Face normalization :enhancing face recognition

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Abstract **This paper presents two approaches of face recognition and effect of geometric and brightness normalization on it.. The algorithm presented here 1) Detects the position of pupils in the face image using geometric relation between the face and the eyes and normalizes the orientation of the face image. Normalized and non normalized face images are given to holistic face recognition approach.**

2) Selects features manually. Then determine the distance between these features in the face image and apply graph isomorphism rule for face recognition. Then apply Gabor filter on the selected features. Algorithm takes into account Gabor coefficient as well as Euclidean distance between features for face recognition. Brightness normalized and non normalized face images are given to feature based approach face recognition methods.

Results demonstrate that the normalized faces can improve the recognition rate in both approaches.

Keywords- face detection, ROI, Face recognition, eye location, face normalization, Eigen face, FLD, Gabor filter, Modified BGM, graph isomorphism

I. INTRODUCTION

Face recognition is a popular research area where there are different approaches. In this paper, a holistic Principal Component Analysis (PCA) based method, namely Eigenface method and Linear Discriminant Analysis (LDA) where LDA is applied after PCA and Feature based approach methods such as Gabor filter, Graph isomorphism, Modified Bunch Graph Matching (Modified BGM) are implemented on the Olivetti Research Laboratory (ORL) face database. The results are compared with respect to the effects of changes in illumination, pose and aging with and without normalization. . Simulation results show that LDA perform slightly well with respect to PCA under changes in pose. However Gabor filter performs well with respect to Graph isomorphism, Modified BGM under changes in illumination.

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. Many eye location algorithms have been presented before [1]. However they are either computationally expensive or unable to precisely localize the double eyeballs. This paper proposes an efficient algorithm for face normalization, normalizing geometry and brightness of faces so as to improve the recognition rate and real time efficiency[2][3]. Algorithm assumes that the face is already detected. Then detect the features such as eyes and mouth using ROI. Then the face normalization is performed. The geometric normalization is carried out by rotation based on the eyeball's location. 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 normalize the face images.

Paper proposes 2 approaches of face recognition. First holistic approach where the object is treated as a whole and second feature based approach where object is represented as a selected collection of abstract features. The experiments showed that after the normalization the face recognition rate of various methods like LDA, Gabor filter, graph isomorphism and Modified BGM was improved by about 4 to 5 percent on the ORL face image database.

II. ALGORITHMS

1. Holistic Approach face recognition: In this approach features such as the eyeball's center and mouth center are detected using ROI followed by orientation normalization. Then recognition of normalized and non normalized face images is performed using Eigen face and LDA face recognition method and results are compared.

The eye's region can be roughly estimated by selecting a candidate window as Region Of Interest [2].

A. Parameter selection for left eye window

1. Coordinates selected for left top window are (30, 12, 50, and 30)
2. Algorithm sorts all the pixels in the windows by the gray value. Choose 15% parts with smallest gray value as the eyeball candidate regions.

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3. The segment threshold T will be obtained and image can be translated to binary image by setting accepted pixels with grey value 0 and setting refused pixels with grey value 255.
4. Complement the binary image and project the binary image window to horizontal and vertical histogram
Commonly the horizontal histogram has two minimum extremes. The lower one corresponds to the eye and the upper one corresponds to the brow.
5. 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 step 2 to 5 by moving ROI window by 3 pixels.
6. Similarly find out left eye y coordinate candidate pixel.
7. Taking median of these will give final point of left eye as

PTR_Hor_left = median (Point_Hor_left_arr);
PTR_Ver_left = median (Point_Ver_left_arr);

PTR_Hor_left and PTR_Ver_left indicates x and y coordinates of left eye ball centre.

B. Parameter selection for right eye window

1. Right eye window is adaptive from the left eye ball center. Its start and end coordinates are
wn_r_x_st = PTR_Hor_left-15,
wn_r_x_end = PTR_Hor_left+15,
wn_r_y_st = PTR_Hor_left+22,
wn_r_y_end = PTR_Hor_left+45.
2. Horizontal and vertical position of the eyeballs can be found by the same way as left eye ball.

