Automated detection of bright lesions from contrast normalized fundus images

[1]Ashish Issac, [1]Rishabh Madan, [1]Malay Kishore Dutta, [2]Carlos M Travieso
[1]Department of ECE, Amity School of Engineering & Technology, Amity University, Noida, India
[2]Signal and Communications Department, IDeTIC, University of Las Pamas de Gran, Canaria, Spain

Abstract

Exudates are one of the abnormalities present in the eye which can lead to vision loss. Many fundus images consist of artifacts which occur during acquisition and hamper the accuracy of exudates detection. There is still a need to develop an image processing based technique for correct segmentation of exudates from the fundus images. This paper presents a computer vision technique to efficiently segment the exudates from fundus images by strategic fusion of techniques such as contrast normalization, top-hat transformation and average filter. The proposed technique is efficient enough to correctly detect exudates from the fundus images and reject the artifacts and reflections. The average computation time for exudates segmentation from fundus images is 11 seconds. The proposed method is computationally efficient and robust and can be used for real time applications

Proposed Algorithm

RGB of the retina is converted to the green channel and this has been selected for exudates detection as the green channel has the highest contrast available and the boundary of exudates is distinguishable in green channel.
The proposed method involves identification of exudates by selecting the best candidate pixels of the following 3 methods:

1. Normalization using statistical features like mean and standard deviation
2. Top-Hat transformation
3. Averaging Filter

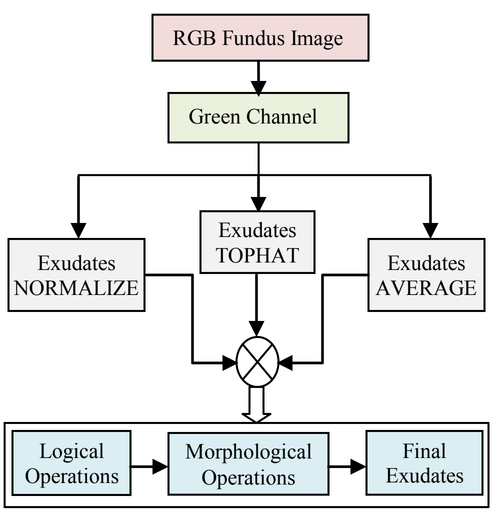

Fig.1. Flow Diagram of Proposed Algorithm

A. Contrast Normalization:

Fig.2 demonstrates the contrast normalization process. This image consists of some bright portion in the left bottom region of the optic nerve head. The process is applied to green channel of the RGB fundus image. In this method the green channel is divided into small blocks and mean and standard deviation for each block is calculated. This mean and standard deviation is used to normalize the contrast of the green channel. Fig. 2(d) shows the contrast normalized image in which only the lesions are enhanced while all the other bright regions, such as optic disc and left bottom region of optic disc, are suppressed

B. Top Hat Transform

Top hat transform is a mathematical morphological operation which is obtained by subtracting the opened image from the original image. Mathematically, Top Hat Transform can be represented as:

$$\mathbf{TH\ (f) = f - (f\ o\ b)}$$

Fig 3 demonstrates the Top Hat transformation process. In the proposed work, a disk shaped structuring element of size 50 is selected. After studying many images, it was observed that the exudates present in the images were not larger than 50 pixels. So, such a structuring element was chosen. Since, exudates are of bright intensity, hence, top hat transform is chosen as it selects all the pixels with high intensity of size less than 50. The top hat transformed image is added to the green channel image and the resultant image is thresholded using its mean and standard deviation to obtain the exudates. Fig 3(d) shows the highlighted exudates as compared to the original green channel.

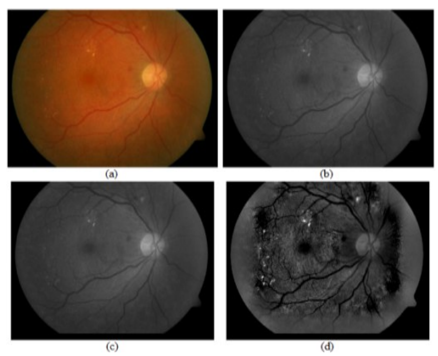

Fig.2: Contrast Normalization: (a) Input Image (b) Green Channel (c) Resized Green Channel (d) Contrast Normalized Image

C. Average Filter:

Fig. 4 demonstrates the averaging filter process. The green channel is filtered by an average filter of size 50*50. The selection criterion for the size of the averaging filter is already explained in previous section. The filtered image is smoothed and the pixels with higher intensities are suppressed while the pixels with lower intensities are raised to bring uniformity in the pixel intensities. When the filtered image is subtracted from the original image, it results in the pixels with high intensity in the original image. The resulting image contains exudates candidates and is thresholded using mean and standard deviation of the image to segment exudates from the image. Fig 4(d) shows the exudates detected from the averaging filter method of neighboring pixels.

