Chapter 4

FACE NORMALIZATION

4.1 INTRODUCTION

Face detection is a process of localizing and extracting the face region from the background. The detected face varies in rotation, brightness, size, etc. in different images even for the same person. Those features are independent of face features and will affect the recognition rate significantly. One method to solve the problem is to normalize the detected faces. The objective of the face normalization is to reduce the effect of useless, interferential and redundant information such as background, hair, cloth etc. so as to enhance the recognition process. In order to normalize the face, the basic feature points are commonly selected by using the center points of the eyes. Many eye location algorithms have been presented before [79] [80] [81] [82]. However they are either computationally expensive or unable to precisely localize the double eyeballs. As shown in Figure 4.1, we proposed an efficient algorithm for face normalization, normalizing geometry of faces so as to improve the recognition rate and real time efficiency. Algorithm assumes that the face is already detected before detecting the features such as eyes and mouth using ROI. Then the face normalization is performed. Geometric normalization is carried out by a rotation based on the eyeball's location and an affine translation defined by locations of the eyeballs. Then, the brightness is normalized by the grey information. Since the algorithm is mainly based on the histogram analysis, it can normalize the face efficiently. The experiments carried out showed that the proposed algorithm can effectively and efficiently

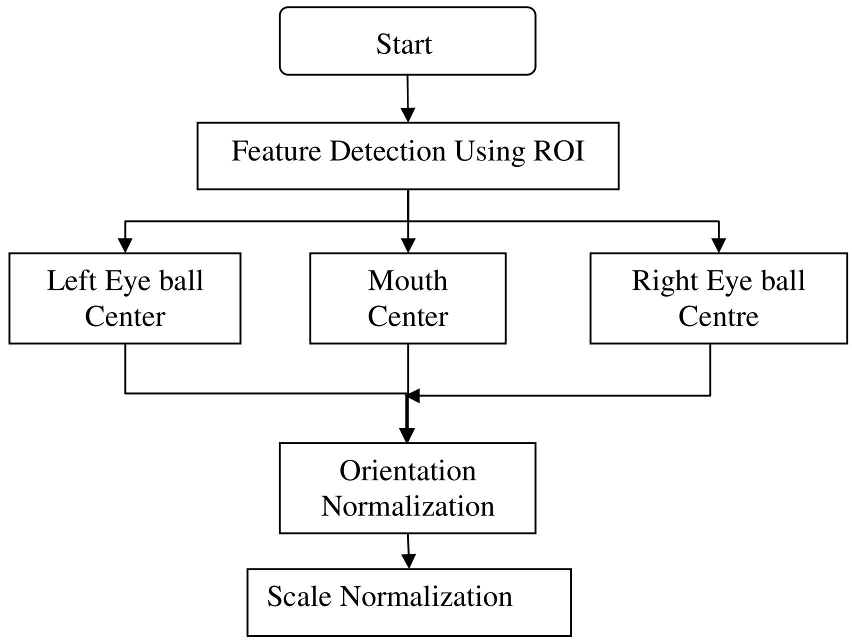


Figure 4.1: Proposed face normalization algorithm

normalize the face images. The experiments showed that after the normalization, the face recognition rate was improved by about 4 to5 percent for various methods on the ORL face image database.

4.2 FEATURE DETECTION

The system of feature detection has detected three features such as left eyeball center, right eyeball center & mouth center. Each feature is detected using Region of Interests (ROI). Following are the steps required for feature detection module.

4.2.1 Eyeball Localization

The eyeball's position is located mainly based on the brightness histogram using pattern matching. In order to reduce the computational cost, we used the brightness histogram and bright feature to detect the eyeball's position. In this algorithm the gray image is processed directly. For simplicity, we defined the left- top point of the image as the origin point of the image coordinate frame (Figure 4.2) [83] [84].

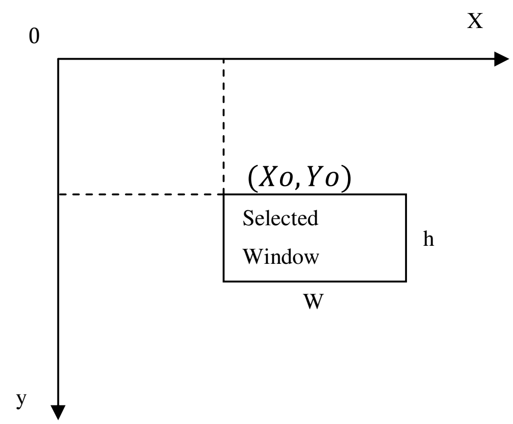


Figure 4.2 : The window selection for eyeball

The eye's region can be roughly estimated by selecting a candidate window as region of interest. In order to cover all the eye regions the rectangle window should be big enough. Denote height and width of the face by h and w, respectively. The parameters of the window have been determined after extensive experimentation.

