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Implementation of Band Pass Filter for Homomorphic Filtering Technique

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Abstract

In order to improve the performance of homomorphic filtering technique for face images, band pass filter is selected to replace the conventional high pass filter in homomorphic filtering technique. Apart from the noise reduction capability, the band pass filter is specifically designed for face images as it is based on the locations of illumination component in Fourier spectrum. The qualitative and quantitative analysis proven that the performance of band pass filter outweighs the conventional high pass filter.

Keywords: Homomorphic filtering technique; Band pass filter; Face images

1. Introduction

Homomorphic filtering technique is one of the image enhancement methods implemented in frequency domain. It is a kind of approach based on the illumination-reflectance image model which is very useful in performing image enhancement by simultaneous brightness range compression and contrast enhancement (Thamizharasi, 2010). There are a few researchers proposing different ways in implementing homomorphic filtering technique to enhance digital images. Adelmann (1998) used several different versions of high pass filter for homomorphic filtering technique. On the other hand, Jellus and Kiefer (2005) and Delac et al. (2006) modified the input image itself to improve the result of homomorphic filtering technique. Recent researches, such as the works by Fan and Zhang (2011) and Zhang et al. (2012) introduced the combination homomorphic filtering technique with other image enhancement methods to improve the quality of enhanced images.

Among the methods proposed, the conventional high pass filters used in homo-morphic filtering technique are not specifically designed to pre-process face images. Hence, a customized filter is needed in order to improve the performance of homomorphic filtering technique for face images.

The rest of this paper is outlined as follow. The second section lays out the specification of the customized filter. Then, the performance of the customized filter will be presented in the third section. Finally, the last section concludes the paper.

2. Methodology

Before designing the filter, a study has been carried out to determine the effect of removing the shadow on face images. The study shows that noise will appear when the shadow is removed from the face image. Since the noise will affect some sensitive face recognition software, the focus for the customized filter is to eliminate the noise components after removing the shadow from poorly illuminated face images. Thus, the proposed filter for homomorphic filtering technique is a band pass filter. This is because noise is high spatial variation and is usually located at high frequency region in Fourier domain. By implementing band pass filter, the high frequency components will be suppressed and eventually noise can be eliminated from the face image.

The band pass filter is designed using high pass and low pass Butterworth filter. In Matlab, it makes use of the simple principle that a band pass filter can be obtained by multiplying a low pass filter with a high pass filter where the low pass filter has a higher cut off frequency than the high pass filter. Eq. (1) and Eq. (2) shows the equation for Butterworth low pass filter and high pass filter respectively. The low pass filter, $H_{LP}(u,v)$ and high pass filter, $H_{HP}(u,v)$ can be multiplied and turn into modified Butterworth band pass filter, $H_{BP}(u,v)$ using the high and low frequency gain (γ_H and γ_L) as shown in Eq. (3).

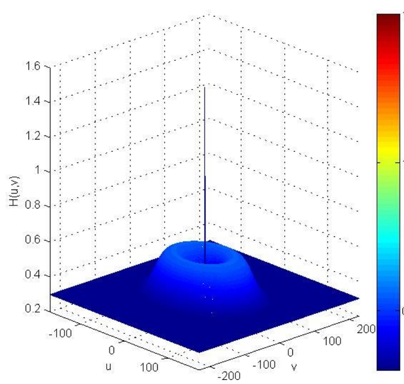
$$H_{LP}(u,v) = \frac{1}{1+\left(\frac{u^2+v^2}{d_0}\right)^n} \tag{1}$$

$$H_{HP}(u,v) = 1 - H_{LP}(u,v) = 1 - \frac{1}{1+\left(\frac{u^2+v^2}{d_0}\right)^n} \tag{2}$$

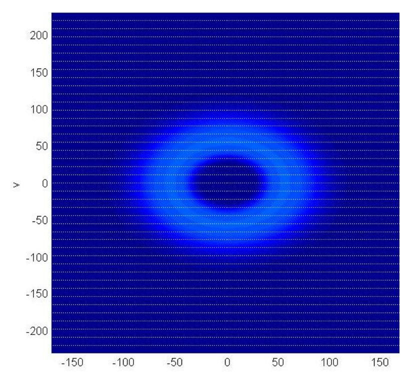
$$H_{BP}(u,v) = (\gamma_H - \gamma_L)[H_{LP}(u,v) \times H_{HP}(u,v)] + \gamma_L \tag{3}$$

where γ_H and γ_L are the high frequency gain and low frequency gain respectively, n is the order of filter, and d_0 determines the cut-off frequency.

