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Background and Noise Extraction from Colored Retinal Images

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Abstract

Retinal images are used for automated diagnosis of Diabetic Retinopathy. Preprocessing of retinal image is required prior to detection of features and abnormalities. The objective of preprocessing segmentation is to separate the background and noisy area from the overall image to enhance the quality of acquired retinal image. We present a method for colored retinal image preprocessing and enhancement. Our technique creates a binary mask to preprocess the retinal image using morphological operations. The preprocessing technique is tested on standard retinal images databases Diaretdb0 and Diaretdb1. The validity of our technique is checked against the experimental results.

1. Introduction

Complication of diabetes, causing abnormalities in the retina and in the worst case blindness, is called diabetic Retinopathy [1]. In the early stages of diabetes, there are no such symptoms but the number and severity predominantly increase with the passage of time. The diabetic retinopathy typically begins as small changes in the retinal capillary [1]. So, retinal images can be used in developing tools to assist in the diagnosis of diabetic retinopathy [2].

A tool which can be used to assist in the diagnosis of diabetic retinopathy should automatically detect all retinal image features such as optic disk, fovea and blood vessel [3], [4], [5] and all abnormalities in retinal image such as microaneurysms [2], [6], [7], hard exudates and soft exudates [8], [9], hemorrhages, and edema[2].

The acquired color retinal images are normally of different qualities and need illumination equalization to enhance the image quality. Figure 1 shows retinal image of three different qualities acquired from standard diabetic retinopathy databases, diaretdb0 and diaretdb1 [10].

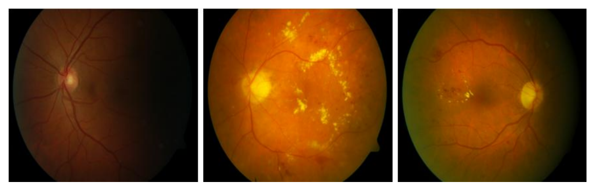

Figure 1. Retinal Images of Different Qualities.

Preprocessing of retinal image is the first step in the automatic diagnosis of diabetic retinopathy and it should be done before detecting retinal image features and abnormalities . The purpose of preprocessing is to remove the noisy area and undesired regions from retinal image. This is required for the reliable extraction of features and abnormalities as feature extraction and abnormality detection algorithms give poor results in the presence of noisy background. Figure 2 shows the input colored retinal image and the preprocessed segmented retinal image.

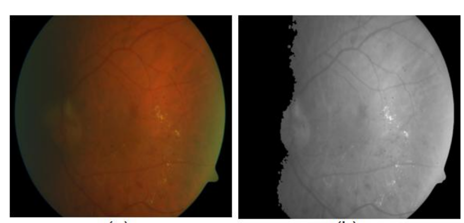

Figure 2. (a) Original Retinal Image (b) Preprocessed Retinal Image.

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Standard contrast stretching techniques have been applied by [2], [11] for preprocessing and noise reduction. In [12], [13] and [14] the local contrast enhancement method is used for equalizing uneven illumination in the intensity channel of retinal images. A large mean filter, large median filter and both are used for retinal image background estimation by [9] and [15]. Wang et al. in [16] have used intensity channel values to detect the dark regions from retinal image. In this paper, we present the retinal image preprocessing technique that detects the dark background using local mean and variance and removes noise using hue and intensity channel values.

This paper is organized in four sections. Section 2 presents the step by step techniques required for colored retinal image preprocessing segmentation. Experimental results are discussed in section 3 followed by conclusion in section 4.

2. Retinal Image Preprocessing

Preprocessing is done to extract retinal image from background. In automatic diagnosis of diabetic retinopathy, the processing of the surrounding background and noisy areas in retinal image is not necessary and consumes more processing time at all stages. Cutting or cropping out the region that contains the retinal image feature minimizes the number of operations on the retinal image.

Figure 3 shows the flow diagram of our preprocessing technique. It creates binary masks for background and noisy areas. A mask is actually a combination of 1's and 0's, 1 is for true retinal image pixels and 0 is for background or noisy pixels. Background mask separates the original retinal image area from dark background and noise mask removes the noisy area from retinal image. Both masks are then combined and morphological operations are done on that combined mask to create the final mask.

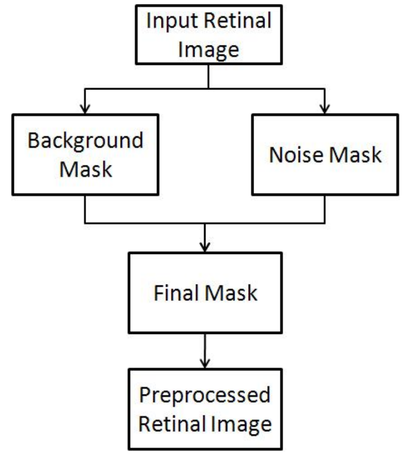

Figure 3. Flow Diagram for Retinal Image Preprocessing Segmentation.