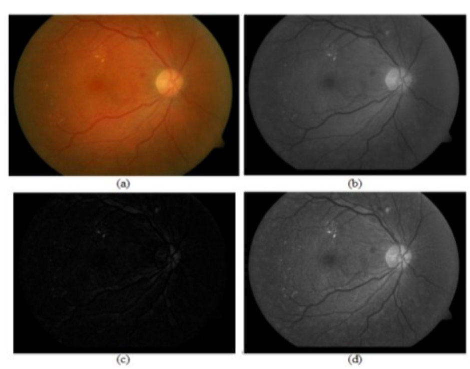

Fig. 3: Top Hat Transformation: (a) Input Image (b) Green Channel (c) Top Hat Transformed Image (d) Green channel + Top Hat Transformed Image

Experimental Results

Fig 5 shows the segmentation results for some of the samples from the DIARETDB1 database. Fig 5(a) is the RGB input fundus image which is subjected to the proposed method. Fig 5(b) shows the final segmented exudates which are obtained by applying some logical operations to the results from all the three methods. Fig 5(c) shows the annotated exudates which are already available with the database. The proposed algorithm has been tested on all images from the database and has shown good segmentation results. Also, there were no exudates detected from normal images. The database consists of images with varied illumination and the segmentation results proved to be satisfactory when tested on all images from the database

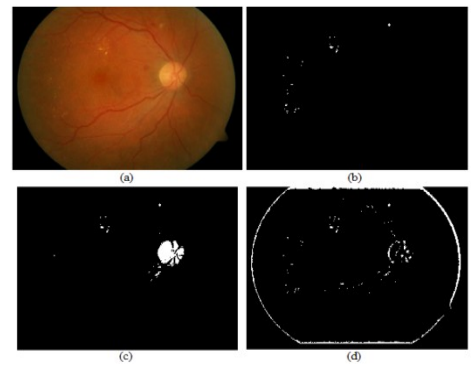

Fig. 4: Exudates after thresholding: (a) Input Image (b) Exudates from Contrast normalization method (c) Exudates from tophat transformation method (d) Exudates from averaging filter method

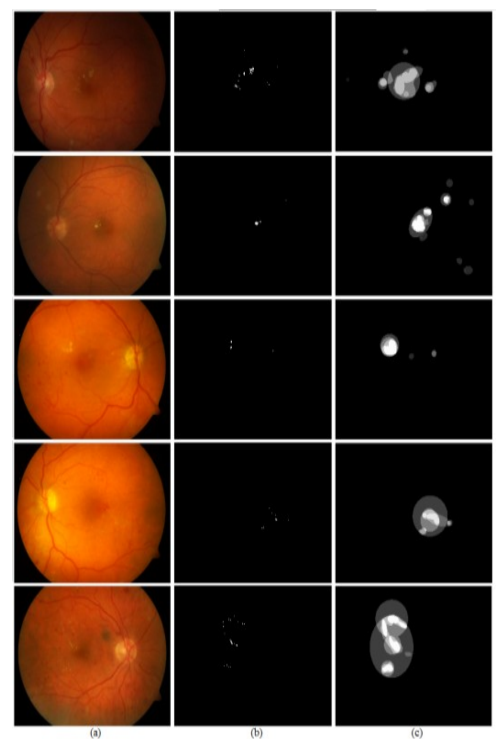

Fig.5: Results: (a) Input Image (b) Exudates detected from proposed work (c) Ground truth for exudates

Conclusions

The proposed algorithm has been able to correctly segment the exudates from fundus images of varying illuminations and images that contain artifacts and reflections. The algorithm is computationally efficient and can be used in the development of a screening tool for Diabetic Retinopathy or Diabetic Macular Edema where exudates play a major role in determination of the disease. The encouraging results from the algorithm make it suitable for real time applications.

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