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Feature Set for the Extraction of Exudates for the Analysis of Diabetic Retinopathy

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Abstract— Diabetic patients suffer from diabetic retinopathy because of prolonged diabetes. This paper deals with some image processing operations to extract exudates with the help of some innovative features for the analysis of diabetic retinopathy. The performance of the proposed method stands out prominent in terms of specificity and accuracy.

Keywords- ***diabetic retinopathy, exudates, fundus image***

I. INTRODUCTION

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 namely mild non-proliferative, moderate non-proliferative, severe non-proliferative and proliferative diabetic retinopathy.

We have proposed a feature extraction method with the help of a few innovative texture based features for an automatic diabetes recognition system. We have extracted exudates which can later be fed to an artificial neural network environment for classification purpose.

Chapter II contains the material being used. Chapter III gives the tabulated list of literature survey. Chapter IV describes the implementation of the proposed algorithm. Chapter V gives the result and comparison of our algorithm. Chapter VI contains the conclusion and future work.

II. MATERIAL

Retinal images are taken with the help of a fundus camera. In the initial algorithm development stage, we have used images captured by a fundus camera with a 45 degree field of view taken at Sankardev Netralaya Eye Hospital, Guwahati, India. The images were stored in TIFF (.tif) file format. For the validation purpose, we have used images from DRIVE database.

III. LITERATURE SURVEY

Some of the related works are listed in Table I.

IV. DESIGN AND IMPLEMENTATION OF THE PROPOSED TECHNIQUES

Here, we have proposed a feature extraction method for the extraction of microaneurysms. The overall block diagram of feature extraction is shown in figure 1.

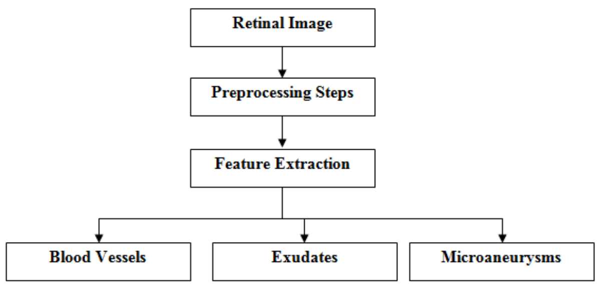

Figure1. Block diagram of feature extraction

A. Morphological Image Processing

If $f(u,v)$ is a finite size grayscale image defined in Z^2 and B is a binary structuring element then

Dilation:

$$(f \oplus B)(u,v) = \max\{f(u-s,v-t) \mid (s,t) \in B\}$$

Erosion:

$$(f \ominus B)(u,v) = \min\{f(u+s,v+t) \mid (s,t) \in B\}$$

Opening: $f \circ B = (f \ominus B) \oplus B$

Closing: $f \bullet B = (f \oplus B) \ominus B$

TABLE I. 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%

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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%

B. Texture Properties:

Texture analysis shown in figure 2 gives the description of an image in terms of variations in the pixel intensities or gray level.

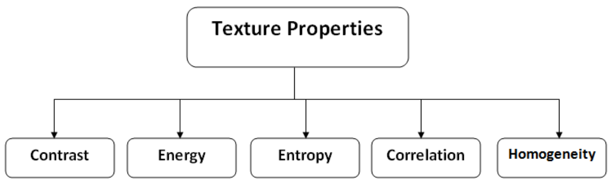

Figure2. Texture Analysis

Gray-Level Co-occurrence Matrix (GLCM) is the computation of the frequency of each pixel pair occurring for different combinations of pixel brightness values in an image. The function "graycomatrix" is used to create the GLCM of the grayscale image. It calculates how often the pixel with value i of the gray level occurs horizontally adjacent to another pixel with value j. Each element (i,j) in the GLCM represents frequent of occurrence. The function "graycoprops" normalizes the GLCM so that the sum of its elements is equal to 1. It calculates the statistics as specified in the property.

