert the original intensity image to gray scale image.

Step-2: Extract the face region.

Step-3: Separate the left eye and right eye portion of the extracted face region.

Step-4: Detect the probable eye region.

Step-5: Perform Generic eye template matching.

Step-6: Mark the face and eye region.

III. EXTRACTION OF THE FACE REGION

First, the original intensity image $I(x,y)$ is converted to gray scale image $im(x,y)$. Then, the Sobel edge detector is applied to the gray scale image im(x, y), $0 \le x \le M-1$ and $0 \le y \le N-1$. Let K(x, y) denotes the obtained edge of the image where, K(x, y) =1 if (x, y) is an edge pixel and otherwise, K(x, y) =0.

Next, the number of *1's* of each column x and each row y are counted and stored as V(x) and H(y) respectively. Now, V(x) and H(y) are computed as described in [19]:

For vertical direction

$$V(x) = \sum_{y=0}^{N-1} K(x,y) \tag{1}$$

For horizontal direction

$$H(y) = \sum_{x=0}^{M-1} K(x,y) \tag{2}$$

Then, the left and right boundary of the head portion are given by the smallest and largest values of x such that $V(x) \ge V(x_0)/3$ where, x_0 denotes the column x with respect to the maximum V(x). And, the y-position y_{min} of the upper boundary of the head is given by the smallest y such that $H(y) \ge 0.05*(x_R - x_L)$. Finally, the y-position, y_{max} is computed as described in [19]:

$$y_{max} = \max_x K(x,y) \tag{3}$$

Figure.1 shows the output image after the extraction of face region.

Figure (a): gray scale image

Figure(b): face region of figure 1

Figure 1: Output (b) obtained after extracting face region of the input image (a).

IV. SEPARATE THE LEFT EYE AND RIGHT EYE PORTION FROM THE FACE REGION

After getting the face region, the left eye and right eye portion [22, 24] is separated according to the Figure 2 (a). From Figure (b) and (c), it can be seen that R_a contains right eye and R_b contains left eye.

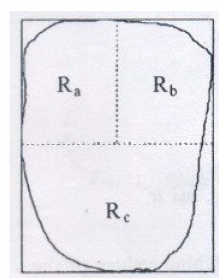

Figure (a): Partition the face region

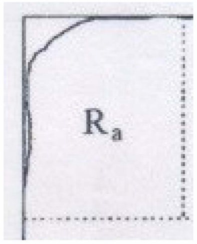

Figure (b): Portion of right eye

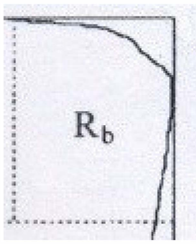

Figure (c): Portion of left eye

Figure 2: Figure (b) and (c) obtained after extracting both eyes from the face region of the input image (a).

V. PROBABLE EYE REGION DETECTION

First of all, some gray level information for the eye region has been collected. After getting the portion of both the eyes, the probable eye regions are searched with the help of a predefined value of gray level pixel information. Then, those pixel values which are satisfying the corresponding gray level information are set to 1 otherwise it is set to 0 [23]. So, the image contains some white and black spots (Figure 3 (a) and (b)). From Figure 3(a-b), it is found that the output image contains some black and white spots. The white spot indicates the probable eye region. Then, the proposed algorithm is applied with some morphological operations for clear visualization of the probable eye region. So, Figure 3 (c-d) contains the probable left and right eye region.

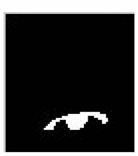

Figure (a): Right eye region

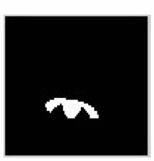

Figure (b): Left eye region

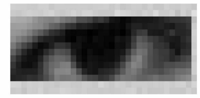

Figure (c): Exact left eye region

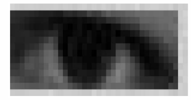

Figure (d): Exact right eye region

Figure 3: Localization of the Probable eye region

VI. TEMPLATE MATCHING

After getting the probable eye region, the canny edge detector is applied to that region. Then, the probable eye region is compared with generic eye template (Figure 4). The generic eye template consists of three concentric circles of radii 5, 6 and 7 units. First, a pixel is selected from probable eye region, and based on that pixel drawn a circle of radius 5 units, if the circle fits inside the probable eye region, then the percentage of matching is calculated for that pixel. Otherwise, the circle is rejected and chooses the next pixel. If the first circle fits inside the probable eye region, then the next two circles are drawn consequently to check whether the circle with the mentioned radii's fits inside the probable eye region or not. If any of the three circles fit inside the above radii's, then the percentage of matching is calculated for each of the three cases in a similar way.

