FACE RECOGNITION USING ORIENTED LOCAL HISTOGRAM EQUALIZATION

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Abstract : In this paper algorithm for illumination compensation is implemented on human face recognition under different lighting conditions. Many researchers gave good results by compensating of low frequency illumination, or capturing of high frequency edges. A simple but effective method namely oriented local histogram equalization which compensates illumination and gives richer information on the orientation of edges is implemented. The features OLHE gives good results when different lighting conditions occur. The recognition rate accuracy has been improved when proposed algorithm for lighting compensation is used.

***IndexTerms* – Face recognition, illumination compensation, histogram equalization.**

I. INTRODUCTION

Many researchers have been worked on human face recognition in the last decades. Face recognition has been made rapid progress but still it is unsolved because of different illumination conditions and head orientation in faces. Some researchers tried to remove illumination effects. The image is product of reflectance and illumination. In digital images illumination is due to low-frequency components [2] of images, while edges belong to high-frequency component [3]-[5]. Many researchers have used histogram equalization technique for compensation of illumination variation [10]. The limitation of histogram equalization is that it operates only when input image contains high intensity information.

The other method having directional histogram namely oriented local histogram equalization (OLHE) used for detecting edges in different directions in given input image.

II. LOCAL HISTOGRAM EQUALIZATION

The method with the directional histogram namely oriented local histogram equalization (OLHE) [1] is extension of local histogram equalization [1] (LHE), because oriented local histogram equalization (OLHE) detects the edges and their orientations, while LHE does not. In LHE, the histogram equalization of each pixel in given image of size m×n can be performed by using,

$$f_h(x) = [\frac{cdf(x) - cdf_{low}}{m.n - cdf_{low}}.(G-1)] \qquad (1)$$

Where x is intensity of the pixel in a given image, cdf(x) is the function to calculate Cumulative Distribution Function (cdf) of the histogram, cdf_{low} is value of pixel with low intensity, and G is the gray values. We define j ≡ m = n. By considering 3×3 window we got nine LHE operators. For LHE, center pixel of 3×3 need to be processed itself. We can define LHE operators as,

$$L_j^{\xi,\eta}(I_{m*n}) = I'_{m*n} \qquad (2)$$

The $f_h(x)$ is used to calculate new intensity of each pixel of given whole image.

III. ORIENTED LOCAL HISTOGRAM EQUALIZATION

The Local Histogram Equalization method (LHE) can be converted into oriented LHE by changing the center pixel positions. The remaining eight operators other than center are directional and oriented and they are called as oriented local histogram equalization (OLHE) operators. For given input image OLHE method produces eight OLHE images.

The definitions of OLHE operators,

$$O_j^{11} = L_j^{\left(\frac{(j-1)}{2}, \frac{-(j-1)}{2}\right)} \qquad O_j^{12} = L_j^{\left(0, \frac{-(j-1)}{2}\right)}$$

$$O_j^{13} = L_j^{\left(\frac{-(j-1)}{2}, \frac{-(j-1)}{2}\right)} \qquad O_j^{21} = L_j^{\left(\frac{(j-1)}{2}, 0\right)}$$

$$O_j^{23} = L_j^{\left(\frac{-(j-1)}{2}, 0\right)} \qquad O_j^{31} = L_j^{\left(\frac{(j-1)}{2}, \frac{(j-1)}{2}\right)}$$

$$O_j^{32} = L_j^{\left(0, \frac{(j-1)}{2}\right)} \qquad O_j^{33} = L_j^{\left(\frac{-(j-1)}{2}, \frac{(j-1)}{2}\right)} \qquad (3)$$

For given image I, after applying eight OLHE operators we got eight OLHE images which are denoted as $O_j^{11}(I)$, $O_j^{12}(I)$, $O_j^{13}(I)$, $O_j^{21}(I)$, $O_j^{23}(I)$, $O_j^{31}(I)$, $O_j^{32}(I)$, $O_j^{33}(I)$. They are called as OLHE images.

3.1 OLHE And LBP Relationship

In LBP [6] comparison of intensities of eight surrounding pixels in a 3×3 window with center pixel is done. If the pixel has high intensity value than center pixel, then it will be assigned with pixel value as '1,' or '0' otherwise. All these results which are binary bit information are then concatenated. Concatenated information is then converted into decimal information.

