ISSN (Print) : 0974-6846
Indian Journal of Science and Technology, Vol 8(32), DOI: 10.17485/ijst/2015/v8i32/87492 , November 2015 ISSN (Online) : 0974-5645

Detection of Optical Disc and Exudates in Colour Fundus Images

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Abstract

One of the visual indications for the presence of diabetic retinopathy is the exudates in the retina area of Fundus images. Detection of exudates is useful information for the early diagnosis of the eye disease. In this paper, a new approach for the detection of exudates is presented. A position based approach is combined with morphological operations for extracting the optical disc and detect the exudates. The proposed method is applied to the standard retinal image dataset and the results are presented.

Keywords: Diabetic Retinopathy, Exudates, Fundus Images Median Filter, Morphological Operations

1. Introduction

Diabetic Retinopathy (DR) is a progressive sight-threatening damage of the retinal microvasculature that happens largely in diabetic patients. The threat comes through the growth of new blood vessels resulting in internal haemorrhage. Early signs of diabetic retinopathy are the red lesions such as microaneurysms, haemorrhages in the retina area, cotton wool spots and the exudates. The small balloon like red color swellings in the retinal vessels are called as microaneurysms and the red colored blood spots that leak into the retina are called as haemorrhages. The leakage of fat and protein into the retina form the fatty deposits called the exudates, which appear as bright yellow lesions. If not properly detected within the early stages, DR can finally cause to irreversible blindness in the patient. Therefore, their detection is important through a pre-screening system. The screening is normally done visually by observing the fundus images of the eye captured using a special fundus camera. An automation of the detection process can assist the ophthalmologists in the diagnosis.

Some of the previous works on this area include the detection of exudates and also the detection of blood vessels. A previous technique[1] used for the removal of the optical disc is the utilization of filter banks. A Bayesian classifier is combined with a Gaussian function to detect the exudates in the retina areas. Performance parameters such as sensitivity, specificity, and accuracy are measured and the results are presented. In an automated method for the detection of the exudates in retinal images[2], exudates candidates were detected using a combination of region growing technique and morphological gradient operation. A rule based classifier was used for classifying the exudates. The method is of limited capability so that it can identify only one type of DR symptoms and needs to be expanded to cover all symptoms.

An improved method of exudates detection[3,4] based on a set of optimally adjusted morphological operators which were used on non-dilated pupil contrast images. The results were compared with the ground–truth validated by ophthalmologists' hand-drawn ground-truths. In[5], the color retinal images were pre-processed using color normalization and contrast enhancement techniques, and

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the retina region was segmented The segmented images established a dataset of regions. In order to classify classify these segmented regions into blood vessels, exudates and microaneurysms, a set of features such as color, size, edge strength and texture were extracted. These features were used as part of an automated DR recognition system.

Color channels for localization and removal of the optical disc has been used previously[6,7] Coarse segmentation using edge detection and fine segmentation using morphological operations were used for exudates detection. An analysis based on false positive and false negative was performed using sensitivity and specificity. The optical disc was detected by considering the largest connected component as the optical disc. Entropy information was also used to detect the optical disc. Fuzzy C-Means clustering was used to detect exudates. A supervised method for blood vessel detection in retinal images is presented in[8]. Neural network was used for pixel classification using gray level and moment-invariant based features. The classification results were compared with the SVM results and good accuracy was observed. In[9], exudates were detected using a multi-scale morphological process. High percentage values for sensitivity and specificity were obtained with this method. A Ridge based segmentation of blood vessels was performed in[10]. The ridges coincide with the centre of the blood vessels. Line elements were identified using the ridges, which become the feature vectors. A KNN classifier was used to get the final classification results. A higher performance than the rule-based methods was observed. A different approach based on two dimensional matched filters[11,12,] was proposed based on the observation that the blood vessels have reduced local contrast.

Other methods for the detection of exudates include techniques based on color and wavelet decomposition[13], a method using mask generation and histogram matching[14], sliding window technique and neural network[15], split and merge algorithm[16], ensemble based method[17] and k-means clustering and morphology[18,19].

Some of these methods described above do not consider the intrinsic characteristics of retinal images. Poor edge detection is another drawback due to the curvy nature of the retina. It is also difficult to cluster the exudates accurately using some of the proposed methods. The presence of optical disc is another problem in the detection of the exudates.

