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IMAGE PREPROCESSING FOR IMPROVED FACIAL RECOGNITION

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ABSTRACT

In this paper a set of preprocessing techniques are proposed which aim to rectify the brightness and contrast of the facial images. Facial illumination index is used to assess the images obtained after preprocessing techniques. Algorithms used in this paper involves either illumination correction or contrast correction. Eigen faces algorithm is used on yale facial database after applying preprocessing techniques like gray-level grouping(GLG) and homomorphic filtering to test the validity.

Keywords: contrast adjustment, GLG, brightness index, Facial recognition, facial pre-processing

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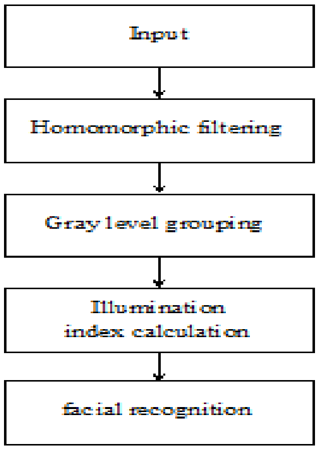
1. INTRODUCTION

The task of facial recognition aims to find similarity between facial attributes thus labeling the face to a particular person. In order to achieve an acceptable accuracy images used for training the facial classifier needs to be preprocessed. Image enhancement is a crucial step in preprocessing which ensures better feature segregation by highlighting the facial details which are unique to each individual. This paper enhances the image by adjusting the contrast and brightness. Some of the successful techniques for contrast adjustment include adap- tive histogram equalization[10],power law transformation[11] and brightness preserving and contrast limited bi-histogram equalization[13]. Various image processing algorithms like Discrete wavelet transform[5], adaptive local ternary patterns method[8],difference of gaussians[6] and gabor based face recognition using LDA[9] have proved to be successful to some extent. The above mentioned algorithms are image specific and require selection of specific parameters in order to obtain satisfactory results. Often low light images are sensitive to the transformations and thus application of algorithms for rectifi- cation may introduce furthermore noise in those images, hence there is a necessity of application of generalized and automated algorithms. This paper achieves illumination correction by application of homomorphic filtering which is effective for low light images, and contrast correction by gray-level grouping, thus obtaining uniform illumination index. The parameters for both the algorithms are kept same for all the images in the database.

2. METHODOLOGY

In this paper image enhancement algorithms are applied on the yale face database which consist of 165 images, it includes 11 images of each person under different illumination conditions. Image is enhanced by brightness and contrast correction, which is achieved by homomorphic filtering and gray-level grouping(GLG) respectively. Homomorphic filtering removes the low frequency components of the facial images and produces images with uniform illumination index. These images are given as input to gray level grouping algorithm. GLG is used to adjust the contrast, which ensures better feature segregation by the face recognition algorithm. Validity of the methodology is tested by calculating illumination index of the processed images and by checking if the illumination index is uniform for the whole database. Eigen faces algorithm is used to perform facial recognition on database.



A) Homomorphic filtering

Intensity of any pixel in an image can be defined as the product of amount of source illumination incident on the spatial co-ordinates of pixel and the reflectance of light from that co-ordinate,

$$f(x,y) = f_i(x,y).f_j(x,y) \qquad (1)$$

f(x,y) represents the image, $f_i(x,y)$ is the incident light weight and $f_j(x,y)$ is the reflected light weight. On both sides of the equation(2) take logarithm , to express the images as the sum of additive components

$$z(x,y) = lnf(x,y) = lnf_i(x,y) + lnf_j(x,y) \qquad (2)$$

Then by taking fourier transform-

$$Z(u,v) = F(u,v) = F_i(u,v) + F_j(u,v) \qquad (3)$$

Here, Z(u,v), F(u,v),F(u,v) is the Fourier Transform of z(x,y).

Where $ln\ f_i(x,y)$, $ln\ f_j(x,y).Z(u,v)$ is passed through a high pass filter

$$A(u,v) = Z(u,v).H(u,v) \qquad (4)$$

H(u,v) is the applied high pass filter and *A(u,v)* is resultant im- age in frequency domain. Afterwards, inverse fourier transform of the result is taken and finally exponent is taken to eliminate the logarithm.The resultant image in the spatial domain is *I(x,y)*

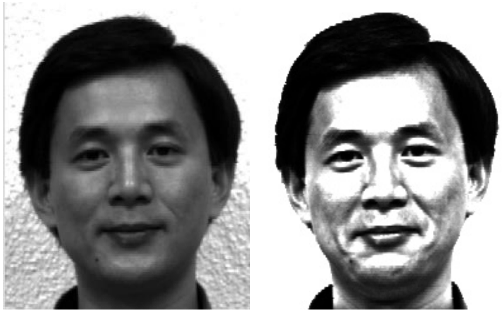


Figure 1 Result of applying Homomorphic filtering on input image(left).

B) Gray-level grouping

After obtaining uniform illumination index of the images, contrast of the images is corrected in order to obtain better feature segregation. GLG is applied on illumination corrected images,as it is efficient and fully automated algorithm which works for all kinds of images. It takes advantage of the uniformity in illumination to output almost similar histograms. In GLG histogram components having similar amplitude are grouped into bins,these bins are then redistributed over the grayscale image so that each group occupies gray level seg- ment of the same size. following the given algorithm of GLG[2]

$$G_n(i) = H_n(k) \; for \; H_n(k) \neq 0 \tag{5}$$

$H_n(k)$ denote the histogram of $I(x,y)$, which is the resultant of the homomorphic filtering, with k representing the gray levels on the gray scale. The first n nonzero histogram components are assigned to $G_n(k)$.

