An Efficient Pre-Processing Method to Extract Blood Vessel, Optic Disc and Exudates from Retinal Images

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Abstract- Automatic detection of retinal feature is always been a challenging factor in the diagnosis and treatment of diabetic retinopathy. Most of the retinal images are of low contrast due to poor illumination during the acquisition process. Hence the feature extraction from unevenly illuminated retinal background is really a challenging task. Image preprocessing is preliminary step, which is most required to ensure high quality for further proceedings. This paper discusses the overview of existing preprocessing methods and presents performance of the proposed method. The principal component analysis (PCA) method is used to enhance the retinal image. The proposed method reduces noise and preserves edges from the retinal images and enhances low contrast images. An efficient preprocessing technique is tested on retinal images from various privately available databases using MATLAB software and the amount of accuracy rate is increased from the result obtained by the proposed method.

Keywords: Acquisition, Diabetic retinopathy, Illumination, Preprocessing

1. INTRODUCTION

Automatic and accurate feature extraction system could provide several useful features for diagnosis of various retinal diseases. Blood Vessel and Optic Disc extraction from retinal images plays a major role in diagnosing difficulties of various diseases [1]. The retinal images have noisy, large variability and low contrast during the image acquisition process [2], which causes inconsistency of automatic feature removal. To avoid this discrepancy, it is necessary to do preprocessing of retinal images. Different techniques have been used by some authors so far. While implementing, since we came across some difficulties which were found in feature extraction of retinal images, the proposed method enables us to compare the obtained result with the results of other existing methods. The proposed method is more efficient, consistent and accurate than the older methods by means of sensitivity and accuracy.

2. IMAGE ACQUISITION

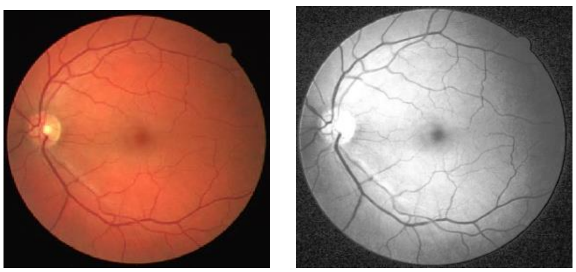
Image acquisition is the action of retrieving an image from some hardware source for processing. The image that is acquired is completely unprocessed. Digital fundus camera is used to capture the retinal images [3] which captures the lighting replicated from the retinal surface. To improve the quality of the retinal image, preprocessing plays an important role which enhances the extraction of features and defects from the retinal images. The retinal surface and the symmetrical position of the light source and camera lead to a poorly illuminated exterior part of the retina with respect to the essential portion. Image processing like image transform, segmentation, feature extraction and disease identifications are implemented intensely in improved method through preprocessing of images.

3. PRE-PROCESSING METHODS

Image preprocessing plays a major role to read accurate data of a digital image. The aim of pre-processing is a development of the image data that conquers unwanted distortions or enhances some image features significant for further processing. There are four classes of image pre-processing techniques according to the size of the pixel neighborhood that is used for the calculation of a new pixel brightness: Pixel brightness transformation, geometric transformation, pre-processing methods that use a local neighborhood of the processed pixel and image restoration that requires knowledge about the entire image.

a) Illumination Correction and Contrast Enhancement

The RGB retinal images are converted into hue, saturation intensity (HSI) space, the homomorphic filter on the intensity component of HSI can be applied to correct the uneven illumination. To find out one of the most effective technique to produce a uniform illumination image, the statistical evaluation was carried out for the red and green components by comparing illumination correction techniques statistically. Figure 1 shows the output of preprocessed image.