All the results of OLHE are stored in separate eight images, instead of concatenation of those images. If we take binarization of those eight OLHE images by thresholding using center pixel intensity in that 3×3 window, we will obtain eight binary images. The output image after finding weighted sum of those eight binary images, the resultant image is compared to LBP result. So we can conclude that the output image of summation of eight binary images and LBP are exactly same. Fig. 1 shows the stepwise illustration of OLHE and LBP relationship.

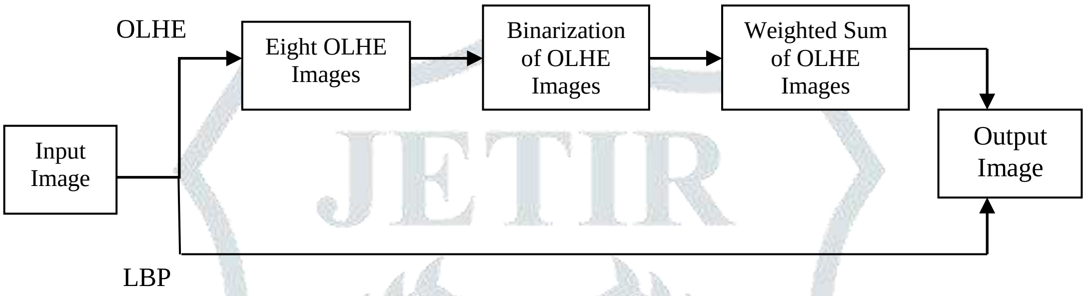


Figure 1 : OLHE and LBP Relationship

IV. FACE RECOGNITION USING OLHE

In this section we apply eight OLHE images in three different ways.

4.1 Cascaded OLHE

The first way is to find concatenation all the resulting eight images of OLHE. The input image of size m×n will produce an image of size 8×m×n. Then we define that new image as,

$$O_j^{cs}(I) \equiv [O_j^{11}(I),\ O_j^{12}(I),\ O_j^{13}(I),\ O_j^{21}(I),\ O_j^{23}(I),\ O_j^{31}(I),\ O_j^{32}(I),\ O_j^{33}(I)] \qquad (4)$$

Where that superscript 'cs' stands for 'cascaded'. O_j^{cs} gives promising face recognition rates that we will see in experimental results.

4.2 Averaged OLHE

Another method of OLHE is Averaged OLHE in which all the resulting eight images of OLHE is summed up with equal weights.
Then we define that new image as,

$$O_j^{avg}(I) \equiv \frac{1}{8} \sum_{i \in \alpha}^{z} O_j^{i}(I) \qquad (5)$$

Where that superscript 'avg' stands for 'averaged', α = {11, 12, 13, 21, 23, 31, 32, 33} while ∑ is the summation of image matrix. $O_j^{avg}(I)$ is more compressed than that of $O_j^{cs}(I)$.

4.3 Masked OLHE

To achieve masked OLHE we will modify the equation of histogram equalization [1] in (1) as,

$$g_m(x) = \begin{cases} 0, & \text{if } \Omega > T_\Omega \\ \text{round}\left[\dfrac{cdf(x) - cdf_{mi}}{j^2 - cdf_{mi}}.254\right] + 1, & \text{otherwise} \end{cases} \qquad (6)$$

Where j is the size of patch, $\Omega \square \equiv \frac{\#\text{pixels with the same intensity}}{j^2}$, and T_Ω is a threshould which was experimentally determined as 0.7. For this scheme we use notation O_j^{msk} ,

$$O_j^{msk}(I) \equiv w.\sum_{i\in\Omega}^{n} O_j^{\prime i}(I) \qquad (7)$$

Where that superscript 'msk' stands for 'masked',$O_j^{\prime i}$, is the new OLHE image with new intensity values by using $g_m(x)$, and the matrix w has same dimension as that of input image.

Once the image is processed by O_j^{cs}, O_j^{avg} or O_j^{msk} we can apply many classification algorithms to perform face recognition. In this paper Nearest Neighbor classification algorithm is used to calculate distance between two OLHE images. We will achieve better recognition results using simple Nearest Neighbor classification algorithm for proposed OLHE.

The Proposed face recognition system algorithm steps are,
Input: Image I.

