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An improved method of automatic exudates detection in retinal image

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Abstract: Diabetic retinopathy is the complications of diabetes, which can eventually lead to blindness. To prevent from blindness of diabetic patient an early detection of diabetic retinopathy is very important. As exudates are the early sign of diabetic retinopathy, we can save diabetic patient from blindness by detecting exudates. In this paper, we have developed an improved method of automatic exudates detection in retinal images using nonlinear background elimination.

Keywords: Diabetic retinopathy, hard exudates, soft exudates, microaneurysm and blindness.

I. INTRODUCTION

Diabetic retinopathy is a vision threatening complications because of diabetes. About 25 thousand people becomes blind in US due to diabetic retinopathy [1]. According to [1], US and Europe, the main cause of blindness is diabetic retinopathy and it is estimated that diabetic retinopathy responsible for 5% of all the world's blindness cases. Early diagnosis of diabetic retinopathy and providing proper treatment [2] can prevent blindness.

The signs of retinopathy are microaneurysms, dot hemorrhages or red lesions, hard exudates or bright lesions and cotton wool spots [1]. Fig. 1(a) shows microaneurysms those are similar to red dots in these images. Fig. 1(b) shows hard exudates those are caused by the damage of the blood-retinal barrier, which leads to fluid rich in lipids and proteins. And Fig. 1(c) shows the dot hemorrhages where vessel walls weaken. Soft exudates has no well-defined borders and referred as cotton wool spots as shown in Fig. 1(d) [1].

Among the signs of diabetic retinopathy exudates are the most important sign. If exudates are detected diabetic retinopathy can be detected at an early stage [1-4]. Kavitha and Duraiswmy [5] described automatic detection of hard and soft exudates using histogram thresholding from color fundus retinal images. Sopharak *et al*. [6] describe a system to detect exudates based on mathematical morphology on fuzzy C-means clustering segmentation and morphological techniques. The accuracy of the system is 99.11%. Basha and Prasad [7] proposed a method for detection of hard exudates in diabetic retinopathy by morphological segmentation and fuzzy logic. Segmentation is performed using fundus images through morphological operations to identify the signs of diabetic retinopathy.

Sargunar and Sukanesh [18] describe classification of diabetic retinopathy using fuzzy c-means clustering, fractal techniques and morphological transformations.

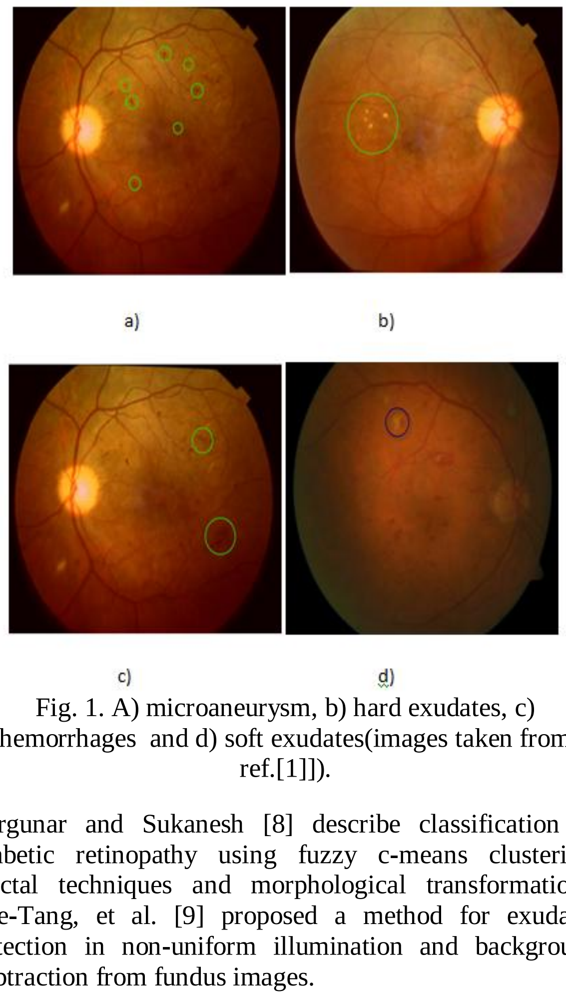

Fig. 1. A) microaneurysm, b) hard exudates, c) hemorrhages and d) soft exudates(images taken from ref.[1]]).