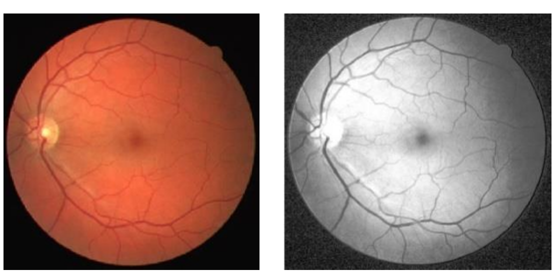


(a) (b)

Figure 1. (a) Original Image (b) Pre-processed Image uses illumination correction

b) Histogram Equalization

This method processes the images in order to adjust the dissimilarity of an image by changing the intensity distribution of the histogram [4]. Using this method the global contrast of images are increased. Very simple method and enhance the contrast of an image. Images with foreground and background that are both bright or both dark formally this method suites well. The gray values that are actually far away from each other in the image makes this method fail. The histogram equalization applied to original image which is shown in figure 2.



(a) (b)

Figure 2. (a) Original Image (b) Pre-processed Image uses Histogram Equalization

c) Morphological Operation

Morphological operation, examine the image with a small pattern is called structuring element. The structuring elements can be any size and make any shapes. The elements positioned in all possible locations in the image and compared with neighborhoods of each pixel. The two basic operations of morphological operations are erosion and dilation [5]. The size of the object can be reduced using erosion operator and increases the size of holes in an image and eliminates minor portion of that image. This operation makes the image darker than the original image. The dilation operation is wise versa of erosion operation likely it expands the size of an object from the original image. The size of the structuring element is most significant to remove noisy parts without damage the objects of interest. The retinal image is pre-processed using morphological operation and the result are shown in figure 3.

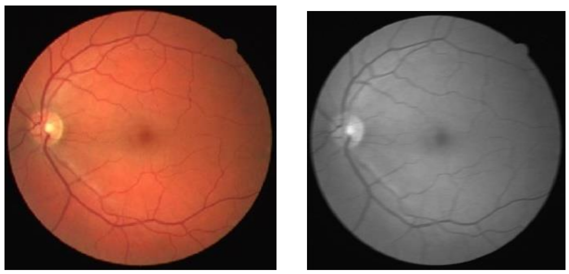
(a) (b)

Figure 3. (a) Original Image (b) Pre-processed Image uses Morphological Operation

d) Gabor Filter

Gabor filter is a primitive method to reduce noise, blur and keeps the necessary structure for further process. It is used for edge detection and it is a linear filter [6]. In Gabor filter, frequency and orientation depictions are same to those of the human optic structure and they are suitable for texture representation and perception.

This method is identically specific to a period and scaling. It is related to quantification of stationary signals. After the segmentation, region can be identified very well, but boundary conditions not defined. The output is shown in figure 4 and the signals are inversely related in time and frequency domain.

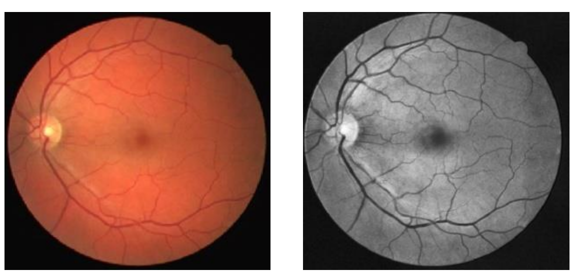


(a) (b)

Figure 4. (a) Original Image (b) Pre-processed Image using Gabor Filter

e) Adaptive Filter

This method reduces impulsive noise of the retinal image without any deprivation to the input image [7]. Without any blurring of edges it smoothens the non-repulsive noise. Maintain edge information in case of high density impulse noises. If impulse noise is much then it does not perform well.



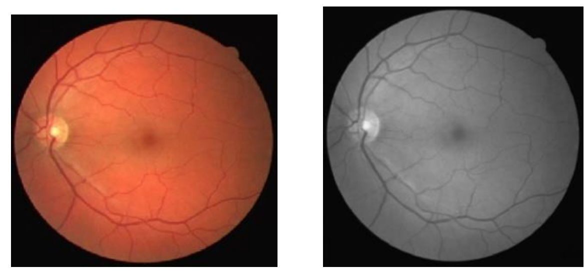
(a) **(b)**

Figure 5. (a) Original Image (b) Pre-processed Image using Adaptive Filter

f) Linear Filter

Image enhancement and transformation can be done using filtering techniques. Filtering an image is highlighted certain features or remove other features. Linear filtering is filtering in which the value of an output pixel is a linear combination of the values of the pixels in the input pixel's neighborhood.