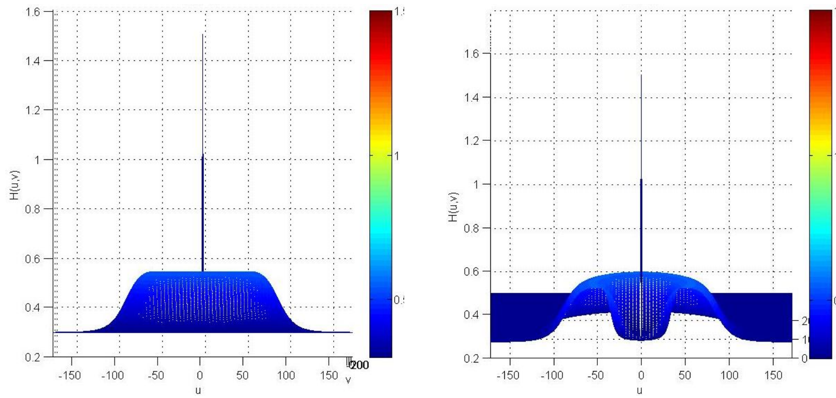
3. Experimental Results



(a)



(b)

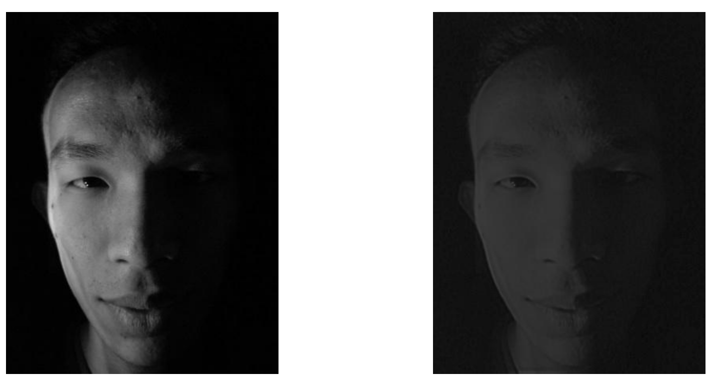


(c) (d)

Figure 1: (a) The perspective plot of a filter design 3, (b) Top view, (c) Side view with *u* axis, (d) Cross-sectional view at *v* axis

As mentioned in Section 2, the main purpose of using band-pass filter is to eliminate the noise produced after the removal of shadow on the face images. The perspective plot of band-pass filter is illustrated in Fig. 1. The optimum parameters band-pass filter are obtained through the simulation using face images captured with a customized casing.

The order for band-pass filter is 10 whereas the lower and upper cut-off frequencies for band-pass filter are 35 pixels and 85 pixels respectively. The value 35 is chosen as the lower cut-off frequency because the maximum location of illumination components from various subjects is situated at 35 pixels from the DC component. On the other hand, the value 85 is chosen as the upper cut-off frequency as it is the minimum location to eliminate the noise components without losing the facial details. Besides, the high and low frequency gain are set as 0.55 and 0.3 respectively.



(a) (b)

Figure 2: (a) A face image with poor illumination, (a) Resultant face image using band-pass filter

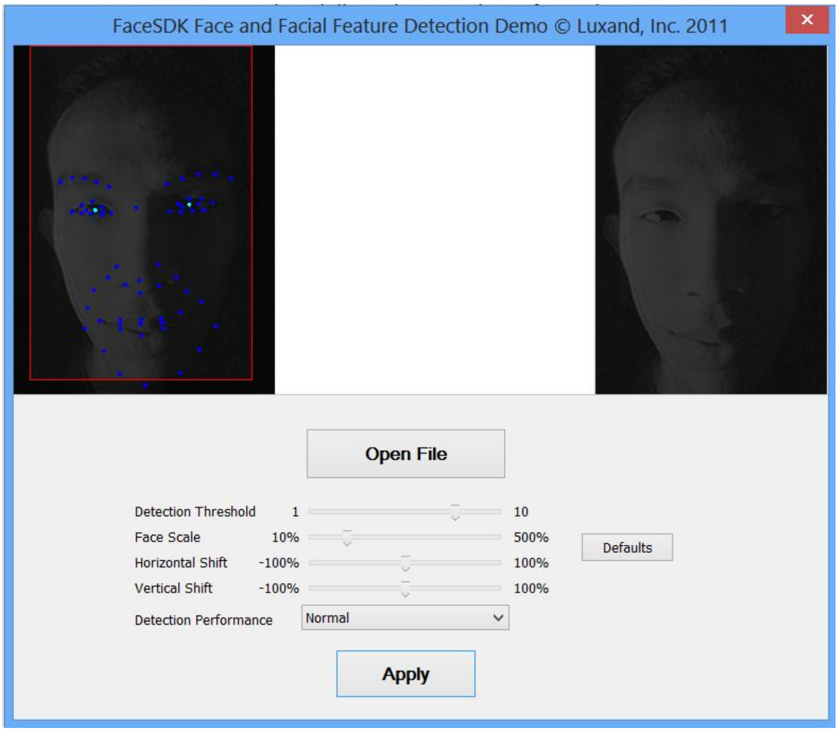


Figure 3: Detected face features from enhanced face image using face feature detection software, Luxand FaceSDK (Luxand FaceSDK, 2013)

The frequency gains are used to control the contributions of illumination and reflectance components. DC component of the output face image is increased by 1.5 times in order to increase the brightness of the image. These parameters are defined in such a way to produce best result of face image enhancement. Fig.2 shows the effect of band-pass filter on a poorly illuminated face images. Since the illumination components are suppressed by the band pass filter, the brightness of the enhanced face image is appeared to be lower than the input face image.