2.1. Background Extraction Mask

We have used local mean and variance based method for background preprocessing. It creates a binary background mask.

Steps for background preprocessing mask are summarized as follows:

1. Divide the input retinal image $I(i, j)$ into non-overlapping blocks with size $w \times w$. In our case $w = 8$.

2. Compute the local mean value $M(I)$ for each block using equation 1 [17] .

$$M(I) = \frac{1}{w^2} \sum_{i=-w/2}^{w/2} \sum_{j=-w/2}^{w/2} I(i, j) \quad (1)$$

3. Use the local mean value computed in step 2 to compute the local standard deviation value $std(I)$ from equation 2 [17].

$$std(I) = \sqrt{\frac{1}{w^2} \sum_{i=-w/2}^{w/2} \sum_{j=-w/2}^{w/2} (I(i, j) - M(I))^2} \quad (2)$$

4. Select a threshold value empirically by working on different retinal images. If the $std(I)$ is greater than threshold value, the block is considered as original retinal image area otherwise it belongs to background.

Figure 4 shows the background masks for retinal images using our local mean and variance method.

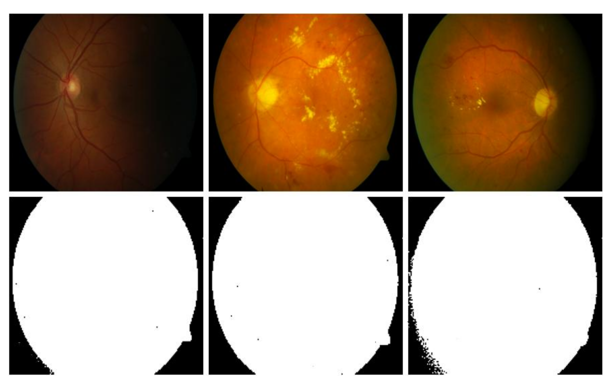

Figure 4. 1st row: Color Retinal Images from database, 2nd row: Background masks for each image.

2.2. Noise Removal Mask

Noise in colored retinal image is normally due to noise pixels and pixels whose color is distorted. In our technique, we create a binary noise removal mask which includes the noisy area and it is applied on retinal image to ensure not to process the noisy area in upcoming steps i.e feature extraction and abnormality detection. In this preprocessing technique, we convert RGB(Red, Green, Blue) retinal image into HSI(Hue, Saturation, Intensity) color space because firstly it is closer to the way a human experiences colors and secondly noise can be easily removed in HSI color space [17].

Steps for noise preprocessing are summarized as follows:

1. Divide the input retinal image $I(i,j)$ into non-overlapping blocks with size $w \times w$. In our case $w = 8$.

2. Use histogram equalization to enhance the contrast between background and foreground.

3. Use a 3x3 median filter to reduce the noise in background of the image [17].

4. Convert the equalized and filtered RGB retinal image into HSI color space using equations 3, 5 and 6 [17].

$$H = \begin{cases} \theta & if B \leq G \\ 360 - \theta & if B > G \end{cases} \tag{3}$$

where

$$\theta = cos^{-1}\left\{\frac{\frac{1}{2}[(R-G)+(R-B)]}{[(R-G)^2+(R-B)(G-B)]^{\frac{1}{2}}}\right\} \tag{4}$$

here R, G and B represent RED, GREEN and BLUE components of RGB retinal image

$$S = 1 - \frac{3}{(R+G+B)}[min(R,G,B)] \tag{5}$$

$$I_n = \frac{1}{3}(R+G+B) \tag{6}$$

5. Calculate N (noise factor) due to inadequate illumination using equation 7.

$$N(I) = \frac{H}{I_n} \tag{7}$$

6. Select a threshold value empirically working on different retinal images. If the $N(I)$ is less than threshold value, the block is considered as normal retinal image area otherwise it belongs to noisy area.

Figure 5 shows the noise masks for retinal images using our noise preprocessing method.

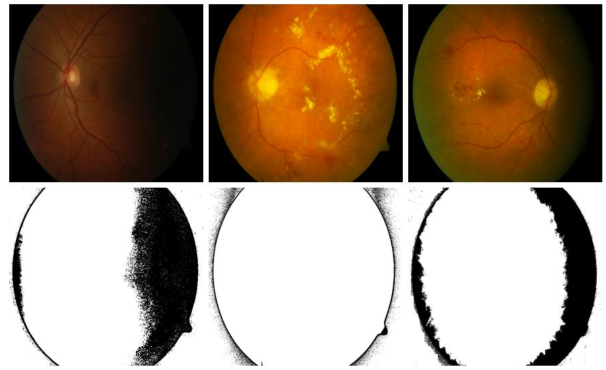

Figure 5. 1st row: Color Retinal Images from database, 2nd row: Noise masks for each image.

