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Exudates Detection in Fundus Images

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Abstract— Diabetic retinopathy is the main cause of vision loss in diabetic patients. It is caused by the damage of retinal blood vessels due to prolonged diabetes. This paper investigates on some image processing operations to extract exudates for the analysis of diabetic retinopathy. The proposed method stands out prominent in terms of specificity and accuracy.

Keywords- *diabetic retinopathy, sensitivity, specificity, accuracy, exudates*

I. Introduction

The effect of diabetes in the eye is called diabetic retinopathy which can lead to partial or even complete loss of vision. Diabetes occurs when the pancreas does not secrete enough amount of insulin. Exudates appeared as bright yellow-white deposits on the retina due to the leakage of blood from abnormal vessels. Their shape and size will vary with the different retinopathy stages. Diabetic retinopathy has four different stages:

- Mild Non-Proliferative: Microaneurysms may occur at this stage. In the blood vessels of the retina, small areas of balloon-like swelling occur.
- Moderate Non-Proliferative: Some blood vessels that nourish the retina are blocked leading to bleeding and development of cotton wool spots.
- Severe Non-Proliferative: Many more blood vessels are blocked thus depriving several areas of the retina with the blood supply. Hence, these areas of the retina send signals so that it can grow new blood vessels for nourishment.
- Proliferative: This is the advanced stage where the signals send by the retina for nourishment trigger the growth of new blood vessels. These blood vessels are abnormal and fragile and grow along the retina and surface of the vitreous gel that fills the inside of the eye. These new blood vessels have thin and fragile walls that leak blood which can cause severe partial vision loss or total blindness.

Here, we have proposed a method which is formulated for the automatic diabetes recognition system. We have captured the exudates which can later be fed to a neural network environment for the classification purpose.

Chapter II contains the material being used. Chapter III contains the performance evaluation parameters. Chapter IV gives the tabulated list of related works. Chapter V describes the design and implementation of the proposed algorithm. Chapter VI gives the result and comparison of our algorithm. Chapter VII contains the conclusion and future work.

TABLE I. PERFORMANCE EVALUATION PARAMETERS

SL. NO.	PERFORMANCE PARAMETERS	FORMULA	DESCRIPTION
1	SENSITIVITY(SE)	$\frac{TP}{TP+FN}$	TRUE POSITIVE RATE
2	SPECIFICITY(SP)	$\frac{TN}{TN+FP}$	TRUE NEGATIVE RATE
3	ACCURACY(ACC)	$\frac{TP+TN}{TP+FP+FN+TN}$	THE DEGREE TO WHICH THE RESULT OF A MEASUREMENT CONFIRMS THE CORRECT VALUE OR A STANDARD

TABLE II. SOME RELATED WORKS

SL. NO.	AUTHORS/YEAR	TECHNIQUES	DATABASE	COLOUR SPACE	SENSITIVITY (%)	SPECIFICITY (%)	ACCURACY (%)
1	RAM ET AL. [1]	CLUSTERING-BASED METHOD AND COLOR SPACE FEATURES	DIARETDB1	RGB, CIE, HSV, HIS	71.96%	-	89.7%
2	SOARES ET AL. [2]	MORPHOLOGICAL OPERATORS AND ADAPTIVE THRESHOLDING	DIARETDB1	GREEN CHANNEL	97.49%	99.95%	99.91%
3	JAYAKUMARI ET AL. [3]	ENERGY MINIMIZATION METHOD USING ECHO STATE NEURAL NETWORK	PRIVATE HOSPITAL	-	90%	-	-
4	KAYAL ET AL. [4]	MEDIAN FILTERING, IMAGE THRESHOLDING	DIARETDB0 DIARETDB1	GRAY SCALE	97.25%	96.85%	-
5	AMEL ET AL. [5]	COMBINE THE K-MEANS CLUSTERING ALGORITHM AND MATHEMATICAL MORPHOLOGY	OPHTHALMOLOGIC IMAGES	CIE LAB	95.92%	99.78%	99.70%
6	ROKADE ET AL. [6]	HAAR WAVELET TRANSFORMATION, KNN CLASSIFIER	MISP, DIARETDB0, DIARETDB1, STARE	GREEN CHANNEL	37.14% 21.87% 12.5% 25.47%	-	-

II. MATERIAL

Images of the retina are taken with the help of a fundus camera which takes images of the internal surface of the retina. In the initial algorithm development stage, we have used images captured by a fundus camera with a 45 degree field of view taken at Shankardev Netralaya Eye Hospital, Guwahati. The images were stored in TIFF (.tif) file format and the size of each image is 576 x 720. For the validation, we have used the images from DRIVE database.

Some benchmark databases which are freely available for the assessment of algorithms are DRIVE, STARE, MESSIDOR etc.

