ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 7, Issue 6 , June 2020

Early Detection of Diabetic Retinopathy

Abhinandan Kalita
Department of Electronics & Communication Engineering, GIMT-Guwahati, Assam, India

ABSTRACT: This paper deals with some morphological operations to extract microaneurysms with the help of a few features for the analysis of diabetic retinopathy. The performance of the proposed method stands out prominent in terms of specificity and accuracy. It gives an average specificity of 90% and average accuracy of 95%. The algorithm is tested using images taken from Omega Eye Clinic & Research Centre, Guwahati database.

KEYWORDS: blood vessels, microaneurysm, fundus image, feature extraction, retinopathy

I. INTRODUCTION

The first signs of diabetic retinopathy are called microaneurysms. They are small circular shaped bulges developed from the weak blood vessels and are the earliest clinical sign of diabetic retinopathy. The number of microaneurysms increases with the stage of the retinopathy and therefore, it is extremely important to detect them during the early stages of development. They appear in clusters as tiny dark red spots (hemorrhages) in the retina. Their sizes range from 10-100 microns. Microaneurysm detection in the early stage can reduce the degree of blindness. The other significant symptoms of diabetic retinopathy are appearance of exudates and abnormal growth of blood vessels. Diabetic retinopathy has four different stages [1] namely mild non-proliferative, moderate non-proliferative, severe non-proliferative and proliferative diabetic retinopathy.

In this paper, 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 the microaneurysms 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 design and 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 Omega Eye Clinic & Research Centre, 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.

Table I. Some related works

SL. NO.	AUTHORS/YEAR	TECHNIQUES	DATABASE	COLOUR SPACE	SENSITIVITY (%)	SPECIFICITY (%)	ACCURACY (%)
1	KRISHNA ET AL. [2] (2013)	ENSEMBLE-BASED MICROANEURYSMS DETECTOR,WALTER KLEIN, AND CLACHE	MESSIDOR	GRAY SCALE	-	-	-
2	ROY ET AL. [3] (2013)	CANNY EDGE DETECTION, MORPHOLOGICAL RECONSTRUCTION	DIARETDB1	GREEN CHANNEL	89.5	82.1	-
3	ADAL ET AL. [4] (2013)	CONTRAST ENHANCEMENT TECHNIQUE, HESSIAN-BASED	ROC	GREEN CHANNEL	-	44.64	-

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 7, Issue 6 , June 2020

		CANDIDATE SELECTION ALGORITHM, AND SVM CLASSIFIER					
4	DING AND MA [5] (2014)	DYNAMIC MULTIPARAMETER TEMPLATE (DMPT) MATCHING SCHEME	ROC	-	96	-	-

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.

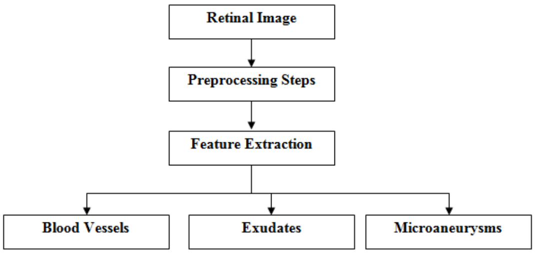

Figure1. Block diagram of feature extraction

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

B. Texture Properties:

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

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:

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

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.

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 7, Issue 6 , June 2020

C. Extraction of Microaneurysms:

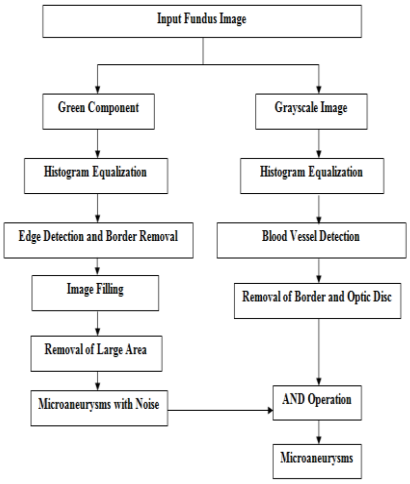

Figure2. Block diagram of microaneurysm extraction

Figure 2 shows the block diagram of the proposed microaneurysm extraction technique. The grayscale image is used to detect the circular border and optical disc mask. The green channel of the image first finds the edges using canny method before removing the circular border to fill the enclosed small area. The larger areas are then removed and applied with AND logic to remove the exudates. The blood vessels and optical disc are then removed to obtain the microaneurysms.