The main contribution in this paper is the development of a position based approach for removing the optical disc from the retinal image. After removing the optical disc, exudates are detected using the morphological operations.

The rest of the paper is organized as follows: In Section 2, the proposed system is explained. The optical disc detection and extraction are explained in Section 3. Section 4 gives the results and Section 5 concludes the paper.

2. The Proposed System

The proposed system employs a filtering stage for pre-processing the image. A position based procedure is combined with the morphological techniques to remove the optical disc and detect the exudates. Figure 1 shows the block diagram of the proposed exudates detection system.

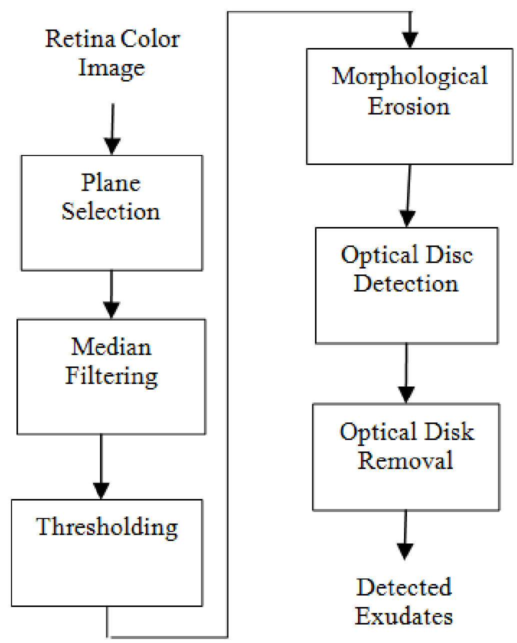
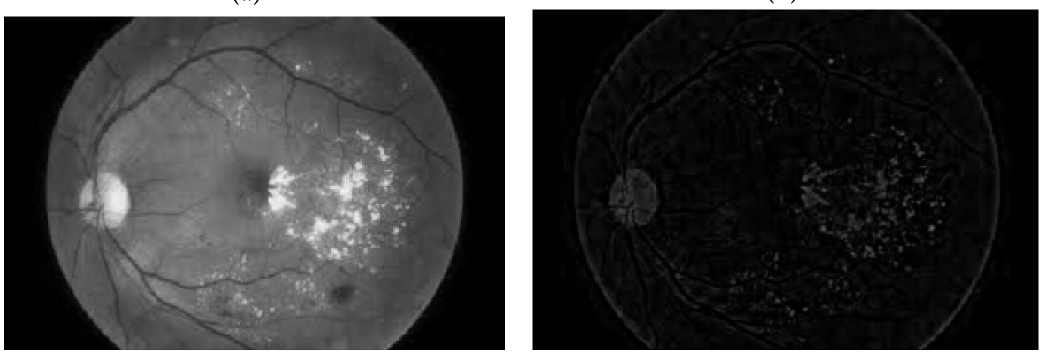


Figure 1. Block diagram of the proposed exudates detection system.

The RGB color retinal images are considered for the detection of exudates. All the three colour planes are not required for locating the retinopathy condition. In a retinal image, the red plane is heavily saturated and also the blue plane is with low contrast. Therefore, the green plane is considered in this work. The green plane has the right amount of contrast to extract the required

(a) (b)



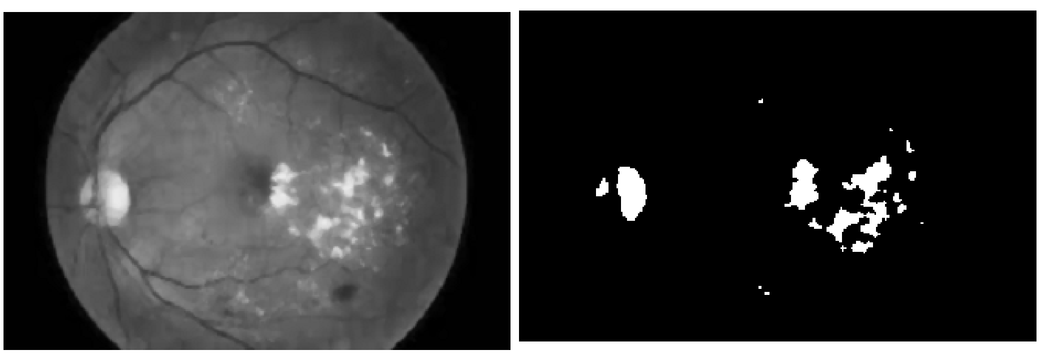
(c) (d)