Homogeneity is the measurement of the closeness of the distribution of elements in the GLCM to the GLCM diagonal and returns a value between 0 and 1. The homogeneity formula is as follows:

$$\sum_{i,j} \frac{p(i,j)}{1+|i-j|}$$

Contrast: Returns a measure of the intensity contrast between a pixel and its neighbour over the whole image. Range = [0 (size (GLCM, 1)-1) ^2]. The formula for contrast is as follows:

$$\sum_{i,j} |i-j|^2 \, p(i,j)$$

Correlation: Returns a measure of how correlated a pixel is to its neighbour over the whole image. Range = [-1 1]. Correlation is 1 or -1 for a perfectly positively or negatively correlated image. The formula for correlation is as follows:

$$\sum_{i,j} \frac{(i-\mu i)(j-\mu j)\, p(i,j)}{\sigma_i \sigma_j}$$

Energy: Returns the sum of squared elements in the GLCM. Range = [0 1]. The formula for energy is as follows:

$$\sum_{i,j} p(i,j)^2$$

Entropy is the statistical measure of the randomness of the grayscale image's texture. The green component of the image is applied with adaptive histogram equalization twice to enhance its contrast and texture. The function "entropy" is then used on the image which returns a scalar value. This represents the entropy of intensity for the image.

C. Extraction of Exudates:

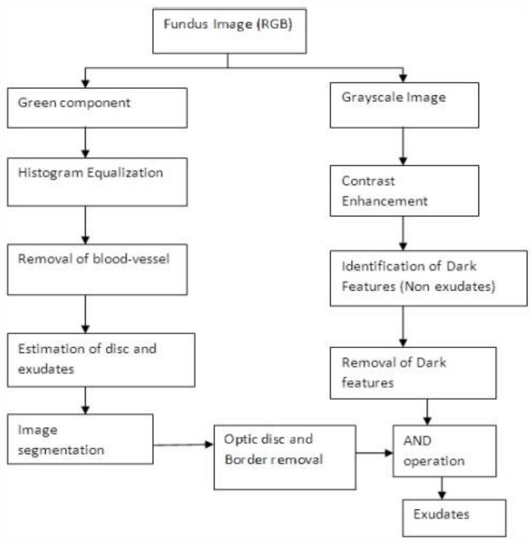

Figure3. Block diagram of exudates extraction

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

V. EXPERIMENTAL RESULTS AND COMPARISONS

The performance of the proposed 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 exudates of the images taken from Sankardev Netralaya Eye

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Hospital, Guwahati, India but could not evaluate the performance of those images due to the absence of ground truth images. Table II summarize the results of this proposed work using DRIVE database. The proposed algorithm detects and segments the microaneurysms at an average specificity of 99.05% and accuracy of 98.1% respectively. The results obtained are compared with the other state of art and tabulated in Table III. Table IV shows the texture properties of the DRIVE database images. Table V shows the texture properties of images taken from Sankardev Netralaya Hospital, Guwahati, India

TABLE II. TABLE SHOWING AVERAGE SPECIFICITY AND ACCURACY USING DRIVE DATABASE

Database	Average Specificity	Average Accuracy
DRIVE	99.05%	98.1%

TABLE III. MICROANEURYSM EXTRACTION RESULTS (DRIVE DATABASE)

Method	Specificity (%)	Accuracy (%)
KAYAL ET AL. [4]	96.85	-
JAYA ET AL. [7]	90	-
ROZLAN ET AL. [8]	-	60
PROPOSED METHOD	**99.05%**	**98.1%**

TABLE IV. TEXTURE PROPERTIES (DRIVE DATABASE)

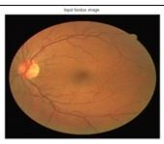
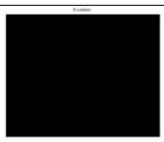
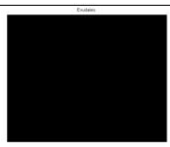
Feature	DRIVE Database: Test Image 1	DRIVE Database: Test Image 2
Image		
Exudates		
Correlation	0.9886	0.9931
Energy	0.3569	0.3598
Entropy	7.731	7.7540
Homogeneity	0.9745	0.9798
Contrast	0.0552	0.0461

TABLE V. TEXTURE PROPERTIES (IMAGES TAKEN FROM SHANKARDEV NETRALAYA EYE HOSPITAL, GUWAHATI, INDIA)

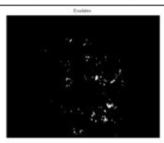
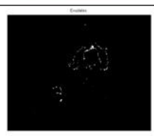
Feature	Sankardev Netralaya Eye Hospital, Guwahati: Test Image 1	Sankardev Netralaya Eye Hospital, Guwahati: Test Image 2
Image		
Exudates	 Area=2459	 Area=1241
Correlation	0.9806	0.9711
Energy	0.2213	0.2613
Entropy	7.6862	7.6644
Homogeneity	0.9713	0.9719
Contrast	0.0576	0.0565

Figure 4 shows a set of output images.