D. Artificial Neural Network:

The ANN used for this paper is a feed-forward back propagation network and uses supervised learning to train the neural network. Supervised learning is by providing the ANN with input data and matches them with output results. Its weights would adjust according to its learning rules as it undergoes training before being tested for accuracy. Figures 3 (a & b) shows the block diagram and hidden layers of ANN.

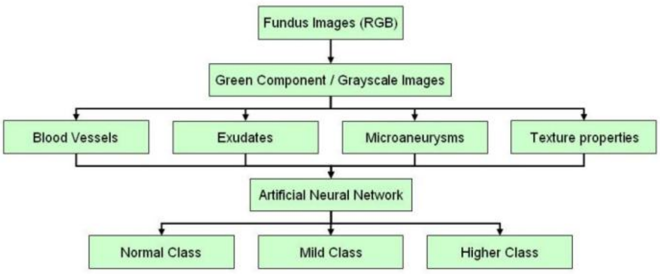

Figure3. a) Block diagram of ANN

The input layer is made up of nodes to accept the 5 data values while the subsequent layers process the values using activation function. There are 10 neurons for each "hidden layer" and the trained network would output binary numbers which represent the 3 different stages.

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 7, Issue 6 , June 2020

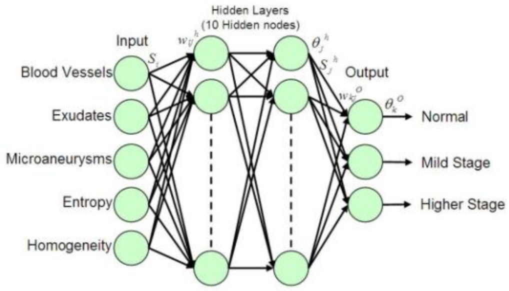

Figure3. b) Hidden Layers

V. EXPERIMENTAL RESULTS AND COMPARISONS

The performance of the proposed algorithm is tested using MATLAB version 7.11.0 (R 2010b). The performance of the proposed microaneurysm extraction results are analyzed with respect to the ground truth images. We have also extracted microaneurysms of the images taken from Omega Eye Clinic and Research Centre, 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 90% and accuracy of 95% respectively. The results obtained are compared with the other state of art and tabulated in Table III.

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

Database	**Average Specificity**	**Average Accuracy**
DRIVE	90%	95%

TABLE III. MICROANEURYSM EXTRACTION RESULTS (DRIVE DATABASE)

Method	**Year**	**Specificity (%)**	**Accuracy (%)**
ROY ET AL. [3]	2013	82.1	-
ADAL ET AL. [4]	2013	44.64	-
DATTA ET AL. [6]	2013	82.64	99.98
PROPOSED METHOD	**2020**	**90**	**95**

Figure 4 shows a set of images taken from Omega Eye Clinic and Research Centre, Guwahati, India where a) the first image is the original input fundus image, b) the second one is the green component image, c) the third is the grayscale image, d) the fourth image is the image and histogram after first adaptive histogram equalization, e) the fifth image is the is the image and histogram after second adaptive histogram equalization, f) the sixth image is the edges of image for circular border detection, g) the seventh image is the result of image fill, dilation and erosion h) the eighth image is the new circular border image, i) the ninth image is the image with blood vessels and noise, j) the tenth image is the area of microaneurysm after removing blood vessels and noise k) the eleventh image is the final microaneurysm image.

Figure4 (a) Input Fundus Image

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 7, Issue 6 , June 2020

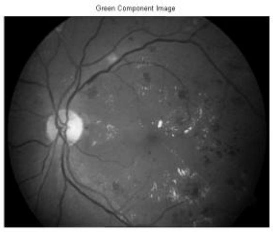

Figure4 (b) Green Component Image

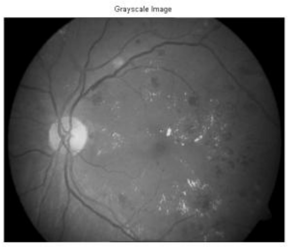

Figure4 (c) Grayscale Image

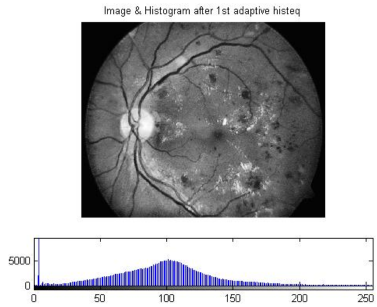

Figure4 (d) Image and Histogram (1st adaptive histeq)