III. PERFORMANCE PARAMETERS

The performances are tested based on certain evaluation parameters which are listed in Table I.

IV. RELATED WORKS

Some of the related works are listed in Table II.

V. DESIGN AND IMPLEMENTATION OF THE PROPOSED TECHNIQUES

Here, we have proposed an important feature extraction method for exudates extraction with the aim of using it in the automatic detection of diabetes from the retinal images. The overall block diagram of feature extraction is shown in figure 1.

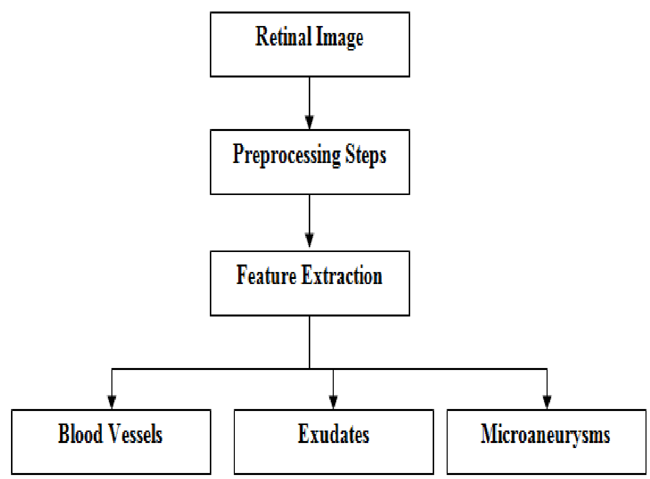
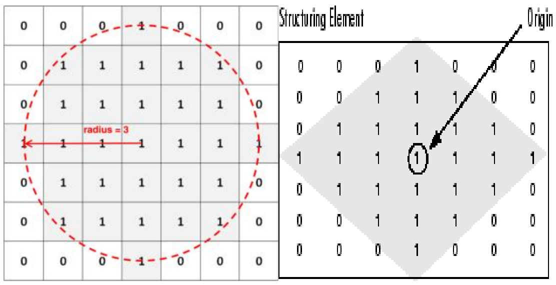


Figure1. Block diagram of feature extraction

A. Morphological Image Processing

Morphological image processing is a collection of non-linear operations related to shape or morphology of features in an image. Morphological techniques probe an image with a small shape or template called a structuring element. The structuring element is positioned at all possible locations in the image and it is compared with the corresponding neighbourhood of pixels. The structuring element is a small binary image, a matrix of pixels each with a value of zero or one. Figure 2 shows different shaped structuring elements.



(a) (b)

Figure 2: Structuring elements with R=3
(a) Disk shaped [taken from Researchgate]
(b) Diamond [taken from Mathworks Documentation]

B. Exudates Detection:

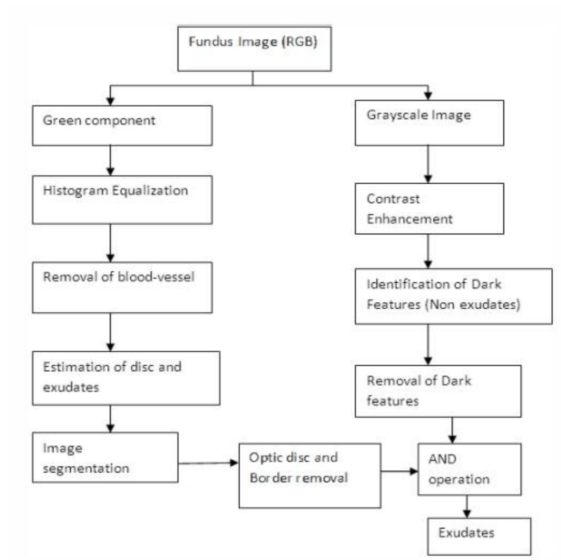


Figure3. Block diagram of exudates extraction

Figure 3 shows the block diagram of the proposed exudates technique.

VI. Experimental Results and Comparisons

The performance of the proposed retinal exudates extraction algorithm is tested using MATLAB version 7.11.0 (R 2010b) with the help of a publicly available DRIVE database. The performance of the proposed exudates extraction results are analyzed with respect to the ground truth images. We have also extracted the exudates of the images taken from Shankardev Netralaya Eye Hospital, Guwahati but could not evaluate the performance of those images due to the absence of ground truth images. Table III summarize the results of this proposed work using DRIVE database. The proposed algorithm detects and segments the exudates at an average specificity of 99.95% and accuracy of 97.81% respectively. The results obtained are compared with the other state of art and tabulated in Table IV.