1) For given image I, after applying eight OLHE operators we got eight OLHE images which are denoted as $O_j^{11}(I)$, $O_j^{12}(I)$, $O_j^{13}(I)$, $O_j^{21}(I)$, $O_j^{23}(I)$, $O_j^{31}(I)$, $O_j^{32}(I)$, $O_j^{33}(I)$. They are called as OLHE images.
2) These OLHE images used in different ways to achieve face recognition system.
   A) Cascaded OLHE
   Concatenate OLHE images to obtain $O_j^{cs}(I)$ using,

$$O_j^{cs}(I) \equiv [O_j^{11}(I), O_j^{12}(I), O_j^{13}(I), O_j^{21}(I), O_j^{23}(I), O_j^{31}(I), O_j^{32}(I), O_j^{33}(I)]$$

   B) Averaged OLHE
   Sum up OLHE images with equal weights to obtain $O_j^{avg}(I)$ using,

$$O_j^{avg}(I) \equiv \frac{1}{8}\sum_{i\in\alpha}^{z} O_j^{i}(I)$$

   C) Masked OLHE
   Multiply w to $\sum O_j^i(I)$ to obtain $O_j^{msk}(I)$ using,

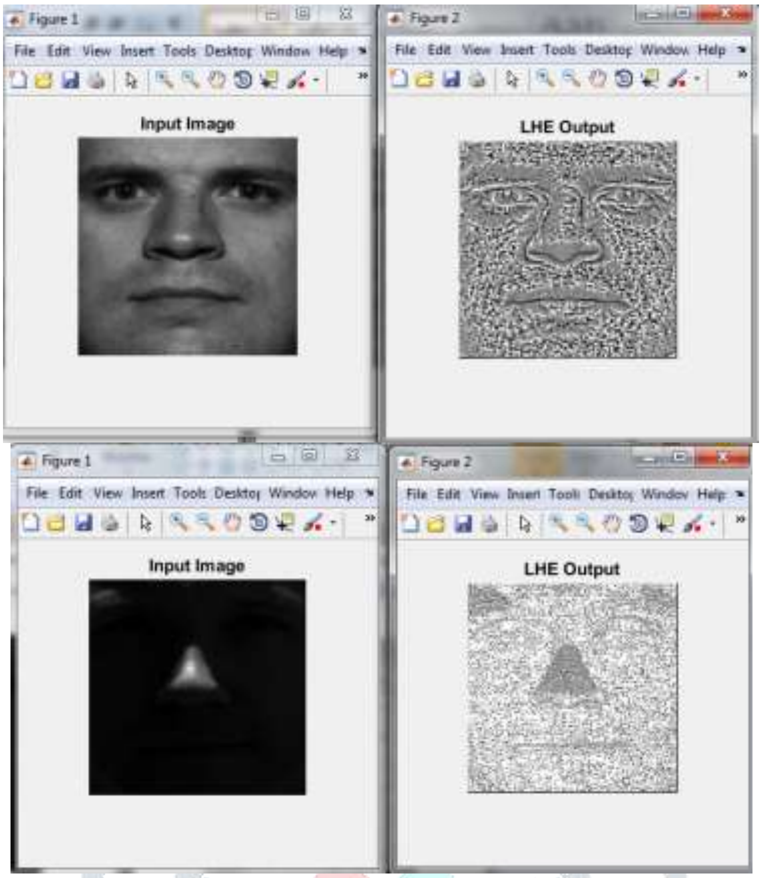
$$O_j^{msk}(I) \equiv w.\sum_{i\in\Omega}^{n} O_j^{\prime i}(I)$$

3) Consider n number of face images represented as I_1, I_2, -----, I_n.
4) After applying O_j^{cs} $\left(\text{or } O_j^{avg} \text{ or } O_j^{msk}\right)$ the OLHE results $O_j^{cs}(I_1), O_j^{cs}(I_2), ------, O_j^{cs}(I_n)$ are stored in database.
5) For given unknown face image I , we apply O_j^{cs} to obtain OLHE image $O_j^{cs}(I)$.

Output: Identified Image using Nearest Neighbor classifier with L2 distance.

V. RESULTS AND DISCUSSION

Sample image from standard Extended Yale B, Yale B, AR [15] database is used to evaluate the performance of face recognition. Figure 2(a) shows sample images from Yale B database which are captured under different lighting conditions, and fig 2(b) shows respective LHE output images.



(a) (b)

Figure 2: (a) input image and (b) LHE output image

Figure 3 shows eight OLHE images after applying eight OLHE operators. These OLHE images are further used for face identification.