Filtering is a neighborhood function, in which the value of any given pixel in the output image is determined by relating some algorithm to the values of the pixels in the neighborhood of the related input pixel. A pixel's neighborhood is some set of pixels, described by their locations relative to that pixel.



(a) (b)

Figure 6. (a) Original Image (b) Pre-processed Image using Linear Filter

4. BIOLOGICAL IMPLICATION AND FEATURE SELECTION

Blood Vessel

When small, slight blood vessels break lower the nerve covering the white of the eye, causing eye redness may mean that a subconjunctival haemorrhage [8]. Blood vessel area of the normal image is 37230.56, and then contraction occurs in diabetic retinopathy, the value of it decreases. The diabetes damages the blood vessels in the retina. If left untreated, diabetic retinopathy can cause blindness [9] [10].

Optic Disc

The optic nerve head in a typical human eye transmits around 1 million neurons from the eye in the direction of the brain [11]. Therefore the optic disc head is considered as a good feature for detecting diabetic retinopathy.

Exudates

An exudate is any fluid that filters from the vascular system into lesions or areas of irritation or swelling. The fluid is composed of serum, fibrin, and white blood cells. Exudates may discharge from cuts or areas of infection [11]. Though, there is a major amount of difference in the number of exudates for a normal or diabetic retinopathy affected image.

5. PROPOSED ALGORITHM

At the stage of retinal image acquisition there is a problem of illumination and may lead to an image with noise especially. To correct this problem the pre-processing is essential to retinal image for further proceeding. The proposed method achieves an increasing rate of sensitivity and specificity. The input images are resized into 256X256. The retinal image is converted from RGB to gray level. The grayscale image is of only 2 dimensions, and the values range between 0-255 that is 8-bit unsigned integers. Therefore, the proposed preprocessing algorithm can only apply to the 2-D image rather than 3-D, hence the image conversion process is essential. Median filter is applied to the grayscale retinal image. Each output pixel contains the median value in a 3-by-3 neighborhood around the corresponding pixel in the input image. A median filter is more effective than convolution when the goal is to simultaneously reduce noise and preserve edges [12].

Contrast limited adaptive histogram equalization was initially developed for medical imaging and it enhances low contrast images. The CLAHE algorithm divides the images into related regions and applies the histogram equalization to each one [13]. This operation makes hidden top features of the retinal image more visible. The entire gray band in employed to state the retinal image. CLAHE is a superior version of AHE or Adaptive Histogram Equalization. Both the methods have overcome the limitations of standard histogram equalization.

Principal component analysis (PCA) is one of the powerful and widely used linear technique in image processing. PCA is used to enhance the retinal image. This method is used to reduce RGB images to gray level in the preprocessing and the gray level images are commonly used in the several image processing and also computer vision fields [14].

This proposed pre-processing method shows the result in better quality of accuracy to segment the retinal features for automatic detection of diabetic retinopathy. This preprocessing technique can be implemented using MATLAB software and the result is obtained. The block diagram of the proposed technique is shown in the figure 7.