C. Mouth center localization

1. Mouth window selection adaptive from left and right eye center points. And its coordinates are

(PTR_Hor_left + PTR_Hor_right / 2) + 25;
(PTR_Hor_left + PTR_Hor_right / 2) + 60;
(PTR_Ver_left + PTR_Ver_right / 2) - 15;
(PTR_Ver_left + PTR_Ver_right / 2) + 15;

2. Find horizontal and vertical position of the mouth center using same procedure of right eye ball center.

D. Face normalization

- *Geometric Normalization Algorithm (G Norm)*

Here both eye ball centers are brought in a straight line as shown in the figure 1. If distance between right and left eye coordinate is between 20 and 30 then only normalize the face image.

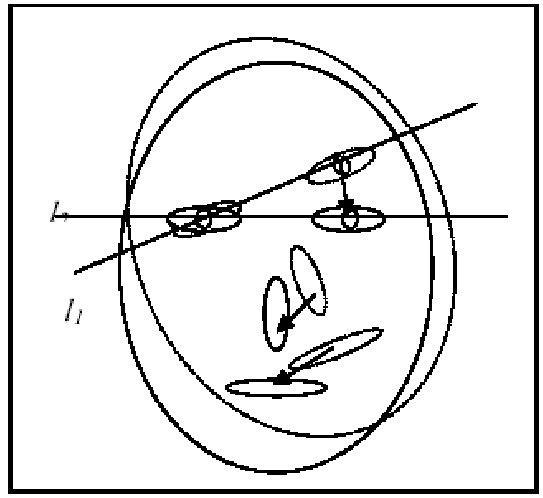


Figure 1 Geometric normalization.

1. Calculate slope and angel between left and right ball center
2. If abs (angle in degree) < 6 then normalized image is obtained by rotating the image by that angle.

Now give normalized and non normalized face images to holistic face recognition approach.

- *Brightness Normalization Algorithm (B Norm)*

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 used brightness normalization method to let the image have the same mean and the same variance [3].
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.

Give brightness normalized and non brightness normalized images to feature based approach of face recognition.

2. Feature Geometric face recognition approach:

In feature based face recognition approach, manually select features such as left eye ball centre and right eye ball center, nose tip and left and right corners of the mouth and store their corresponding coordinates (x, y) in a file called landmarks DB. Perform brightness normalization. Then apply feature based face recognition methods such as Gabor filter, graph isomorphism and modified BGM and compare recognition rate with and without brightness normalization.

A. Graph isomorphism face recognition algorithm

Connect selected five features by lines to each other and graph is form called face graph. Create adjacency matrix called graph file FV_graph_file to store Euclidean distance between these graph points/nodes. The distance of point from itself is taken as 0. Graph isomorphism technique is used for face recognition. Iso means same and morphism means structure. Algorithm compares 2 face graphs to check whether they are having same structure [3].

B. Gabor filter face recognition algorithm

1. Algorithm uses manually selected landmarks as shown below in Figure 6 to produce the bunch graph. Save this file as landmarks file [6].
2. Generate Gabor filter with parameter as
sz_factor = 4,
lamda_param_set = {4, 4√2, 8, 8√2, 16},

Theta _set = $\{0, \pi/8, 2\pi/8, 3\pi/8, 4\pi/8, 5\pi/8, 6\pi/8, 7\pi/8\}$,
phi_param_set = $\{0, \pi/2\}$.
80 Gabor filters are generated save this file as gabor_filter _profile as shown in Figure 9.
3. Perform convolution of each feature with Gabor filters and save coefficient (Gabor jet) in file FV_file. Gabor jets, in this case referred to as model jets.
4. After creating a face graph for two images, their similarity can be computed by comparing Gabor jets using Euclidean distance.

