International Journal Research of Leading Publication (IJLRP)
E-ISSN: 2582-8010 ● Website: www.ijlrp.com ● Email: editor@ijlrp.com

Microaneurysm-Based Diabetic Retinopathy Detection from Fundus Images

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Abstract

Through the precise extraction of the area and number of microaneurysms from colour fundus pictures, this research proposes an enhanced diabetic retinopathy detection system. Diabetic retinopathy must be detected and treated with routine eye screening. The eye condition known as diabetic retinopathy is brought on by long-term diabetes mellitus that damages the retina. Tiny red spots on the retina known as microaneurysms are formed by the swelling of a delicate blood artery segment. The first step in preventing DR is identifying MA in the primary stage, which is extremely important. Numerous techniques have been put forth for DR diagnosis and detection. Two features—the number and area of MA—have been established in this research. First, pre-processing methods such as morphological processing, histogram equalization, and green channel extraction were employed. Principal component analysis, Contrast Limited Adaptive Histogram Equalization, morphological processes, and average filtering have all been used to discover microaneurysms. DR has been classified using a Support Vector Machine.

Keywords: Retinal Blood Vessels, Support Vector Machine, Microaneurysm, Exudates

1. Introduction

DR is asymptomatic; it does not affect with view until it reaches at progress stage. Therefore, screening of DR is crucial for insulin dependent and non-insulin dependent diabetic patients as both types are at risk of Diabetic retinopathy. DR has two stages, namely non proliferative diabetic retinopathy (NPDR) and proliferative retinopathy (PDR). NDPR is early stage of retinopathy. In this stage, blood vessels decrease in size, enlarge like balloon and damage retinal blood vessels begin to leak fluid into retina. PDR is advance stage of retinopathy. In this stage, abnormal RBV bleeds into vitreous. In addition to this, scar tissue may be formed from ruptured blood vessels, which may pull on the retina leading to retinal detachment. The World Health Organization estimates that diabetes affects over 347 million people and will rank as the seventh leading cause of death globally by 2030 [1]. Diabetes patients frequently have retinal abnormalities over time as a result of a new barrier known as DR. A 77% likelihood of acquiring DR exists for people over 35 who have had diabetes for more than 15 years [1]. The cause of DR is chronic diabetes mellitus. Retinopathy is the term for retinal injury, which causes the blood vessels to suffocate, leak, and proliferate erratically [2].

Developing a system that can recognize patients with DR using retinal colour fundus images is the goal of this article. For the early diagnosis of diabetic retinopathy, colour fundus pictures are frequently utilized. Figure 1 displays an example of a digitized retinal colour fundus picture. Diabetic

retinopathy can be identified by a number of symptoms, including cotton wools, hard exudates, retinal hemorrhages, and microaneurysms.

In this paper, we are focusing on the early detection of diabetic retinopathy by finding the microaneurysm in fundus images. Microaneurysms are small red dots on retina which is the first important indication of diabetic retinopathy. The earliest sign of the DR is the dilation of vein in retina. The small capillaries may also undergo early changes, leading to occlusion. This results in small bulges in vascular walls, called microaneurysm. Diabetic retinopathy detection contains three steps -pre-processing of colour fundus images, diagnostic feature extraction and classification of DR. Pre-processing is important stage of detection of microaneurysmbecause noise, poor contrast, and uneven illumination plague medical photographs. A number of techniques have been developed to use digital color fundus images to detect DR. A pre-processed image is necessary for all approaches. The fundus image undergoes pre-processing to improve contrast. In computer vision, feature extraction is crucial. The classifier's parameters are trained using the extracted features. Support vector machines are used to classify diabetic retinopathy. SVM maximizes the margin between the data and the separation planes in order to reduce the upper bound of generalization error. SVM performs exceptionally well in classification. Regression is another usage for it. Quadratic programming and the Lagrange multiplier are used to optimize.

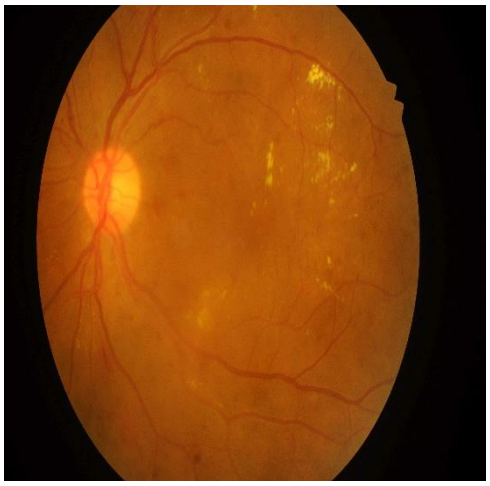

Figure: 1 Colour Retinal Fundus Image

The following is how the paper is structured: An overview of relevant research on automated methods for detecting diabetic retinopathy, particularly microaneurysm identification, is included in section II. The suggested approach for DR detection is described in Section III. Results are presented in Section IV.