Coordinates selected for left top window are (30, 12, 50, 30) i.e. height = 20 and width = 18. It can be established that in the selected window, that brightness of the eyeballs and the eyebrow is darker than other regions. The selected window as shown in Figure 4.4 (b) is displaced left to right and top to bottom taking initial displacement as zero and increase it in the step of 3 till it reaches 12. All pixels in the window are then sorted by the grey value. First value is taken as threshold and all such nonrepetitive thresholds are then determined. Maximum threshold is the last value. Eyeball candidate region is chosen as the 15% parts with smallest gray value.

$$T = g(x, y)(0.15 \ * N) \tag{4.1}$$

$$f(x) = \begin{Bmatrix} 0 & x < T \\ 255 & x > T \end{Bmatrix} \tag{4.2}$$

The segment threshold T will be obtained by equation (4.1), where $g(x, y)(i)$ is grey value of pixel with sorted index number as i, and its coordinate is (x, y). N is the total number of the pixels in the window. Eyeballs and eyebrow from the face can be segmented. The image can be translated to binary image by setting accepted pixels with grey value 0 and setting refused pixels with value 255 as equation (4.2). Thus threshold image is obtained by setting all pixels in ROI with intensity greater than or equal to threshold and others as black as shown in Figure 4.4 (c). Complement the binary image and project the binary image window to horizontal and vertical histogram

$$P_v(y) = \sum_{x=1}^{N} I(x, y) \tag{4.3}$$

$$P_v(x) = \sum_{x=1}^{N} I(x, y) \tag{4.4}$$

We can establish the histogram as equation (4.3) and (4.4). Commonly the horizontal histogram has two minimum extremes. The lower one corresponds to the eye and the upper one corresponds to the brow. We then sort horizontal histogram in descending order. If distance between two indexes of horizontal histogram is between 4 to 10 then horizontal left index is 2 otherwise it is assigned as 1. If there are at least 4 white pixels to the left or right of this pixel then it will be a probable left eye x coordinate candidate pixel. Else repeat above steps. Similarly find out left eye y coordinate candidate pixel. Taking median of these will give final point of left eye.

Horizontal and vertical position of the right eyeballs can also be obtained similar to the method of left eyeball center. If coordinates of the center point are between the ranges given then only we will select it, otherwise finding center point procedure will be carried out again.

4.2.2 Mouth Center Localization

Mouth window position is established from left and right eye center points. It's coordinates are determined as follows;

Horizontal position of left eye + (Horizontal position of right eye)/2 + 25;

Horizontal position of left eye + (Horizontal position of right eye) /2+60;

Vertical position of left eye + (Vertical position of right eye)/2 - 15;

Vertical position of left eye + (Vertical position of right eye)/2 + 15;

Taking percentage threshold as 40, horizontal and vertical position of the mouth center is determined using same procedure as that of right eye ball center.

4.3 FACE NORMALIZATION

After detection of features these faces are now normalized by geometric normalization. Then normalized database is created .These normalized faces are recognized applying PCA, LDA, EBGM, PCA and LDA taken together.

This section presents major steps in the face normalization process which is to normalize face images of the same person to those in similar orientation. If vertical distance between right and left eye coordinate is between 20 and 30, then only the face is normalized. A line segment is drawn joining two center points of the detected eyeballs as shown in Figure 4.3. Slope between left and right eye ball center is

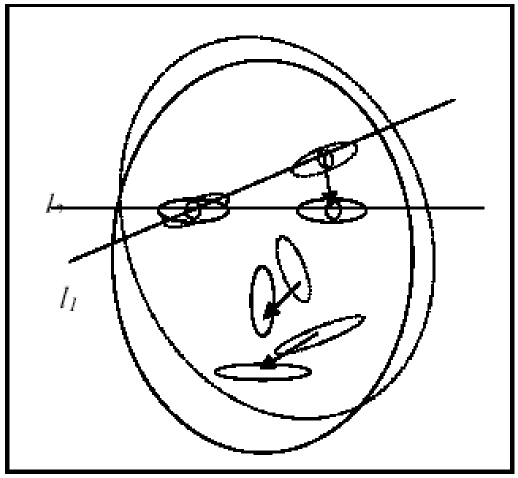


Figure 4.3: The rotation correction procedure when eye locations are given

calculated. Angle between this line and the horizontal line is then determined.

If this angle is less than 6 then normalized image is obtained by rotating image by angle in degrees. Otherwise given image is considered as normalized image.

4.4 BRIGHTNESS NORMALIZATION ALGORITHM

The face images captured at different times or positions often have different brightness. These commonly affect the recognition significantly. In order to reduce the affection of the brightness, we use a brightness normalization method to let the image have the same mean and the same variance value.

1. Mean center the pixel values in the source image.
2. Linearly smooth the edges of the source image across a 30 pixel border.
3. Normalize the contrast of the new image with histogram equalization.