2.3. Final Mask for Preprocessing

Final mask is prepaid by combining background mask and noise mask. Before applying final mask to retinal image, morphological operations i.e. morphological erosion and morphological dilation are applied to final mask.

Mask that is formed by the combination of background mask and noise mask contains single pixel noise and edge pixels. We have used square structuring element for erosion that removes all white single pixel noise from final mask but it increases the black single pixel noise. In order to remove the black pixel noise, same square structuring element is used for dilation. Final noise free mask is then applied on retinal image for its preprocessing segmentation. Figure 6 shows the noise free final masks for retinal images.

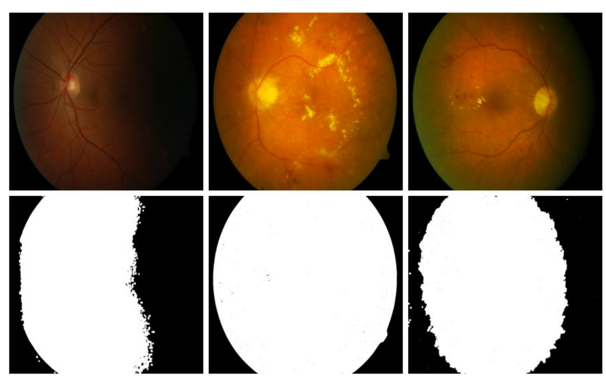

Figure 6. 1st row: Color Retinal Images from database, 2nd row: Final masks for each image.

3. Experimental Results

We have extensively tested our algorithms using standard diabetic retinopathy retinal image databases diaretdb0 and diaretdb1 [10]. Diaretdb0 contains 130 retinal images while diaretdb1 contains 89 retinal images. These databases contain overall 219 retinal images of different qualities in terms of noise and illumination. The decision for accurately processed and poorly processed images is based on human eye observation. Number and percentage of accurate preprocessed retinal images and poorly preprocessed retinal images are summarized in table 1. Retinal images of different illumination and noise values are shown in figure 7.

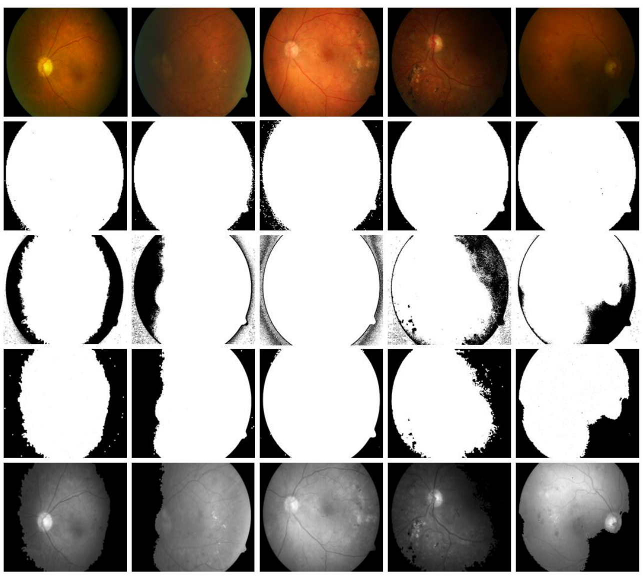

Figure 7. 1st row: Color retinal images from database, 2nd row: Background mask, 3rd row: Noise mask, 4th row: Final mask, 5th row: Final Preprocessed retinal images.

Figure 7 shows the background masks, noise masks, final masks and final preprocessed retinal image for each color retinal image. These results support the validity of our technique and show that our technique gives good results for both low and high noisy areas.

4. Conclusion

In this paper, colored retinal images are preprocessed by extracting background and noise effect from the image. The problem with retinal images is that the quality of acquired images is usually not good. So, it is necessary to improve the quality of retinal image. In this paper, preprocessing mask is prepaid by combining the background mask and noise mask. Morphological operations are applied on final mask to remove single pixel noise and edge pixels. The results are confirmed by visual inspection of preprocessed images taken from the standard diabetic retinopathy databases.

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Table 1. Results

Masks	Accurately Processed (Numbers)	Accurately Processed (%)	Poorly Processed (Numbers)	Poorly Processed (%)
Background Preprocessing	217	99.08	2	0.92
Noise Preprocessing	202	92.23	17	7.77
Final Preprocessing	201	91.78	18	8.22

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