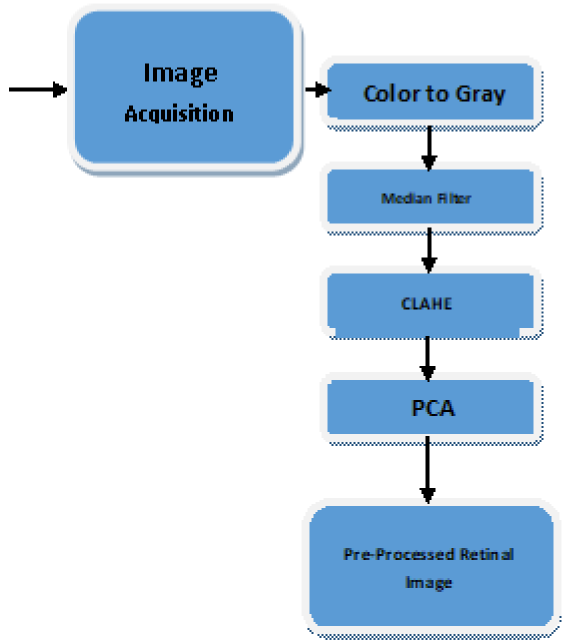


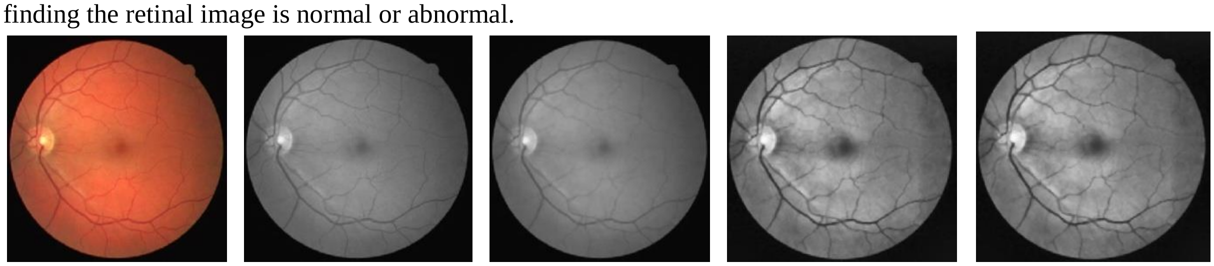
Figure 7. Block Diagram of the Proposed Pre-Processing Technique.

6. RESULT AND DISCUSSION

The experimental result of the novel pre-processing techniques is shown in the figure 2 and figure 3. The new algorithm for the preprocessing method is executed and tested in MATLAB software. The retinal images taken from Drive dataset. Both normal and abnormal retinal images are used to test the proposed method. The results are compared with existing pre-processing methods. The proposed method is more efficient and accurate than the older method by means of sensitivity and accuracy and it produces the result in an improved manner. Since the MATLAB is widely used programming language to perform the numerical computation and data visualization. Entire implementation of the proposed method is written using this MATLAB programming language. The sample output is shown in the figure 8 and 9.

7. CONCLUSION

Diabetic retinopathy is a disease which is increasing commonly in the recent days and has become one of the main causes of blindness among working-age people. By conducting appropriate analysis and treatment, the risk of severe vision loss can be significantly reduced. Automatic retinal image analysis tool for early diabetic retinopathy detection shall help to reduce the amount of work associated with manual grading as well as save diagnosis costs and time. Many research efforts in the last several years have been devoted to developing automatic tools to help in the detection and evaluation of diabetic retinopathy lesions. However, there is a large variability and unevenness in the databases and evaluation criteria used in the literature, which still makes the task difficult. This proposed preprocessing technique enhances the quality of retinal image and removes noise, which could be easy to segment the retinal features to identify the diabetic retinopathy. Principle component analysis technique is used to pre-process the retinal image that is acquired completely unprocessed. This method enhances the retinal image to do further image processing to extract the features of retinal image. This proposed algorithm may be useful for ophthalmologists to detect the disease in easy manner. The future work is based on the segmentation of retinal image features like blood vessels, optic disc and exudates. The segmented features are applied to the classifier for finding the retinal image is normal or abnormal.



(a) (b) (c) (d) (e)

Figure 8. Pre-processed Image (Normal). (a) Original Image (b) Grayscale Image (c) Median filtered Image (d) CLAHE applied Image (e) Enhanced image using PCA

(a) (b) (c) (d) (e)

Figure 9. Pre-Processed Image (Abnormal). (a) Original Image (b) Grayscale Image (c) Median filtered Image (d) CLAHE applied Image (e) Enhanced image using PCA

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