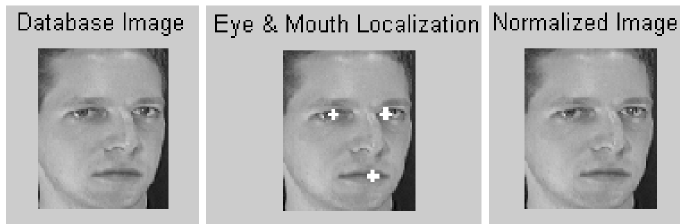
The edge of the image is smoothed to reduce its effect in frequency space. Pixel values are weighted by 30 where 30 is the distance from the edge. Pixels greater than 30 pixels from the edge are not modified. This smoothes the image edge from actual pixel values in the center of the image to zero at the edge of the image. The algorithm then performs contrast and brightness normalizations.

4.5 EXPERIMENTAL RESULTS

Figure 4.4 shows some of the experimental result of left eyeball, right eyeball and mouth center detection and normalization of face image. Figure 4.5 shows result of brightness normalization. First column of Figure 4.6 shows the original images from ORL face database, and second column shows left and right eyeball center detection and mouth center localization. And the third column shows normalized face image. It is easily found that the normalization results are obviously more standard and more like each other than original groups, which can reduce the difficulty of recognition.

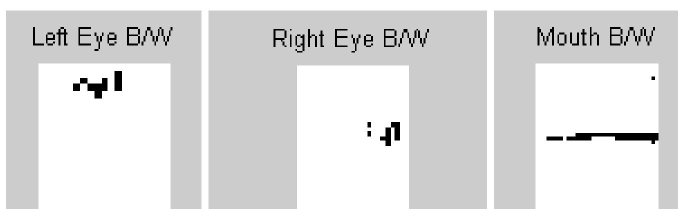
The proposed algorithm has been implemented on ORL database consisting of 400 images to verify the results. [24]. Figure 4.4 shows the results, obtained at the major steps of the geometric normalization (G Norm) algorithm, of face images. The input images were properly selected so that the eyeballs are not easy to detect. For some images given in Figure 4.6 it was hard to see the eyeballs of the person, and hence their localization was difficult. However, the results show that the algorithm can detect their positions with an acceptable accuracy. As shown in Figure 4.6 the algorithm can correctly localize the eyeball even with the glasses.

The face images were trained and recognized based on PCA, FLD, and Gabor Wavelet face recognition method. Algorithm used 1 to 10 images of a person to train and used the other remaining as well as all images for testing. The correct recognition rate is given in table 4.1. The results shown in table 4.2 prove that this method can improve the recognition rate of faces.



(a)

(b)



(c)

Figure 4.4:(a:c) The result of eyeball's and mouth center localization and face normalization

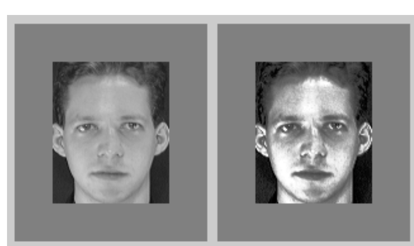


Figure 4.5: Result of brightness normalization.

Figure 4.6: Experimental results on ORL database

Table 4.1: Recognition rate for various face recognition methods

Training Images		1	2	3	4	5	6	7	8	9	10
Train + Test Images	PCA	80	89.2	89.2	90	92	95.2	95.5	95.7	96.7	97
	PCA & G Norm	80.5	88.7	89.2	90.2	93.2	95.2	95.7	95.7	96	96
	FLD	--	97.75	98.25	99.5	99	95.5	92.75	92.25	93	94.75
	FLD & G Norm	--	90.75	89	94	93.5	95.5	94.75	97	98.75	99.5
	Gabor Wavelet	54.5	67.75	76.25	82.25	86.75	89.25	92.25	95	97.25	98.5
	Gabor Wavelet & B Norm	52.75	67.25	79.75	86.25	89.25	92.25	93.75	95.25	96.25	97.25

4.6 CONCLUSION

In this work effective and efficient feature detection method based on eyes location has been proposed. We presented results of performance test of face recognition algorithms on the ORL database. The well known PCA algorithm is first tested as a reference performance. Then FLD and Gabor Wavelet algorithm were tested. All the three algorithms were tested with and without normalization. Highest recognition rate of 99.5% was found for FLD along with G Norm. It has been found that as the number of training images is increased recognition rate increases. Lowest recognition rate of 52.75% is observed for Gabor Wavelet along with B Norm algorithm when there is only one training image sample. With only one training sample this result is 80.5 % in case of PCA. This may be because of the fact that for PCA whole image is taken for face recognition whereas in case of Gabor wavelet only 5 feature points are considered.

Results shown in table 4.1 demonstrate that normalization method can effectively detect the feature such as eyeball center with and without spectacles and normalize the face images by geometric as well as brightness normalization and improve recognition rate.