C. Modified BGM face recognition algorithm

In Modified BGM face recognition approach, Graph isomorphism face recognition and Gabor filter face recognition are combined and face recognition is carried out. The combined algorithm is as follows

1. Read the feature vector file FV_file from Gabor filter face recognition and graph file FV_graph_file from graph isomorphism face recognition method.
2. Train vectors first by FV_file and then by FV_graph_file.
3. Give the test vector to the classifier. Classifier compares 2 vectors and chooses minimum Euclidean distance as a measure for recognition [3].

III. EXPERIMENTAL RESULTS

To verify the proposed algorithm, it was implemented and experiments were conducted on ORL database. Figure 2 shows some of the experimental result of left eyeball, right eyeball and mouth center detection and normalization of face image. Figure 4 shows result of brightness normalization. First column of Figure 3 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. We carried out comparison experiments of face recognition with and without face normalization. The algorithms used for face recognition are Eigen face [4], LDA (Linear Discriminant Analysis) [5] graph isomorphism face recognition [3], Gabor filter [6] and Modified BGM [3]. Figure 3 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 3 it was hard to see the eyeballs of the person, and hence their localization was difficult. However, the result demonstrated that the algorithm can detect their positions with an acceptable accuracy. As shown in Figure 3 some person wears glasses. It is shown that the algorithm can correctly localize the eyeball even with the glasses. Figure 5 shows result of manual feature selection. Figure 6 shows result of face graph creation. Figure 7 shows adjacency matrix of distances between features. Figure 8 shows preprocessed image. Figure 9 shows creation of 80 Gabor filters. 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 1. The table results prove that these methods of normalization can improve the recognition rate of faces.

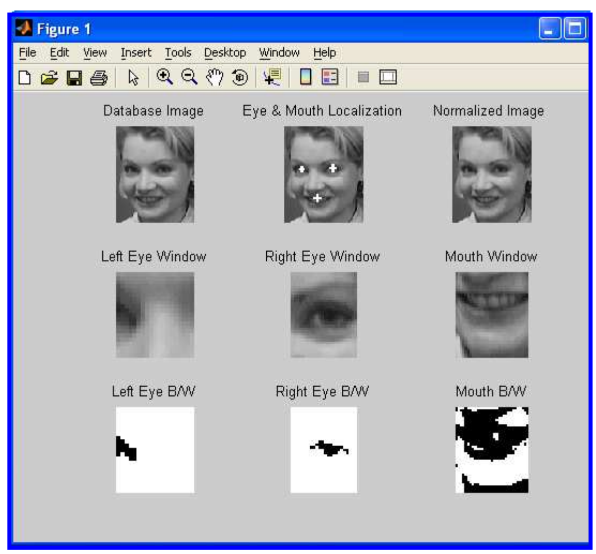


Figure 2 The results of eyeball's and mouth center localization and face normalization.