Sargunar and Sukanesh [8] describe classification of diabetic retinopathy using fuzzy c-means clustering, fractal techniques and morphological transformations. Sae-Tang, et al. [9] proposed a method for exudates detection in non-uniform illumination and background subtraction from fundus images.

At first they estimate the background and then they detect the exudates. Walter *et al*. [10] detected exudates on the green band of color fundus image.

They apply mathematical morphology and thresholding for exudates detection.

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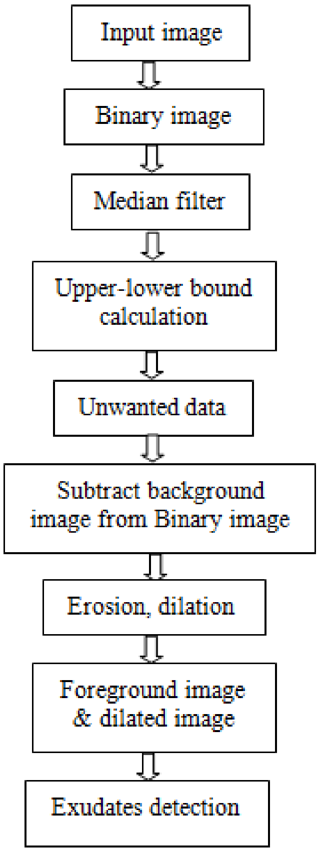

Fig.2. Flow diagram of the proposed method

Reza et al. [11] proposed the method for exudates detection using green band of image and preprocessing steps such as average filtering, contrast adjustment, and thresholding, morphological opening, extended maxima operator, minima imposition, and watershed transformation. All of the methods have some limitations. To overcome the limitations we propose an improved method of automatic exudates detection in retinal images.

The rest of the paper is organized as follows. Section II describes the methodology of the proposed method, section III discusses the experimental results and discussion. Finally section IV describes the conclusions of the paper.

II. METHODOLOGY

At first color fundus image is taken as input. Then image is converted to grayscale by thresholding. In the thresholded image mean filter of 30x30 mask size is applied where, Sae-Tang, et al. [9] previously used average filtering of mask size 20x20 .Then upper bound of the image is calculated by adding constant to the filtered image and lower bound can be calculated by subtracting another constant from the smoothed image. As experimentation we set these values as 20 and 15 respectively which was chosen by the authors [9].

Any pixel outside this limit would be considered as unwanted data such as fovea, blood vessels, and dark lesions.