If all the circles are rejected, then the next pixel is chosen, and the algorithm proceeds in a similar way until none of the pixels is left. Next, the median value of all the obtained percentage of matching is calculated. Finally, the center of the eye is detected based on the median value of the corresponding pixel. So, in this way the center of both eyes are detected by the proposed algorithm.

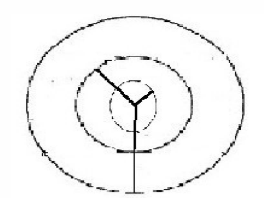

Figure 4: Generic eye template

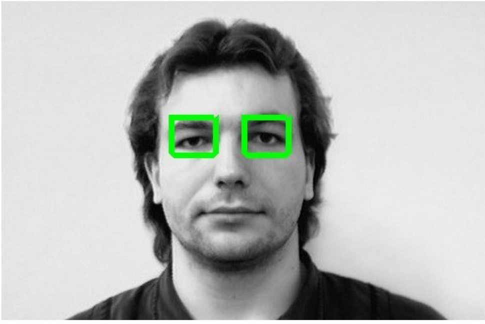

Figure 5: Eye detected

VII. TO CALCULATE THE REGION OF THE BOUNDARY BOX TO DETECT A FACE

Based on the center of the eyes, the marking on the face bounding box of the input image is determined [25]. The width bb_{xw} of this image (in pixels) is defined by:

$$bb_{xw} = \frac{zy\_zy}{2 * puple\_se} * d_{GT} \qquad (4)$$

Where, d_{GT} is the distance (in pixels) between both center of the eyes, and zy_zy = 139.1 (mean width of a human face) and pupile_se = 33.4 (half of the inter-pupil distance) are anthropometric constants given by Farkas[22]. If the value of y_up is equal to pupil_se, the position of the bounding box can be computed.

The above procedure is applied to mark both the face and eye region from the input image (see figure 1 (a)) to produce the overall output image (see Figure 6).

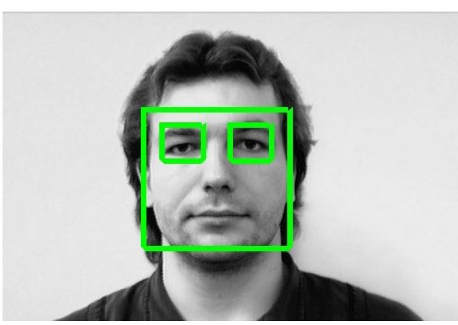

Figure 6: Face and eye detected

VIII. EXPERIMENTAL RESULTS

For the experimental purpose, the proposed algorithm is evaluated using the standard face images taken from Full Faces. This database belongs to *Geez, the* face database of the University of *Bern,* Switzerland. This database consists of 150 male and female faces among which 30 are frontal faces, 63 are left right head movement faces, and the remaining 57 are up down head movement faces. The final results are shown in Table 1.

Table 1: Overall Performances of the proposed algorithm

Types of faces	**No. of in face in face database**	**No. of face detected**	**Percentage of face detected**
Frontal faces	30	28	93.33
Left right head movement faces	63	40	63.50
Up down head movement faces	57	37	64.91

IX. CONCLUSION

The face detection is very challenging domain in face recognition. Though there are much modern and accurate software today for face detection or facial parts recognition, but this approach is totally new and also less complex and easier to handle.

In the previous work described in [27], the eye detection module consists of five parts. But, the calculation of cost of feature points, separability and circular Hough transform involves a lot of mathematical deductions. Also, a lot of algorithms have been used successively which makes the system complex in nature. The algorithms also needed a lot of time and computer memory to identify the eye region.

This paper would serve some area of future scope for further modifications. This paper considers only frontal face images. So, in the future, it will try to work on varying pose images.

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