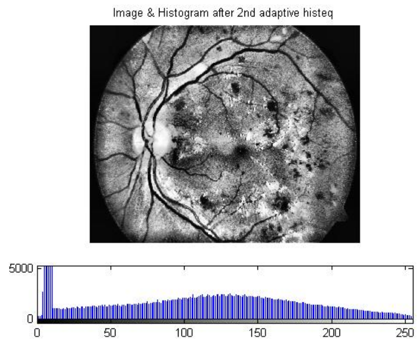

Figure4 (e)) Image and Histogram (2nd adaptive histeq)

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 7, Issue 6 , June 2020

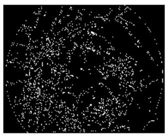

Figure4 (f) Edges of Image for Circular Border Detection

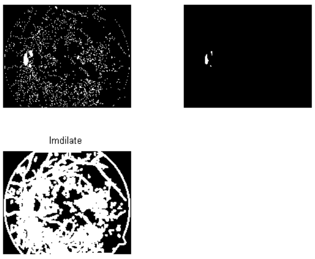

Figure4 (g) Image Fill, Dilation, Erosion

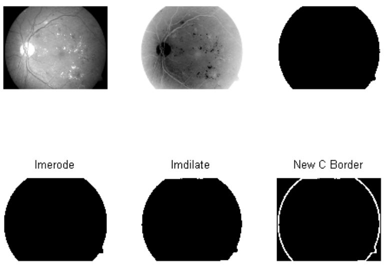

Figure4 (h) New Circular Border

Figure4 (i) Blood Vessels and Noise

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 7, Issue 6 , June 2020

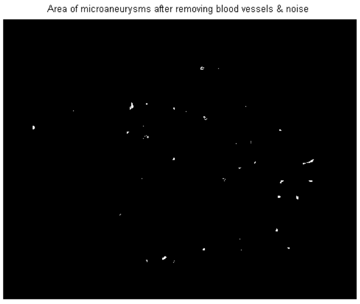

Figure4 (j) Area of Microaneurysm after Removing Blood Vessels and Noise

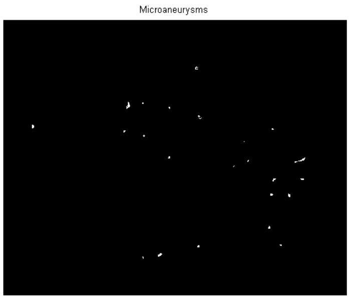

Figure4 (k) Microaneurysms

VI. CONCLUSION

From the experimental results shown in tables II, III, 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 90% and average accuracy of 95%. This work can be further extended to extract exudates 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.

REFERENCES

1. N. Amrutkar, Y. Bandgar, S. Chitalkar, S.L. Tade, “Retinal blood vessel segmentation algorithm for diabetic retinopathy and abnormality detection using image subtraction,” *International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering,* Vol.2, Issue 4, April 2012.
2. N. Venkata Krishna, N. Venkata Siva Reddy, M. Venkata Ramana, E. Prasanna Kumar, “The Communal System for Early Detection Microaneurysm and Diabetic Retinopathy Grading Through Color Fundus Images,” *International Journal of Scientific Engineering and Technology*, Volume 2 Issue 4, pp : 228-232, ISSN : 2277-1581, 1 April 2013.
3. Rukhmini Roy, Srinivasan Aruchamy, Partha Bhattacharjee, “Detection of Retinal Microaneurysms using Fractal Analysis and Feature Extraction Technique,” *International conference on Communication and Signal Processing*, April 3-5, 2013, India.
4. Kedir Adal, Sharib Ali, Desire Sidibe, T.P. Karnowski, Edward Chaum, Fabrice Meriaudeau, “Automated detection of microaneurysms using robust blob descriptors,” *SPIE Medical Imaging - Computer-Aided Diagnosis*, Orlando - FL, United States. pp.8670-22, Feb 2013.
5. Shan Ding and Wenyi Ma, “An Accurate Approach for Microaneurysm Detection in Digital Fundus Images,” *IEEE 22nd International Conference on Pattern Recognition*, pp. 1846-1851, 2014.
6. Niladri Sekhar Datta,Himadri Sekhar Dutta, Mallika De, Saurajeet Mondal, “An Effective Approach: Image Quality Enhancement for Microaneurysms Detection of Non Dilated Retinal Fundus Image,” *Elsevier: International Conference on Computational Intelligence: Modeling Techniques and Applications*, Procedia Technology , pp. 731 – 737, 2013.
7. G. B. Kande, P. V. Subbaiah, T. S. Savithri, "*Feature extraction in digital fundus images*,” Journal of Medical and Biological Engineering, vol. 29, No. 3, 2009.
8. M.Goldbaum,S.Moezzi,A.Taylor,S.Chatterijee,J.Boyd,E.Hunter,and R.Jain, “Automated diagnosis and image understanding with object extraction, object classification and interferencing in retinal images," *International Conference on Image Processing*, vol. 3, p.695698, September 1996.
9. A.Osareh,B.Shadgar,and R.Markham, “A computational-intelligence-based approach for detection of exudates in diabetic retinopathy images," *IEEE Transaction on Information Technology in Biomedicine*, vol.13,p.535545, july 2009.