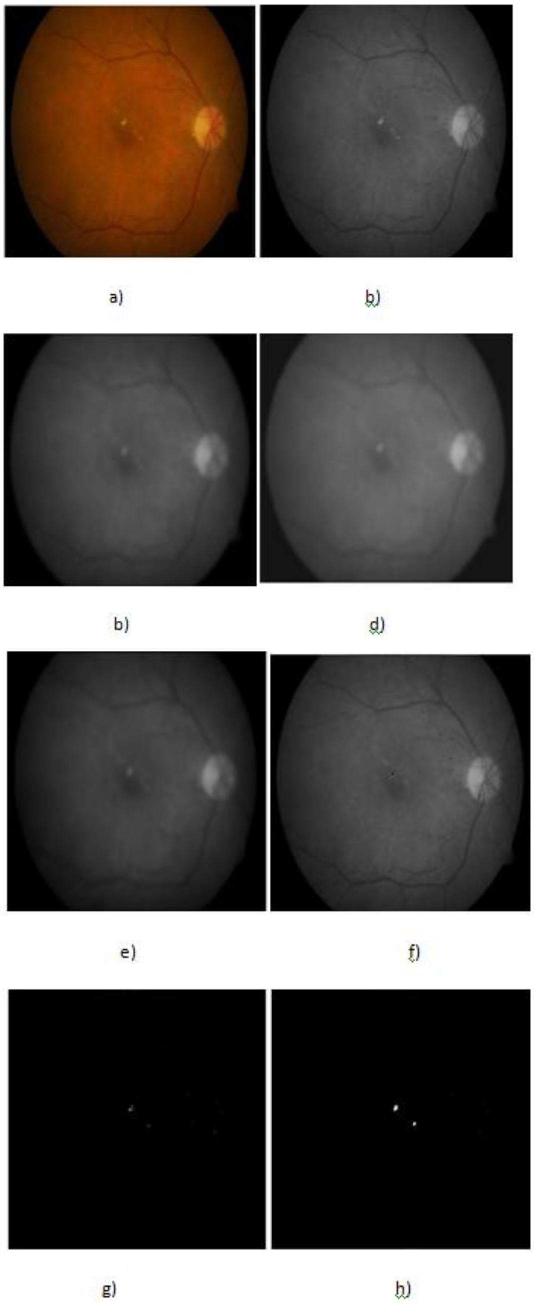

Fig. 3. a)input image, b)binary image, c)mean filtered image, d) upperbound image, lower bound image f) unwanted data, g) foreground image and h) exudates image

The pixels that have intensities higher than the upper bound or lower than the lower bound are defined as unwanted data. For the detection of exudates, the background is subtracted from the gray scale image to obtain the foreground of image. Now in the foreground image only exudates and optic disks are remain.

Then optic disk is removed by erosion and dilation. Finally, exudates are detected by and operation between dilated image and foreground image. The flow chart of the methodology is shown in Fig. 2 and the output of the method is shown in Fig. 3.

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III. EXPERIMENTAL RESULTS AND DISCUSSION

TABLE 1
NOTATION FOR EXPERIMENTAL VALIDATION [9]

Notation	Meaning
TP	A number of exudates pixels correctly detected
TN	A number of non-exudates pixels which are correctly identified as non-exudates pixels
FP	A number of non-exudates pixels which are detected wrongly as exudates pixels
FN	A number of exudates pixels that cannot be detected

We have tested our system with forty-six color fundus images from Bangladesh Eye Hospital, Dhaka, Bangladesh and evaluate the performance of the our method. We compare our system with opthamologist hand drawn ground truth and the proposed method of the author [9]. For experimental validation results, sensitivity, specificity, accuracy, and positive predictive value (PPV) are calculated images those contain exudates. The definition of True positive (TP), true negative (TN), false positive (FP), and false negative (FN) are shown in Table 1 [9] and Sensitivity, specificity, accuracy, and PPV are then defined as follows [9].

Sensitivity = TP / (TP+FN)
Specificity = TN / (TN+FP)
Accuracy = (TP+TF) / (TP+TF+FP+FN)
PPV = TP / (TP+FP)

Table 2 shows the comparison of experimental results with the results of the authors [9] proposed method in percentage. The positive predictive value of existing method is 92.8115 and our method is 94.8791 which proofs that our method is better than the existing method.

TABLE 2
COMPARISON OF THE RESULT

Average	Sensitivity	Specificity	Accuracy	PPV
Sa-Tang et al. [9] proposed method	91.8377	99.9037	99.7866	92.8115
Our Method	93.5577	97.82033	99.9624	94.8791

IV. CONCLUSION

Diabetic retinopathy is the main cause of blindness for the diabetic patient. Exudates are the major sign of retinopathy. If exudates are detected properly then blindness can be prevented. So we try to improve our method so that diabetic retinopathy can be detected properly and save the diabetic patient from blindness.

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