Figure 2. (**a**) Original color image. (**b**) Red plane. (**c**) Green plane. (**d**) Blue plane.

information for exudates detection. Figure 2 shows the red, blue and green planes extracted from the fundus image.

The green plane of the input image is pre-processed using a median filter. The median filter is basically a nonlinear filter and is more effective than convolution based filters with less effect on the high frequency component[19]. It is normally used when there is arequirement to prserve the edges while removing the noise. A 3x3 neighbourhood of pixels around the current pixel is considred for the filtering operation. The filtered image is shown in Figure 3(a).

The filtered image contains the blood vessels, optical disk and the exhudates. Compared to the optical disk and the exhudates, the remaining region in the image contains low intensity pixels. Hence, by seleting a suitable threshold, the background can be removed. In order to fix the threshold, the histogtam of the image is used. The threshold is fixed based on the graylevel distribution of the pixels in the histogram, and the image is thresholded.



(a) (b)

Figure 3. (**a**) Filtered image. (**b**) Image after thresholding.

The image after the thresholding operation is shown in Figure 3(b).

3. The Optical Disc Detection and Extraction

The image obtained after the thresholding operation contains the exhudates, optical disk and the microaneurysms[22]. It can be observed from the retina image that the optical disc is always positioned at the left half or the right half of the image in the central area, depending on whether the left eye or the right eye is imaged. A sub-image containing the optical disc can be formed by extracting the central row and the adjacent rows.

First, the middle row from the image is extracted by finding the size of the image and the middle value. Another 10% of the rows from the top and bottom area of the middle row are appended to the middle row to form a sub-image[18]. The subimage alone is enough to detect the optical disc as well as the exhudates. In the sub-image, the number of objects are found by using 4-connectivity between the adjacent pixels. After identifying the objects, the perimeter of each image is found. Since the microaneurysms are very small dots, morphological operations are used to remove them from the sub-image. A square shaped structuring element is used for the erosion operation. Once the small images are removed, the sub image will contain the optical disc and the exudates. The perimeter information is used to identify the number of pixels in the multiple objects in the sub-image.

It can be observed that the optical disc is normally the object with the largest area. Hence, it is possible to remove the optical disc by examining the area of different objects. Instead of finding the actual area, the number of pixels in the perimeter of each object is found. The object with the largest number of pixels is the optical disc. In order to exclude the possibility of false detection of an exudate as the optical disc, shape information is also taken into account. The original sub-image and the sub-image obtained after removing the microaneurysms and the optical disc is shown in Figure 4(a) and (b) respectively.

The processed sub-image is placed back to the original position in the retinal image to get the green plane. Figure 4 (c) shows the binary image obtained from the green plane with the exudates detected.

4. Simulation Results

In order to evaluate the algorithm, fundus images available in the public domain and maintained by the Machine Vision and Pattern recognition Research Group, Laboratory of Information Processing, Lappeenranta University of Technology, Finland has been used[17]. The database consists of 89 colour fundus images of which 84 contain at least mild non-proliferative signs. Images were

