Face localization for facial features extraction using symmetrical filter and linear Hough transform.

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Abstract

In this paper, face localization for facial feature extraction is presented. The method consist three steps: (1)facial features enhancement using symmetrical filter, then the morphological process is applied to examine the edge, peaks and valley fields. (2) Line construction using linear Hough transform and (3) localization of face region based on the constructed lines and the elimination of excess area outside of face boundary.

Key words: face localization, symmetrical filter, linear Hough transform.

1. Introduction

Face detection defined by [1] is the following: given an arbitrary input image, find the location and size of the human face in the image. There is no assumption made regarding the number of the faces in the image. In face localization it is normally assumed that the input image only contains one face in the foreground. Face segmentation as defined by [2] is described as a process as finding the location and actual shape of face(s) appearing in a given image. Face segmentation is more challenging because it not only locates the position of human face, but also segments the actual shape of complete human face [3]**.**In this paper, we will discuss our approach for face localization, which will start with coarse face region extraction. Our algorithm tries to localize the face with the complete facial features and if possible, it will segment the face to get the actual shape of complete human face. The localized or segmented face could be further processed for facial features extraction such as eyes, nose and mouth detection, which is a key requirement for face recognition. Among those facial features, eyes are the most salient feature due to its interocular distance which is constant among people and not easily effected by moustache or beard.

1.1 Face region extraction and facial features enhancement

Our algorithm extracts the face region using a similar method to the one shown in [4].

Fig1. A head-shoulder image

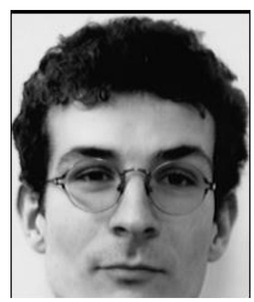


Fig.2 The face region extracted from the image of Fig.1

Then the estimated face area is further cropped by removing the top region of the face image where hair lies. If hair is not found in the top region the image is left uncropped

Figure3 Cropped face region.

After that, a symmetrical filter is applied to the cropped face region to remove sharp edges and occluded dark patches while maintaining the salient features of the eyes

0	-2	-4	-2	0
-2	2	6	2	-2
-4	6	8	6	-4
-2	2	6	2	-2
0	-2	-4	-2	0

Figure 4 Symmetrical mask

Figure 5 The face region after we apply the symmetrical mask on figure 3.

1.2 EXTRACTION OF THE EDGE, VALLEY AND PEAK INFORMATION

Let I(x,y) be the image obtained by cutting off the face region from the original intensity image given as input. We produce an edge image E(x,y), a valley V(x,y) and a peak image P(x,y) in the following ways. E(x,y) is given by applying the Sobel operator to I(x,y). The valley V(x,y) and peaks P(x,y) images are obtained from mathematical morphology as follows.Let G(x,y) denote the image obtained by applying a grayscale closing [6] to I(x,y) and H(x,y) be the image obtained by applying a grayscale opening [6] to I(x,y). Then, the valley image V(x,y) is given by G(x,y) minus I(x,y) and the peak image P(x,y) is given by I(x,y) minus H(x,y). The mathematical morphology is followed by linking process based on the gradient of the edge field. This process is useful to combine isolated edge pixels in the filtered image while reducing the effect of white spots on irises. In figure 5, we could observe that there are broken edges and isolated pixels where the edges are not connected and they are visibly different from their surrounding neighbours. The best example to illustrate this condition is by observing the eye area. We notice that the eyeball is not totally full of black pixels and it contains dots of white pixels due to reflection. This effect can be reduced by linking process and therefore better peak and valley images are obtainable.

Figure 6 The output after linking process

After the linking process, we obtain the final enhanced image by combining the linked image, the edge image, the peak and valley fields in the following way.

$$H(i,j) = L(i,j) + E(i,j) + I(i,j) - V(i,j)$$

Where $H(i,j)$ is the enhanced image, $L(i,j)$ the image after linking process, $I(i,j)$ the original image, $V(i,j)$ the valley image. The output of the enhanced image is shown in figure 7 below.

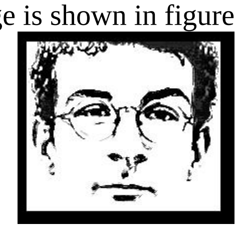


Figure 7 Enhanced image

Figure 8 compare the valley and peaks for the image before enhancement and after we apply the symmetrical filter, linking process and image enhancement.

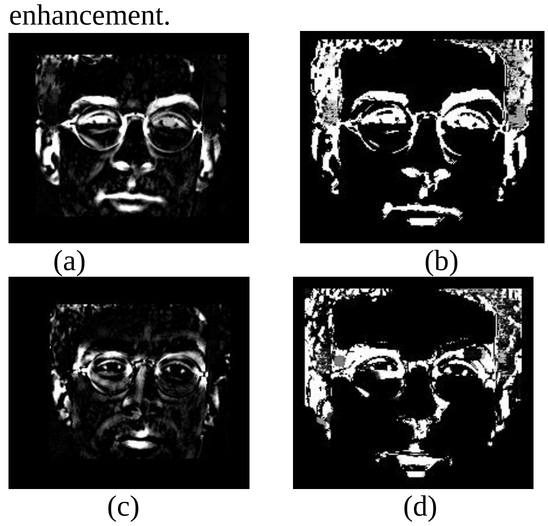


Figure 8 Comparison the valley image (a) before image enhancement (b) after image enhancement. Comparison of peaks image (c) before image enhancement (d) after image enhancement

