Illumination Normalization Methods for Face Recognition

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Abstract

This paper describes three methods (logAbout, homomorfic filter and wavelet) for illumination normalization and compares their contributions for posterior face recognition using Principal Component Analysis (PCA).

1. Introduction

Illumination is considered one of the most difficult tasks for face recognition. Variations caused by pose, expression, occlusion or illumination is highly nonlinear, and making the detection task extremely complex.

Well known contrast enhancement algorithms, such as histogram equalization, are global methods which do not consider important image details applied for face recognition [1]. Logarithm transformations enhance low gray levels and compress the high ones. They are useful for non-uniform illumination distribution and shadowed images, however they are not effective for high bright images [2]. Homomorphic filters enable dynamic range compression and contrast enhancement simultaneously, but they are limited by image sizes of $2^n x 2^n$ [2].

Shan *et al.* [3] investigated several illumination normalization methods and propose some novel solutions, such as Gamma Intensity Correction (GIC), Region-based strategy combining GIC with Histogram Equalization (HE) and Quotient Illumination Relighting (QIR) method. Chen *et al.* [4] employed a discrete cosine transform (DCT) to compensate for illumination variations in the logarithm domain. This method not requires any modeling steps and can be easily implemented in a real-time face recognition system.

In this paper we present a comparison between three methods from the literature, such as logAbout [2], homomorphic filter [5], and wavelet-based [1] to discover which method is better to face recognition task.

2. Compensation illumination methods

This section presents a brief description of the methods commonly used for illumination compensation.

2.1 LogAbout

The logAbout method proposed by Liu *et al.* [2] can be implemented by applying a high pass filter followed by a logarithm transformation described by:

$$g(x,y) = a + \frac{\ln(f(x,y)+1)}{b \ln c} \qquad (1)$$

where *f(x,y)* is the original image, *a*, *b* and *c* are parameters which control the location and shape of the logarithm distribution.

2.2 Homomorphic Filter

In this method the original image is split vertically in two halves, generating two sub-images from the original one (figure 1). Afterwards the filter is applied in each sub-image and the resultant sub-images are combined to form the whole image. In this method was used a first order ($n = 1$) Butterworth high pass filter with a cutoff frequency $D_0 = 0.25$. Then, the original image is divided horizontally, and the same procedure is applied [5]. The two resultant images are grouped together in order to obtain the output image, given by:

$$I_{HMMOD}(x,y) = \frac{1}{2}.[I_{HMV}(x,y) + 0.75.I_{HMH}(x,y)] \qquad (2)$$

where $I_{HMV}(x,y)$ is the vertically divided image, after the application of homomorphic filter, and $I_{HMH}(x,y)$ is the horizontally divided image.

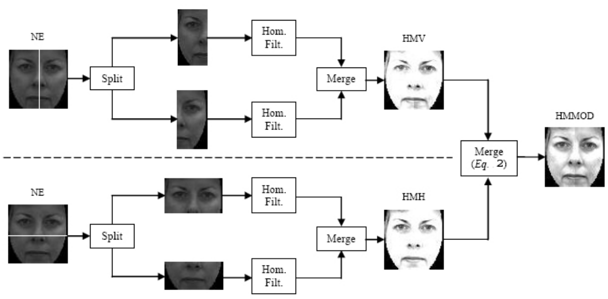

Figure 1: Homomorphic filter variation [5]

2.3 Wavelets

In this method the image is decomposed in high (sub-bands LH, HL and HH of figure 2) and low frequencies (LL2). Then histogram equalization is applied on the approximation coefficients (low frequency), and at the same time the details are enhanced (high frequency) by multiplying each element of the detail coefficient matrix by a scale factor (>1) [1].

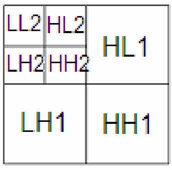

Figure 2: Multi resolution structure

The image is reconstructed from its approximation coefficients and details coefficients in all the three directions by using the inverse wavelet transform, resulting the normalized image.

3. Face Recognition using PCA

PCA is a method for pattern recognition in a given database and expresses the similarities and differences with respect to a target image [6]. The PCA method consists in calculating the mean value of the training data set, the covariance matrix, the eigenvectors and the eigenvalues. The mean value of each image class is calculated and projected into PCA space to be the neural network input data set. The PCA space has reduced dimensionality without much loss of information.

After training, a Learning Vector Quantization (LVQ) neural network is able to identify if a face image belongs or not to the database.

4. Results

We used a subset of Yale Face Database B [7] containing grayscale images of 10 people, each one under 20 different illumination conditions.

The recognition rate resulting from PCA and LVQ neural network without applying illumination normalization is 77%. Table 1 shows results obtained by applying each normalization methods before using PCA.

Table 1: Recognition rate from each method

Method	Recognition Rate
Without illumination normalization	77%
Homomorfic filter	79%
LogAbout	91%
Wavelet	93%

5. Conclusions

In this work three illumination normalization methods was compared. The results show that with the illumination correction there is an improvement in the recognition rate, the wavelet method generates the best result, improving the recognition rate by 16%. This is due the fact that face image resultant from wavelet processes has not only enhanced contrast but also enhanced edges and detail that will facilitate the further face recognition task [1].

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