$Ln(i)$ and $Rn(i)$ which is the left and right limits respectively of the gray-level interval represented by $Gn(i)$ needs to be noted. Let a be the first occurring smallest $Gn(i)$ and i_a is the group index corresponding to the smallest $Gn(i)$. Group $Gn(i_a)$

is merged with the smaller of its two adjacent neighbors, and the gray-level bins $G_n(i)$ are adjusted to create a new set of bins $G_{n-1}(i)$ as follows

$$G_{n-1}(k) = \begin{cases} G_n(i) \; for \; i = 1,2,..,i'-1 \\ a + b \; for \; i = i' \\ G_n(i+1) \; for \; i = i'+1, i'+2,..,n-1 \end{cases} \tag{6}$$

$$b = \min\left(G_n(i_a - 1), G_n(i_a + 1)\right) \tag{7}$$

$$i' = \begin{cases} i_a - 1 \; for \; G_n(i_a - 1) \leq G_n(i_a + 1) \\ i_a \; elsewhere \end{cases} \tag{8}$$

The left and right limits, $L_n(i)$ and $R_n(i)$ are adjusted accord-ingly.

The ungrouping of bins is achieved by applying the transfer function $T_{n-1}(k)$ to the histogram of the original image

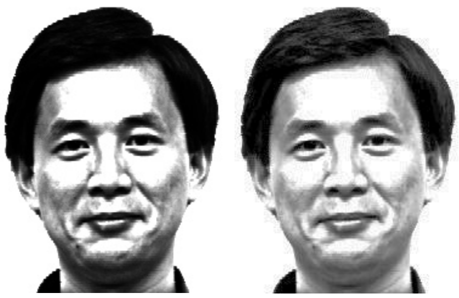


Figure 2 Result of applying GLG on input image(left)

Figure 3 Result of applying GLG on a poorly contrasted image(left)

C) Illumination index calculation

After image correction the illumination index is uniform for all the images in the database. The illumination index can be computed as proposed[3]. The technique computes dark regions in an image by assigning each pixel a numerical value based on its neighbouring pixel intensity to estimate the quality. Let p define the index for neighboring pixels, which ranges from 0 to 7 for 8 neighbors. I_c and I_p define the intensity values at p^{th} neighboring pixels and central pixel respectively. The dark regions in an image are detected by T_{low}, which is the threshold value, then *code* at central pixel location *(xc,yc)* (provided I_c<T_{low}) is defined as:

$$code(x_c, y_c) = \sum_{p=0}^{7} E(I_p - I_c)/8 \tag{9}$$

The *code* is 1 if I_c>T_{low} Function *E(.)* used in equation (9) is defined as follows:

$$E(x) = \begin{cases} 1, if\ abs(x) > t \\ 0, otherwise \end{cases} \tag{10}$$

If the difference between I_c and I_p is greater than the threshold t , E(.) is 1 ,otherwise E(.) is 0 thus pixel gets a value in between 0 to 1,overall illumination based quality is obtained by adding all the code

$$Q_1(x) = \sum_{i=1}^{M} \sum_{j=1}^{N} \frac{code(x_i, y_i)}{M*N} \tag{11}$$

M and *N* are the dimensions of the image

D) Face recognition

The preprocessed images are given as input to the eigen face algorithm[12],which applies principal component analy- sis(PCA) on the matrix consisting of all the input images. PCA yields the prominent facial features. Recognition is done by expressing images in terms of prominent features obtained.

3. EXPERIMENTAL RESULTS AND OBSERVATIONS

The illumination index of the raw images and the processed images is calculated and compared. It has been found that all the 165 images have illumination index between 0.9 to 0.95. For images of the same person the difference in the index is not more than 0.02. By trial and error T_{low}, which defines the the threshold value of *code* is found to be 0.54 and *t*, which defines the threshold value of *E(x)* is found to be 0.009. TABLE I compares the illumination index value of images of a single person before preprocessing and after preprocessing.

Eigen faces algorithm is used to test the validity of the proposed method. When the model is trained on 75 images and tested on 90 images, the accuracy obtained is 97.77 percent. TABLE II shows the results of eigen face algorithm on the preprocessed image.

4. CONCLUSION

Facial recognition is best performed when effective algo- rithms are used. In order to ensure the algorithms behave similarly on all images, illumination index of the images must be uniform. The combination of homomorphic filtering and gray-level grouping achieves higher accuracy when tested with eigen face algorithm.

Table 1 Illumination index

Before preprcoessing	After preprocessing
0.75	0.9293
0.85	0.925
0.852	0.919
0.654	0.917
0.86	0.93
0.86	0.92
0.58	0.924
0.856	0.93
0.841	0.926
0.861	0.93
0.840	0.926

Table 2 Accuracy

Training Image per person	Testing images per person	Accuracy
1	10	84
2	9	93.3
3	8	95
4	7	97.14
5	6	97.77
6	5	97.33

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