Preprocessing Techniques for Face and Facial Expression Recognition

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Abstract

In the last years, face and facial expression recognition have become a popular area of research in computer vision. It is typically used in network security systems and access control systems but it is also useful in other multimedia information processing areas. Performance of the face verification system depends on many conditions. One of the most problematic is varying illumination condition. In this paper, we present new preprocessing approach to eliminate illumination effect from the human face images. The different stages include Median filtering, 2D Gabor filter is used for Edge enhancement and Histogram Equalization for Image contrast illumination. Hence an enhanced image is produced by using Hybrid filters this helps in an efficient way of preprocessing image for any further digital image processing work.

Keywords: Face and Facial expression, Median Filter, Gabor Filter, Histogram Equalization.

1. Introduction

A biometric recognition system is an automated system that verifies or identifies a person's identity using a person's physiological characteristics and/or behavioral characteristics [1]. Face recognition is one of the biometric pattern recognition techniques, has been growing rapidly in the past few years for its multiple uses in the area of Law Enforcement applications and the second is the availability of feasible technologies after several years of research [2].

Person identification is done by the system but whenever there is varying illumination in the face images it will affect the performance of the computerized recognition system. Human face images are taken under the uncontrolled environment due to that illumination is also varying in the face images. Many approached have been proposed by various researchers in last few years still illumination is one of the major challenging task in the human face recognition.

M Sharif et al. [6] proposed an illumination normalization technique which works at the preprocessing stage of face recognition and divides the input image in small segments. After that, each segment is normalized individually to deal with illumination issue. The normalization is done with a transfer function known as probability density function (PDF) similar to histogram equalization. After individual processing of segments, the method joins these segments back to form a single image. Then the computed single image is processed further for noise removal using a low pass Gaussian and for contrast enhancement using Un-sharp filter. The method is tested on Yale dataset and is compared with some previous illumination methods using PCA.

The difference between the previous method and proposed technique is described as follows. In this paper image enhancement is done with three steps. The first step is to remove noise with Median filter, the second step is to make edge enhancement with Gabor filter. The third step is image enhancement which is done by Histogram Equalization.

The rest of this paper is organized as follow: in Section 2 presents Median filter, 2D Gabor filter, Histogram Equalization techniques. In Section 3, presents the new preprocessing technique with its results. In Section 4, gives evaluation with existing techniques. In Section 5, finally the conclusion is given.

2. Preprocessing Techniques

2.1. Median Filter

Noise is an unwanted signal in the image. The noise in the image is of three types Salt and Pepper noise, Impulse noise, Gaussian noise. A Median Filter operates over the window by selecting the median intensity in the window. The advantages of using Median filter is of its robust average, that is its unrepresentative pixel in the neighborhood does not affective the

median value and also it has the quality of preserving sharp edges.

A color image is represented as set of three 2D arrays which is R, G and B that is the intensity of Red, Green and Blue signals that combine to form color image [3]. An image contain Salt Pepper noise will have dark pixel in bright region and bright pixel in dark region. Here Median filter is used to remove these RGB Salt and Pepper noise by replacing each pixel by the median value of itself and its neighbors.

The output image quality is measured with metrics Peak Signal to Noise Ratio (PSNR). The PSNR is defined as the ratio between the maximum possible power of a signal and the power of distorting noise that affects the image quality. The value of PSNR indicates the high quality of the image. The PSNR is defined via Mean Squared Error (MSE) which is the given noise free image with noisy approximation. The Peak Signal to Noise Ratio is calculated for the noise free output image.

$$\mathrm{MSE} = (1/(\mathrm{m} * \mathrm{n})) * \mathrm{sum}(\mathrm{sum}((\mathrm{f} - \mathrm{g})\ \hat{}\ 2)) \quad (1)$$

$$\mathrm{PSNR} = 20 * \log(\max(\max(\mathrm{f})))/((\mathrm{MSE})\hat{}0.5) \quad (2)$$

According to the Equation (1) and (2), f is the matrix data of original image, g represents the matrix data of noisy image where m is the numbers of rows of pixels of the images and n represents the number of columns of pixels of the image and finally max (f) is the maximum signal value that exists in original image.

MSE is calculated for the original input image and the noisy image. Then the PSNR value is calculated for the output image, the value is high and this result shows that the filtered image has improved its quality with the original input image. Thus the Median Filter plays efficiency in noise removal. The noise may of different types and for any type of noise this Median filter produces an improved efficiency.

2.2. Gabor Filter

Filters are used to remove noise, sharpen contrast, detect edges and highlight contours. Filter are divided into linear and non-linear. Filters are used in wide applications for Pattern Analysis, Facial Recognition, Iris Recognition, Optical Character Recognition, and Fingerprint Recognition because of its major factors like Computational Properties and Biological Relevance [4].

Gabor Filter is a linear filter used for Edge Enhancement. It works as a Band pass filter for the local spatial frequency distribution, achieving and optimal resolution in both Spatial and Frequency domain. Gabor filter Frequency and Orientation is similar to that of human visual system. Its impulse response is Sinusoidal wave multiplied by Gaussian function. This filter has multiplication convolutions property and various transforms, image property, operators, frequencies and features in detecting edges. The filter traces the region value and is sensitive to collinear and elongated segments. The advantage is possibility of creating filters which are selective for orientation.