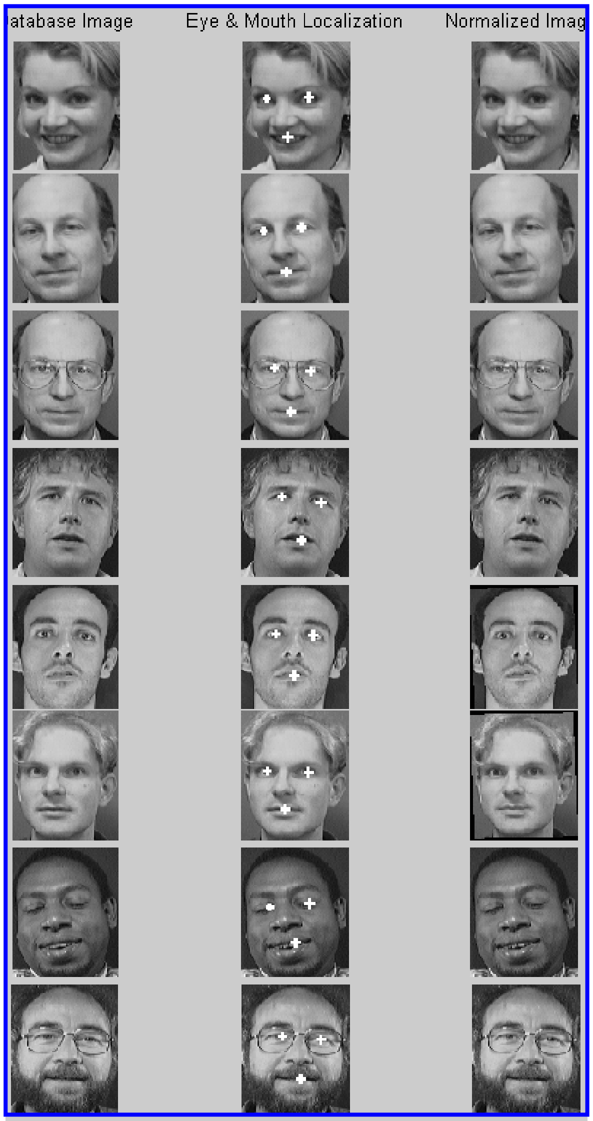


Figure 3 The results of Geometric Normalization on ORL database

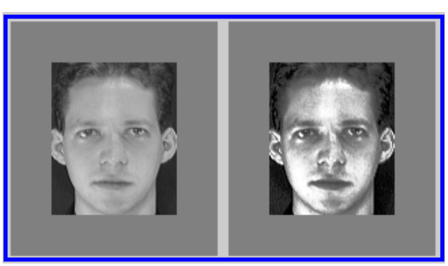


Figure 4 Result of brightness normalization

Figure 5 Manual Feature selection

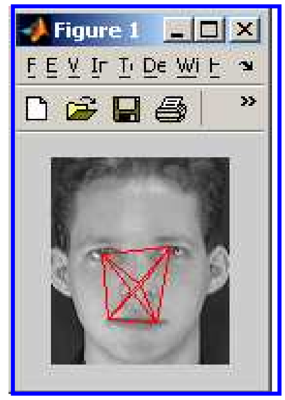


Figure 6 Face graph creation.

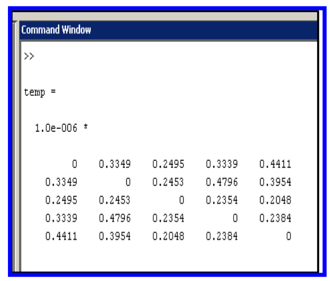


Figure 7 Adjacency matrix

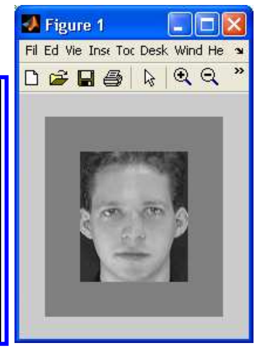
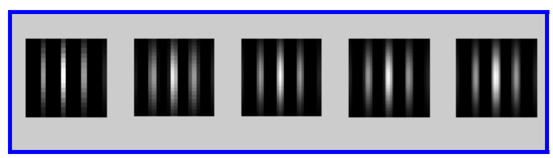
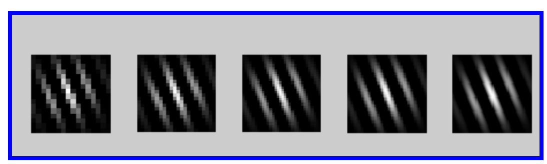


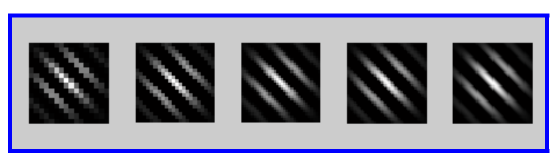
Figure 8 Preprocessing image



Φ=0, θ=0, λ=4,4R2, 8, 8R2, 16.