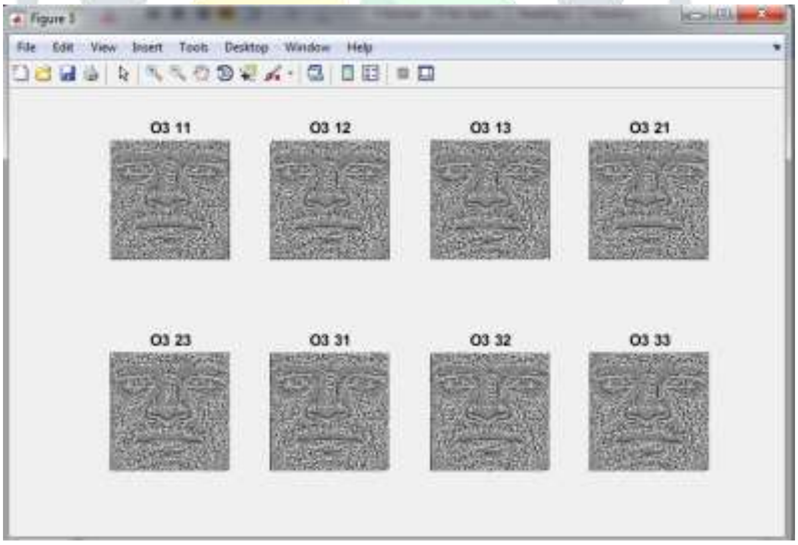


Figure 3: OLHE images

The OLHE images are also used to discuss the OLHE and LBP relationship. Some results of OLHE and LBP relationship on Extended Yale B database are as shown in Fig 4. We conclude that LBP image and output image of summation with eight binary images are exactly same.

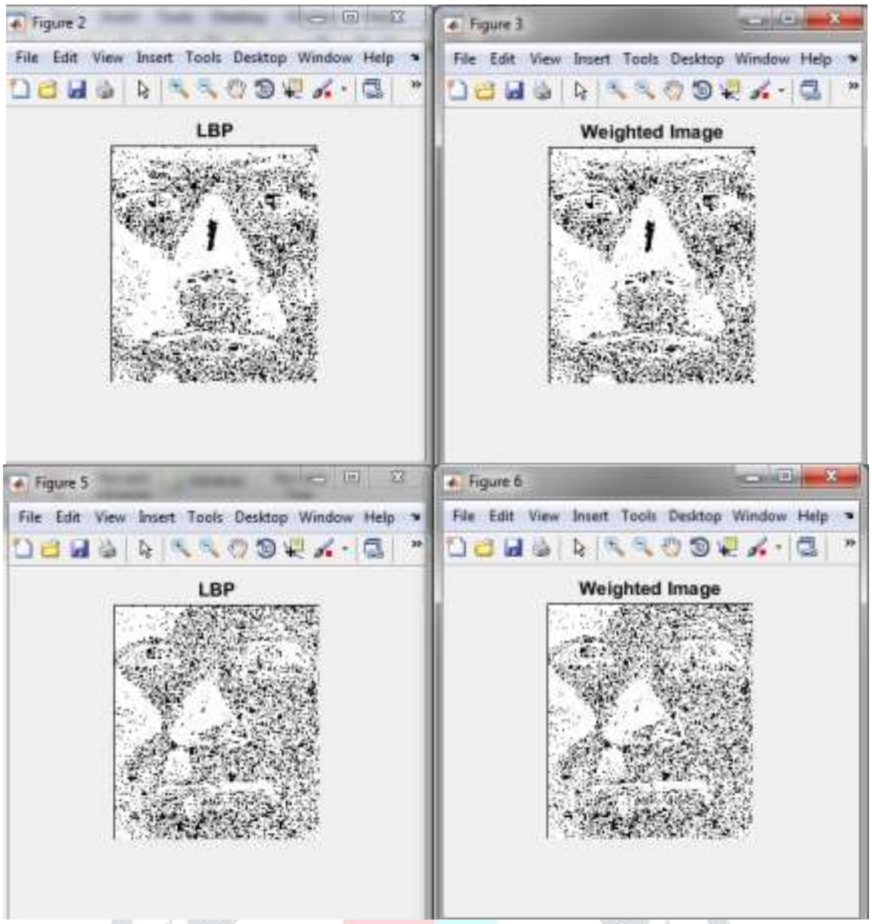


Figure 4: OLHE and LBP relationship

Table 1 shows recognition rate results on AR [8] face using LHE and different methods of OLHE. Recognition rate of the face recognition system is calculated using

$$\text{Recognition Rate} = \frac{\text{Number of correct mathches}}{\text{Total number of test samples}} \times 100 \qquad (8)$$