Table III. Table showing average Specificity and Accuracy using DRIVE database

Database	Average Specificity	Average Accuracy
DRIVE	99.95%	97.81%

Table IV. Exudates Extraction Results

Method	Specificity (%)	Accuracy (%)
RAM ET AL. [1]	-	89.7
KAYAL ET AL. [4]	96.85	-
JAYA ET AL. [7]	90	-
ROZLAN ET AL. [8]	-	60
SOMAN ET AL. [9]	-	88
PROPOSED METHOD	**98.7**	**98.6**

Figure 4 shows a set of output images.

Figure4 (a) Input Fundus Image (RGB)

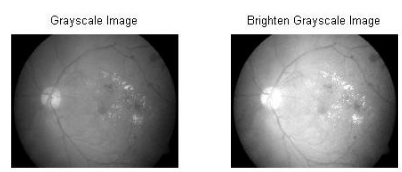


Figure4 (b) Grayscale Image

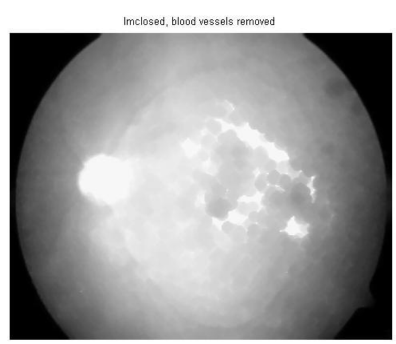


Figure4 (c) Blood Vessels Removed

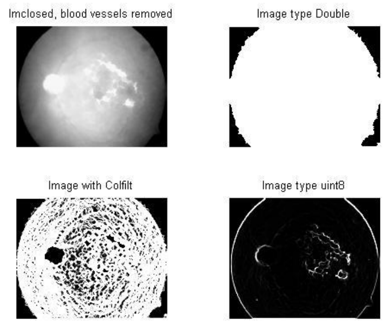


Figure4 (d) Image with colfilt

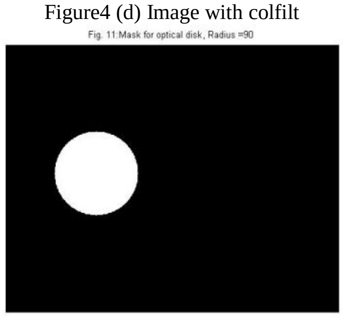


Figure4 (e) Mask for optic disk

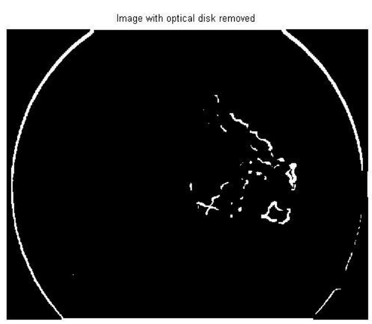


Figure4 (f) Optic disk removed

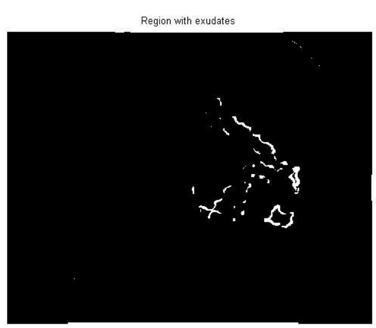


Figure4 (g) Region with exudates

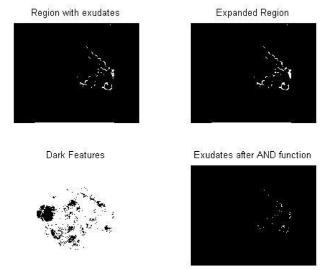


Figure4 (h) Exudates after AND function

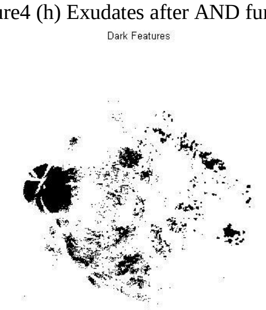


Figure4 (i) Dark features

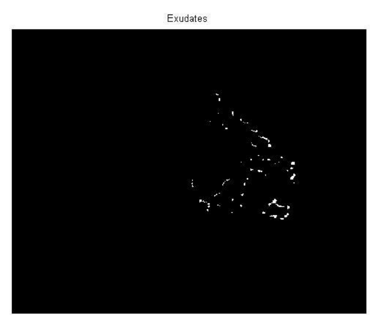


Figure4 (j) Exudates

VII. CONCLUSION

From experimental results, it can be concluded that the proposed method leads to fairly satisfactory results in terms of specificity and accuracy. This work can be further extended to extract microaneurysms and blood vessels from the retinal images. The extracted features can be fed to a neural network environment for proper classification and automatic detection of diabetic retinopathy.

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