Φ=0, θ=π/8, λ=4,4R2, 8, 8R2, 16.



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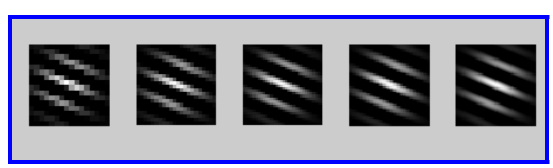

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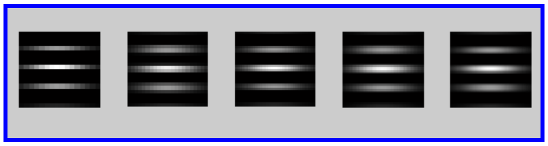
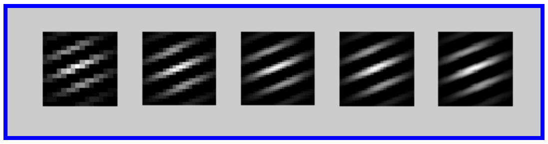
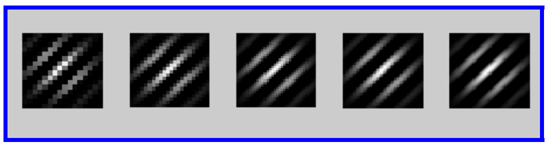


Φ=0, θ=4π/8, λ=4,4R2, 8, 8R2, 16.



Φ=0, θ=5π/8, λ=4,4R2, 8, 8R2, 16.



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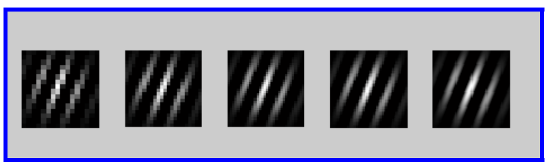
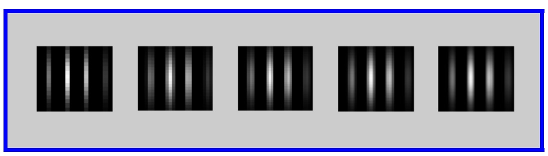
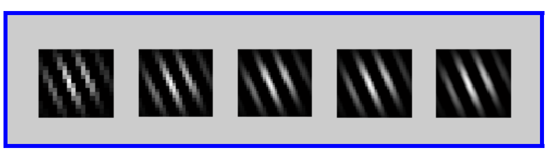


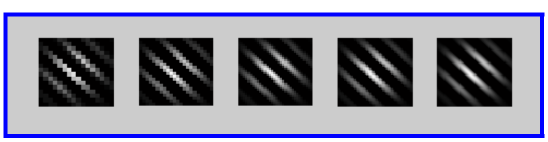
Φ =0, θ=7π/8, λ=4,4R2, 8, 8R2, 16.



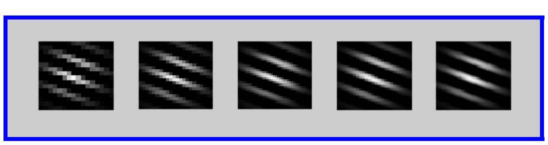
Φ = π/2, θ=0, λ=4,4R2, 8, 8R2, 16.



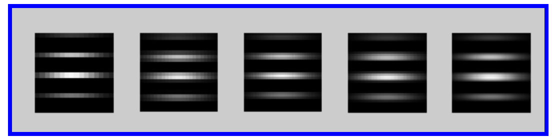
Φ = π/2, θ= π/8, λ=4,4R2, 8, 8R2, 16.



Φ = π/2, θ= 2π/8, λ=4,4R2, 8, 8R2, 16.



Φ = π/2, θ= 3π/8, λ=4,4R2, 8, 8R2, 16.