1.3 Linear Hough transform

The edge field E(x,y) obtained in the last section is reused in the linear Hough transformation. For every edge pixel, the line angle can be varied from 0° to 180° with an increment of 1°. The distance from the origin to the nearest point on the line is calculated. Both the angle and the discretized distance will become an index to the 2-D accumulator array where its frequency is accumulated. Then an accumulator array is used to store the frequency of various lines for every single edge pixel. After the accumulation process, a data reduction scheme is employed to reduce the size of the accumulator array and therefore avoid redundancy. The accumulator array is divided into 2x2 subarrays. For each 2x2 subarray only one major value is retained (out of four) while the remaining three values are set to zero. In our experiment θ is restricted until from 0°-30° and 0°-45°. By applying this approach, the size of array will not be a major drawback in the execution time of our program. Figure 9 show the edges and the line constructed using Linear Hough transform.

(a) (b)

Figure 9 (a) Edges of the image (b) Lines constructed using Hough transform.

1.4 Using constructed line for face localization and segmentation

Finally, selected lines will be constructed around the face region based on the information from the accumulator array. The constructed lines will be used to localize face region by eliminating areas outside the face boundary. The examination of each line involves inspecting the minor area covered by the line and the intensity pixel distribution lying on the respective line. The line will divide the image into two areas, namely minor area and major area as shown in figure 10. We will examine the minor area to check if the area is less than 30% of the total area.

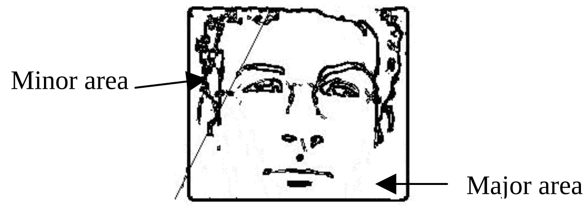


Figure 10 One of the line divided the image into minor area.

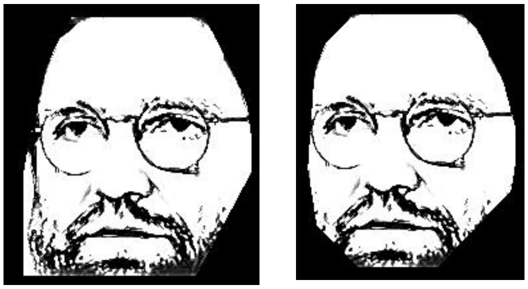
From our experiment, if the percentage of the minor area over the total area is higher than 30%, it will dissect part of the face region and therefore erroneous. For each line with area less than 30%, we will examine the pixel distribution lying on the respective line and if the black pixels are greater than 70% of the total pixels on the line, the pixel in the minor area will all be set to zero. The second threshold is used to indicate that the line should lie on the hair. The process stops when there is no more line to consider.

1.5 Experimental results

The efficiency of this method was tested on university of Bern face database which contains 300 frontal faces under controlled lighting conditions. The database is characterized by small changes in facial expression and immediate changes ($\pm 30°$) in head pose, with two images for each of the poses right, left, up, down and straight. Using the 300 face image in the database, line constructed by varying the angles (θ) from 0°-30° and from 0°-45° are examined. For simplicity, let θ_1 to represents bounded angles of 0°- 30° and θ_2 for bounded angles of 0°-45°. Table 1 shows the experimental result for θ_1 and θ_2. For θ_1, the maximum line investigated is 30° and for θ_2 the maximum line investigated is 45°.

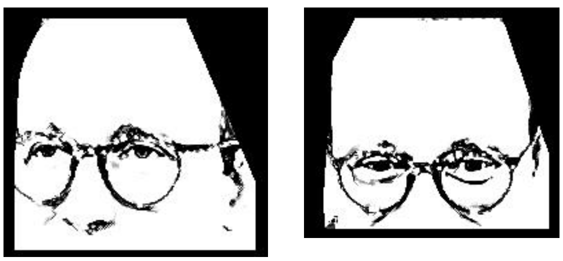
Facial features	θ_1	θ_2
Eyes	100%	100%
All (eyes,mouth,nose)	85%	85%
Mouth eliminated	8%	8%
Mouth and nose eliminated	1.33%	1.33%
Eye corner eliminated	0.33%	0.66%

Table 1 Comparison of the facial features contains in the localizes face for θ_1 and θ_2



θ_1 θ_2

Figure 11 Differences localize face between θ_1 and θ_2



(a) (b)

Figure 12 sample of the localize face with (a)Mouth eliminated (b)Mouth and nose eliminated

Figure 13 Sample of the eliminated eye corner for θ_2

Summary

In this paper, face localization for facial feature extraction is presented. The coarse region of the face is extracted, and then the facial features are enhanced using symmetrical filter. The morphological process is applied to produce the edge, peaks and valley fields. Lines are constructed in the face region using Linear Hough transform and the constructed lines are used to localize face region by eliminating areas outside of the face boundary. For the two bounded angles, the face localization rate which contains all facial features are 85%, while the rate for images that contain both eyes is 100% and the future works will concentrate on eye detection or eye feature extraction.

References

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