Gabor filters with 2D are used to extract feature at every pixel of input image. Short Gabor filters are used for Space invariant intensity images and curved line traces. The long Gabor filter for gray level characteristics and straight line traces. The filter can be viewed as sinusoidal plane of part frequency and orientation, modulated by a Gaussian envelope. The parameter of Gabor filter is its frequency, standard deviation and orientation. The filter is designed by number of dilations and rotations and when it is convolved with signal is called as Gabor space. Its multiplication convolution property the Fourier transform of Gabor filter response is the convolution of the Fourier transform of Harmonic function and Fourier transform of Gaussian function.

The parameters of the Gabor filter are fine-tuned with different orientation and wavelength.

The Gabor filter function is represented as

$$g(x, y, \lambda, \theta, \psi, \sigma, \gamma) = \exp\left(-\frac{x'^2+\gamma^2 y'^2}{2\sigma^2}\right)\cos\left(2\pi\frac{x'}{\lambda}+\psi\right) \quad (3)$$

where λ is the wavelength of the sinusoidal factor, θ is the orientation of normal to stripes of Gabor function, ψ is the phase offset, σ is the Standard Deviation of Gaussian envelope, γ is the spatial Ratio and specify the elliptically the support of the Gabor function. The parameters of the filter are changed for different wavelength and orientation the enhancement of edges is reached at a particular orientation with its different parameter values.

2.3. Histogram Equalization

Histogram is a graphical representation exhibiting a visualization of distribution of data.

Image Histogram acts as a graphical representation of lightness or color distribution in digital images. Histogram represents the relative frequency of occurrence of various gray levels in the image. The types of Histogram are Dark, Bright, Low contrast and equalized image [5].

The advantage of Histogram is its spatial domain processing techniques, its multiplication is used for image enhancement, it provides an efficient image statistics, and it is also very effective in the areas like image compression and image segmentation. In the Histogram the horizontal plot represents the corresponding gray level values and the vertical plot provides the normalized values.

3. Proposed Technique

To handle the illumination normalization problem for face and facial expression recognition, this paper proposes Hybrid filters with Histogram equalization to enhance quality of image. Over all stages of the proposed preprocessing technique is shown in Figure 1.

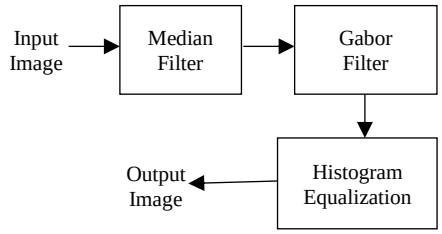

Figure 1. Proposed Preprocessing Technique

3.1. Normalization

The step involved in processing the image is the original color image is taken as input image. The noise contained in the image will have dark pixel in bright region and bright pixel in dark region. Here Median filter is used to remove the noise by replacing each pixel by the median value of itself and its neighbors. Before noise removing, change to gray image and resize image with Bi-Linear Interpolation. In this Interpolation the output pixel value is a weighted average of pixels in the nearest 2 by 2 neighborhood pixels. The resized image has the (128x128) pixel size. Figure 2 shows the steps involved in removing noise from an input color image.

Figure 2. Steps involved in Normalization.

3.2. Edge Enhancement

The noise free image is again sent as an input image to the Gabor filter. The parameters of the Gabor filter are fine-tuned with different orientation and wavelength. Figure 3 shows the output image of the hybrid filters.

Figure 3. Hybrid Filtered Image.

3.3. Contrast Enhancement

The preprocessing for contrast enhancement of the image is done with Histogram equalization. The hybrid filtered image is applied with Histogram equalization for contrast enhancement. Figure 4 shows how the output image is well contrasted.

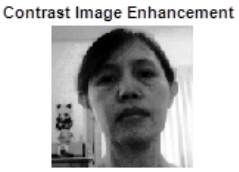

Figure 4. Contrast Image Enhancement.

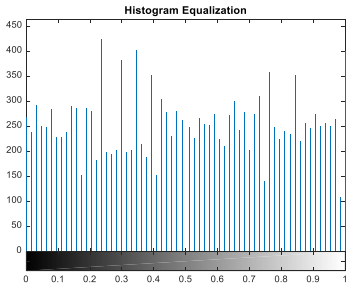

Figure 5. Histogram for Equalized Image.

The Histogram Equalization is represented for the output Contrasted image figure 4. Figure 5 shows the efficiency of image contrast enhancement as a graphical representation.

4. Evaluation with Existing Technique

For the purpose of experimentation, the images were taken from the Yale database. The experiments were performed on the following facts. A total of fifty images were taken, five of each person or class. Processing on the selected images was performed using the proposed as well as previous illumination normalization techniques based on preprocessing.

The processed images were then tested for face recognition using Principal Component Analysis (PCA) as a face recognition technique and recognition rate was noted. The comparison of proposed approach with existing technique and the recognition rate is shown in Table 1.

Table 1. Comparison of proposed technique with previous method using PCA for face recognition

Technique	Successfully Recognized	Incorrectly Recognized	Recognition Rate
M Sharif et al.[6]	34	16	68%
Proposed Technique	41	9	82%

The experiment shows that the proposed technique is performed better than other technique and provided good recognition accuracy.

5. Conclusion

In this paper the enhancement is done with three steps. The first step is to remove noise in color image; the second step is to make edge enhancement with Gabor filter for the noise free Median filter image. The third step is image enhancement which is done by Histogram Equalization. The proposed method of using Hybrid filters with Histogram Equalization produce an improved quality and enhanced quality of image.

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