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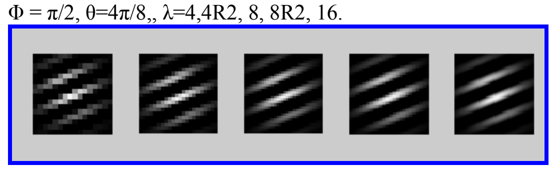
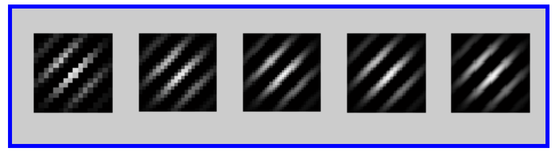
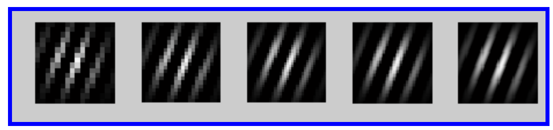


Φ = π/2, θ= 5π/8, λ=4,4R2, 8, 8R2, 16.



Φ = π/2, θ= 6π/8, λ=4,4R2, 8, 8R2, 16.



Φ = π/2, θ= 7π/8, λ=4,4R2, 8, 8R2, 16.

Figure 9 80 Gabor filter.

IV. CONCLUSION

This paper presented a fast algorithm for normalizing face images. The algorithm normalizes the input images to images with similar orientation and brightness. Algorithm was implemented and its performance was verified, which demonstrated that this method can effectively detect the features such as eyeball center with and without spectacles and normalize the face images by geometric as well as brightness normalization and improve recognition rate for holistic as well as feature based approach.

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TABLE I. RECOGNITION RATIO IN PERCENTAGE FOR VARIOUS FACE RECOGNITION METHODS

Training Images, nots		***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***
Test Images only	Eigen Face	78.6	85.9	84.6	83.3	83.5	87.5	87.5	87.5	85	-
	GNorm + Eigen Face	76.6	84.6	83.5	82.9	85	87.5	86.6	87.5	82.5	-
Train + Test Images	Eigen Face	80.7	88.7	88.7	89	91	92.7	95.2	96.2	96.7	-
	GNorm + Eigen Face	79	87.7	88	88.5	91.2	93.5	94.5	94.5	95.5	-
Test Images only	LDA	-	85.3	85.3	90	89.5	85.6	83.3	86.2	87.50	-
	GNorm + LDA	-	88.4	84.2	90	87	88.7	82.5	85	90	-
Train + Test Images	LDA	-	97.7	98.2	99.5	99	95.5	92.7	92.2	93	94.7
	GNorm + LDA	-	90.7	89	94	93.	95.5	94.7	97	98.75	99.5
Test Images only	GRAPH Isomorphism	5.27	10.12	6.07	7.91	7	7	8.75	7.5	10	--
Train + Test Images	GRAPH Isomorphism	14.75	13.5	10.75	13	12.5	13	12.25	11.50	13.50	13.25
Test Images only	Gabor Filter	49.4	59.6	66.0	71.2	74.5	75.6	76.6	78.7	77.5	-
	BNorm + Gabor Filter	--	59.0	71.0	77.5	79	83.7	84.1	82.5	77.5	-
Train + Test Images	Gabor Filter	54.5	67.7	76.2	82.2	86.7	89.2	92.2	95	97.2	-
	BNorm + Gabor Filter	52.7	67.2	79.7	86.2	89.2	92.2	93.7	95.2	96.2	-
Test Images only	Modified BGM	14.1	23.1	23.9	31.6	35.5	36.8	41.6	45	50	--
	BNorm + Modified BGM	25.8	23.4	32.1	40.4	42.5	45.6	44.1	48.7	47.5	--
Train + Test Images	Modified BGM	22.7	38.5	45.5	55.7	62.7	65.2	71.5	74.7	78	82
	BNorm + Modified BGM	33.2	38.2	51.5	61.5	66.7	73.2	74.5	79.2	80.5	85