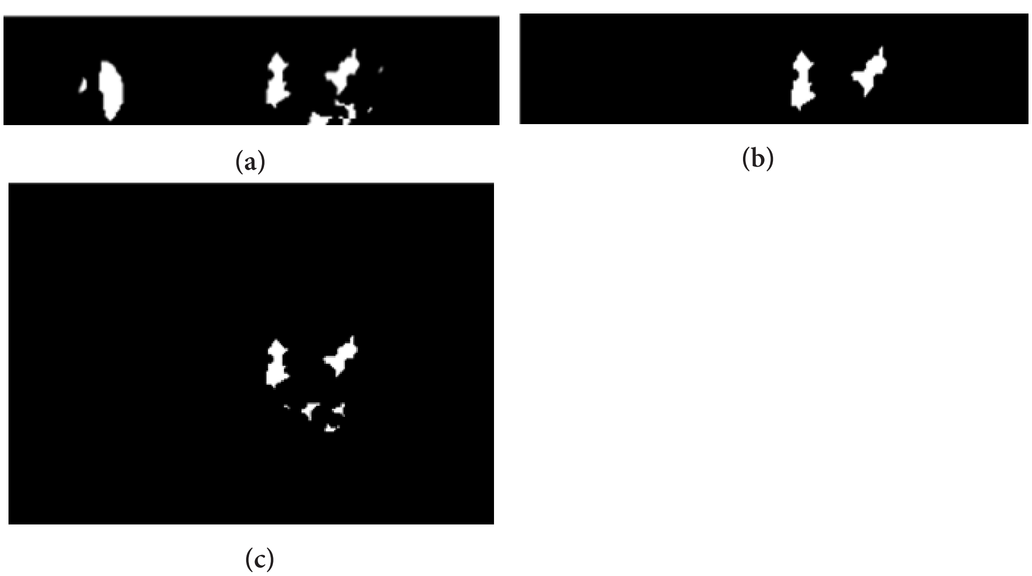


Figure 4. (**a**) Sub-image. (**b**) Sub-image after the removal of optical disc. (**c**) Exudates.

captured using the same 50 degree field-of-view digital fundus camera with varying imaging settings. These images are captured using a Canon Cr-1 fundus camera with a field of view of 45°. The size of each fundus image is 1500x1152. The exudates are successfully extracted using the proposed technique for all test images. A sample set of images are shown in Figure 5.

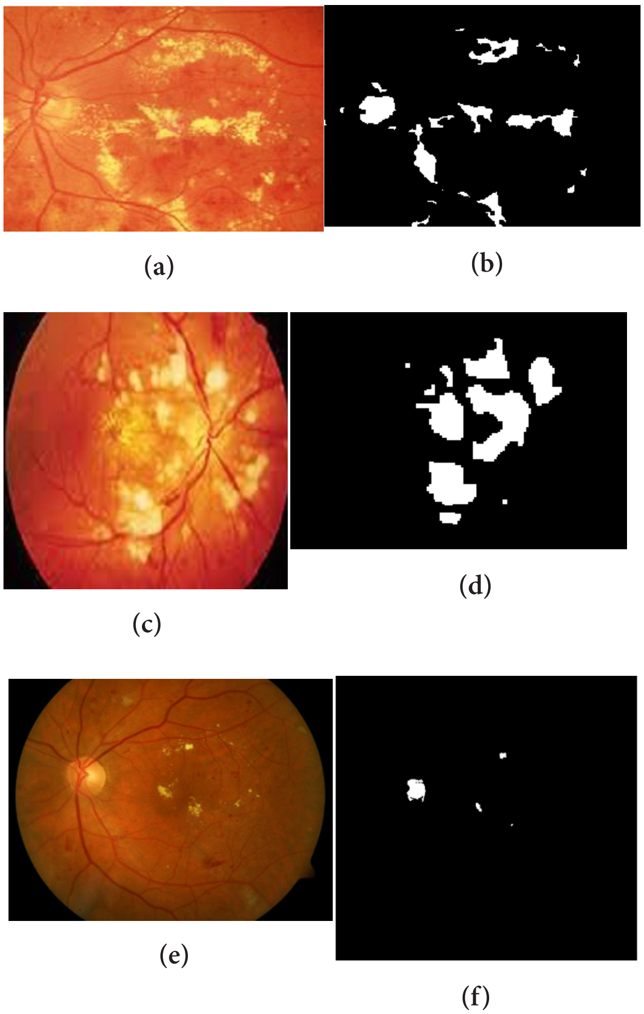


Figure 5. Sample color fundus image and the extracted exudates.

5. Conclusion

An approach for the detection of the optical disc and the exudates is proposed in this paper. The optical disc is properly extracted from the retinal image using the perimeter information. The small dots are eliminated using morphological operations. The exudates are detected from the green plane of the input fundus color image. For retinal images containing mild lesions, the algorithm needs to be fine tuned by replacing the simple threshold with a more proper scheme to get accurate results.

6. References

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