Figure4 (a) Input Fundus Image (RGB)

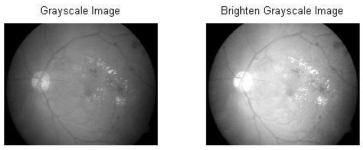


Figure4 (b) Grayscale Image

Figure4 (c) Blood Vessels Removed

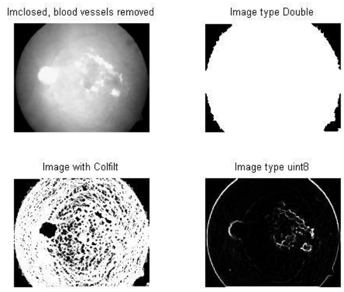


Figure4 (d) Image with colfilt

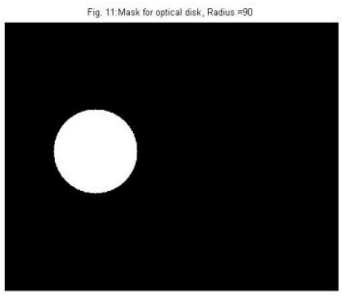


Figure4 (e) Mask for optic disk

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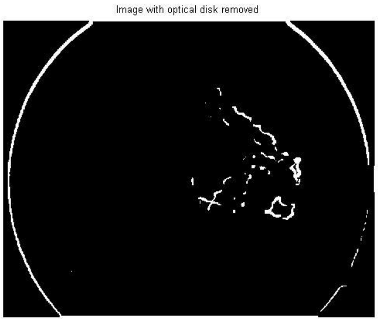

Figure4 (f) Optic disk removed

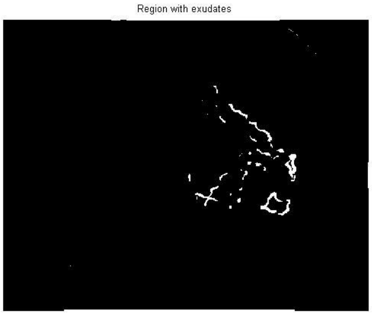

Figure4 (g) Region with exudates

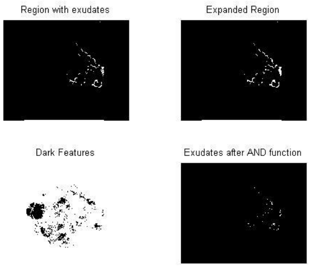

Figure4 (h) Exudates after AND function

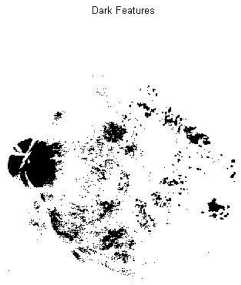

Figure4 (i) Dark features

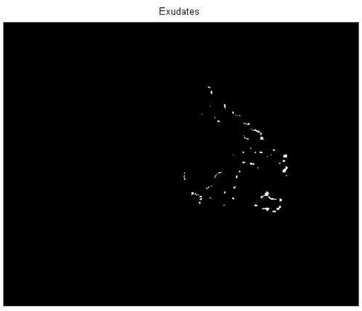

Figure4 (j) Exudates

VI. Conclusion

From the experimental results shown in tables II, III, IV and V, it can be concluded that the proposed method leads to a satisfactory result in terms of specificity and accuracy. It gives an average specificity of 99.05% and average accuracy of 98.1%. This work can be further extended to extract microaneurysm and abnormal growth of blood vessels from the retinal images. The extracted features can be fed to an artificial neural network environment for further processing.

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