ISSN: 2350-0328

International Journal of Advanced Research in Science, Engineering and Technology

Vol. 7, Issue 6 , June 2020

10. Y.Hatanaka,T.Nakagawa,Y.Hayashi,T.Hara, and H.Fujita, "Improvement of automated detection method of hemorrhages in fundus images," in *30th Annual International IEEE EMBS Conference*, August 2008.
11. A. Youssif, A. Ghalwash, and A. Ghoneim, "Optic disc detection from normalized digital fundus images by means of a vessels direction matched filter," *IEEE Transactions on Medical Imaging*, vol.27,p.1118, January 2008.
12. M. Neiemeijer, B. Ginneken, M. Cree, A. Mizutani, G. Quellec, C. Sanchez, B. Zhang, R. Hornero, M. Lamard, C.Muramatsu, X.Wu, G. Cazuguel, J.You, A.Mayo, Q.Li, Y. Hatanaka, B.Coehener, C.Roux, F. Karray, M.Garca, H. Fujita, and M. Abramo®, "Retinopathy online challenge Automatic detection of microaneurysms in digital color fundus photographs," *IEEE Transactions on Medical Imaging*, vol.29,pp. 185- 195, January 2010.
13. L. Zhang, Q. Li, J. You, and D. Zhang, "A modified matched filter with double sided thresholding for screening proliferative diabetic retinopathy," *IEEE Transactions on Information Technology in Biometrics*, vol.13,pp. 528-534, July 2009.
14. T. Walter, P. Massin, A. Erginay, R. Ordonez, C. Jeulin, and J.C. Klein, "Automatic detection of microaneurysms in color fundus images," *Medical Image Analysis*, vol. 11,pp.555-566, May 2007.
15. G. Quellec, M. Lamard, P. Josselin, G. Cazuguel, and C. Roux, "Optimal wavelet transform for the detection of microaneurysms in retinal photographs," *IEEE Transactions on Medical Imaging*, vol.27, p. 12301241, Sept.2008.
16. Junichiro Hayashi, Takamitsu, Joshua Cole, Ryusuke Soga, Yuji Hatanaka, Miao Lu, Takeshi Hara, and Hiroshi Fujita, "A development of computer-aided diagnosis system using fundus images," *Proceeding of the 7th International Conference on Virtual Systems and Multimedia*(VSMM 2001), pp.429-438,sept2001.
17. N.Singh and R.C.Tripathi, "Automated early detection of diabetic retinopathy using image analysis techniques," International Journal of computer Applications, vol.8, No.2, pp.18-23, Oct.2010.
18. Vallabha,D.,Dorairaj,R., Namuduri K.R., and Thompson, H., "Automated detection and classification of vascular abnormalities in diabetic retinopathy," *38th Asilomar Conference on Signals, Systems and Computers*, Nov2004.
19. Y.F. Ming, "Identification of diabetic retinopathy stages using digital fundus images using imaging," Master's thesis, School of Science and Technology, SIM University, 2009.
20. Akara Sopharak, Bunyarit Uyyanonvara, Sarah Barman and Tom Williamson, "Automatic Microaneurysm Detection from Non-dilated Diabetic Retinopathy Retinal Images," *Proceedings of the World Congress on Engineering* , Vol II, WCE 2011, London, U.K, July 2011.
21. Luca Giancardo, Fabrice Meriaudeau, Thomas P. Karnowski, Kenneth W. Tobin, Yaqin Lic and Edward Chaum, M.D., "Microaneurysms Detection with the Radon Cliff Operator in Retinal Fundus Images," *Proceedings. of SPIE*, Vol. 7623, 2010.

AUTHOR'S BIOGRAPHY

Mr. Abhinandan Kalita pursued Bachelor of Engineering in 2010 and Master of Technology in 2012 from Gauhati University, Assam, India. He is currently working as an Assistant Professor in Department of Electronics and Communication Engineering, GIMT-Guwahati, Assam, India since 2012. He is a life member of ISTE, ISRD & IAENG and professional member of IEEE. He has published around 09 research papers in reputed international journals and conferences. His main research work focusses on Digital Image Processing, Pattern Recognition, Biometrics and Artificial Intelligence. He has 8 years of teaching experience.