The performance of the band pass filter is evaluated based on the recognition rate of face recognition software, Luxand FaceSDK (Luxand FaceSDK 4.0, 2013). It is a cross-platform face detection that provides the coordinates of 66 facial feature points (including eyes, eye-brows, mouth, nose and face contours) for feature detection. It also provides a threshold function to adjust the sensitivity of the face detection. Hence, the evaluation is performed by inspecting the feature detection results of this software as well as the highest achievable threshold value by the face images. The detection result is considered successful if the software manages to detect all the important face features. Fig. 3 shows the face recognition software and a detected face image.

Qualitative analysis is performed on 80 poorly illuminated face images taken from 20 subjects and the collected results are presented in the box-and-whisker plot as shown in Fig. 4. It shows that the quality of poorly illuminated face images are enhanced after applying the band pass filter. In fact, the performance of band pass filter outweighs the conventional high pass filter due to its noise reduction characteristic. Although some of the input face images are hardly detectable by the software, the respective enhanced face images can be detected at lower threshold values after applying band pass filter.

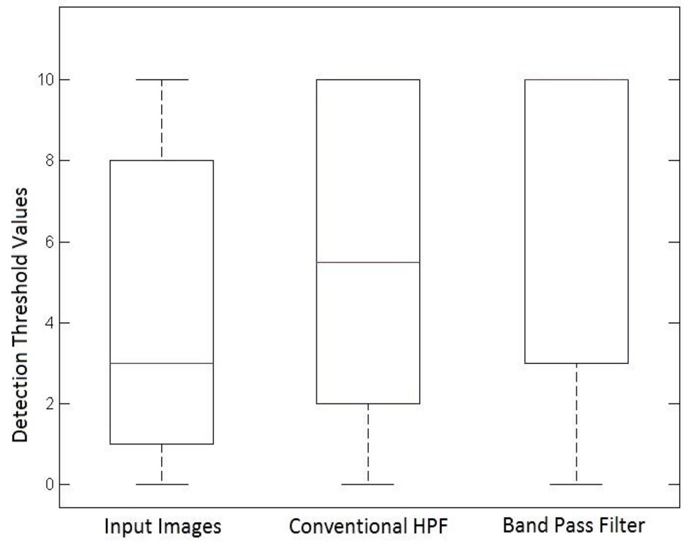


Figure 4: The box-and-whisker plot for the detection threshold value of input face images and the enhanced face images using conventional high pass filter and band pass filter

On top of that, entropy function is used in quantitative analysis to determine the information contained in the input and output face images taken from 20 subjects. To make a reliable comparison, the entropy values obtained from 80 face images are presented using box-and-whisker plot as shown in Fig. 5.
The result shows that the entropy values for enhanced face images are lower as compared to the input face images. This is due to the loss of information after sup-pressing the illumination components. Besides, the entropy values are also affected by the brightness of face images. Therefore, the enhanced face images have lower entropy values after suppressing the illumination components. By comparing the entropy values of face images enhanced by conventional high pass filter and band pass filter, it is clearly seen that the enhanced face images from band pass filter have higher entropy values. This is because the presence of noise components significantly reduces the entropy values. Thus, based on quantitative analysis, band pass filter is more suitable to be implemented in homomorphic filtering technique.

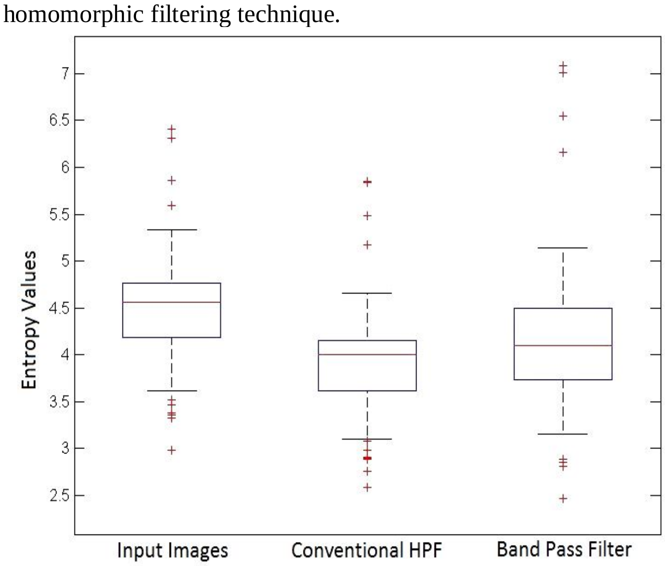


Figure 5: The box-and-whisker plot for entropy values of input face images and the enhanced face images using conventional high pass filter and band pass filter

4. Conclusion

Band pass filter is designed based on the illumination locations of the poorly illuminated face images. It is able to suppress the noise components generated after the removal of shadow from the poorly illuminated face images. The performance of band pass filter is evaluated using qualitative analysis. The result obtained shows that band pass filter gives better enhancement result as compared to the conventional high pass filter due to it noise reduction characteristics.

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