Table 1: Recognition rate using LHE and different methods of OLHE

Method		LHE	Proposed Method 1 Cascaded OLHE	Proposed Method 2 Averaged OLHE	Proposed Method 3 Masked OLHE
Recognition Rate (%)	Window Size				
	3	60	96.67	80.33	86.67
	5	76.67	95	86.67	93.33
	7	86.67	95	90	96.67
	9	93.33	93.33	93.33	93.33

We can see that by using larger window size for LHE can achieve better recognition results in face identification while the cascaded OLHE can achieve better results for smaller window. Cascaded OLHE method gives good results as compared to other methods of OLHE. Figure 5 shows graphical representation of the recognition rates of LHE and different methods of OLHE

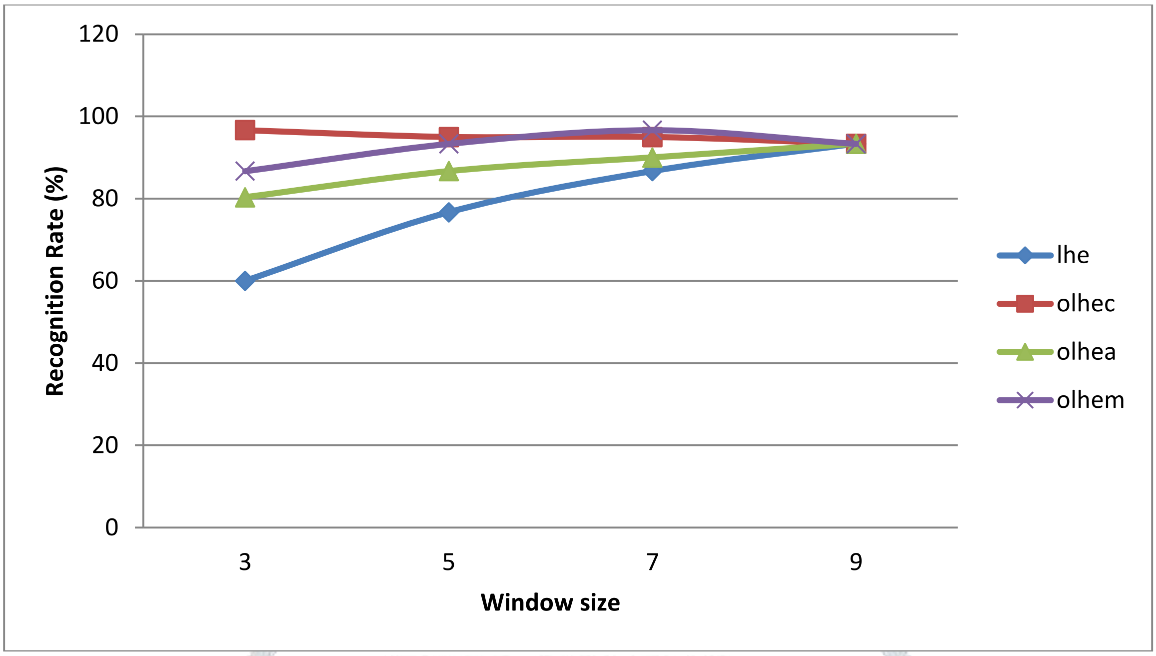


Figure 5: Recognition rate of face image using LHE and different methods of OLHE on AR face database with different window size

VI. CONCLUSION

In this paper orientated local histogram equalization (OLHE) is implemented that captures edges along with their orientations. The oriented local histogram equalization is the method which compensates illumination of human faces under different lighting conditions.

We get significant face identification rate because OLHE compensates illumination and gives richer information on orientation of edges. The features of OLHE give good edge preserving capability and give better results under various lighting conditions.

The feature combination of OLHE images could be done more effectively besides the methods implemented in this paper. The different ways of feature extraction schemes could be developed by applying different sizes of window with different lighting conditions to produce better results of face identification.

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