2. Literature Review

Diagnosing and screening for diabetic retinopathy is a prominent area of research, and many academics are working to advance this field of study. In order to overcome the drawbacks of manual screening, including its high cost, low sensitivity and specificity, time commitment, and limited human detection capacity, automated detection of diabetic retinopathy screening was proposed. Finding the need for a referral for additional treatment is the goal of automated detection for screening. An

automated method for detecting hemorrhages and microaneurysms in color eye fundus images has been proposed by Sergio Bortolin junior et al. [1].

This method consists of five methods: pre-processing, enhancement of low intensity structure, detection of blood vessels, elimination of blood vessels, and elimination of fovea. Green channel and CLAHE are used for pre-processing. Enhancement of low intensity has been achieved with the help of applying alternating sequential filtering (ASF). Detection of blood vessels and elimination of blood vessels was performed by applying ASF and morphology opening with multiscale structuring element. Sarni Suhaila Rahim et al. [2] proposed several techniques for detection of microaneurysm. They have used adaptive histogram equalization, discrete wavelet transforms, and filtering and morphology process for pre-processing. Area of pixels, mean and standard deviation are the extracted features of DR. Decision tree, K-nearest neighbor, polynomial kernel SVM and Radial basis function (RBF) kernel SVM have been used for classification. R. A. Welikalaet al. [7] used two vessel segmentation methods, such as standard line operator and modifiedline operator and latter apply SVM for dual classification.

3. Scheme for Proposed Diabetic Retinopathy Detection

Diabetic retinopathy detection system consists three main steps: pre-processing techniques,feature extraction and classification techniques. There is verity of techniques have beenproposed in literature for pre-processing, feature extraction and classification of DR. wepropose different combination of pre-processing, feature extraction and classificationtechniques to improve DR detection. The architecture of the system is shown in Figure 2. Fundusimages are taken from database DIARETDB1.

A. Pre-processing

Color retinal fundus images must undergo pre-processing because they frequently exhibit noise, light fluctuation, and low contrast. The improvement is required because fundus photos are affected by noise and uneven lighting. The fundus image undergoes pre-processing to enhance contrast. Certain information, including the image's red and blue components, is frequently eliminated prior to processing in order to improve the contrast of retinal images. Because it shows the largest contrast between the optic disc and retinal tissue as well as the best vessels/background contrast, the green channel is frequently used in pre-processing.The choroid's vascular structure is evident, and the red channel is comparatively bright. Although they can be seen, the retinal vessels don't contrast as well as the green channel. Blue Channel has minimal information and is loud.

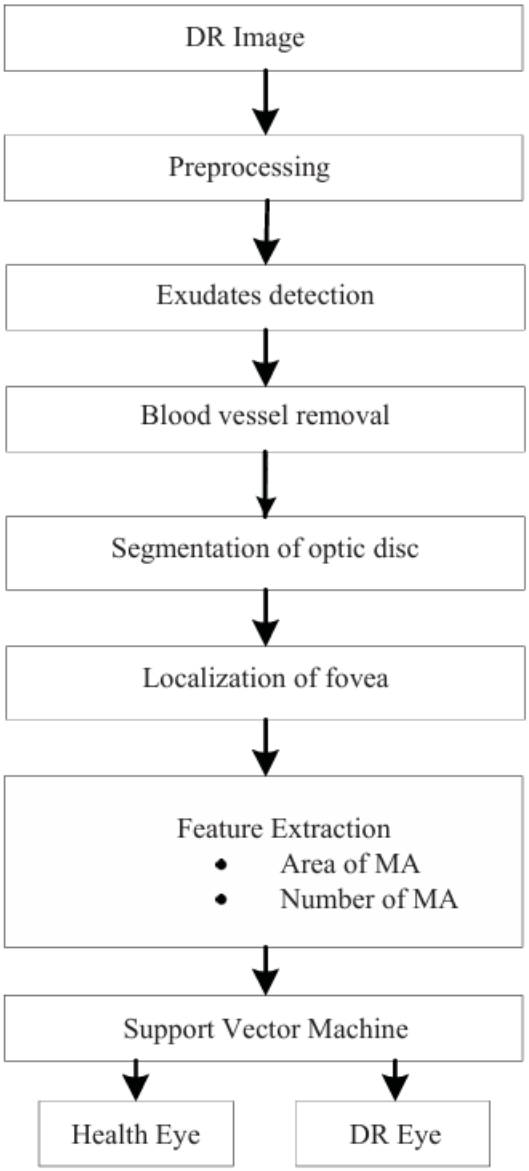

Figure: 2 Block diagram of DR detection

For contrast enhancement, adaptive histogram equalization, or ADHE, is employed. In order to reallocate the image's intensity value, ADHE computes multiple histograms. Therefore, ADHE is more suited to boost edge enhancement and regional contrast in each area of the image [8]. To eliminate noise, mathematical morphological operations are used. The purpose of the closing process is to eliminate noise from the object zone.

Exudates are removed from the color fundus picture during pre-processing. Since exudates and microaneurysms have the same color, exudate detection is essential for microaneurysm detection. The pre-processed green channel image, which is further improved by ADHE, is used to detect exudates. Following that, a marker was created using a median filter, and the exudates were extracted by subtracting the marker from the median filtered image using a morphological approach. Figure3 displays the image of the exudates extraction.

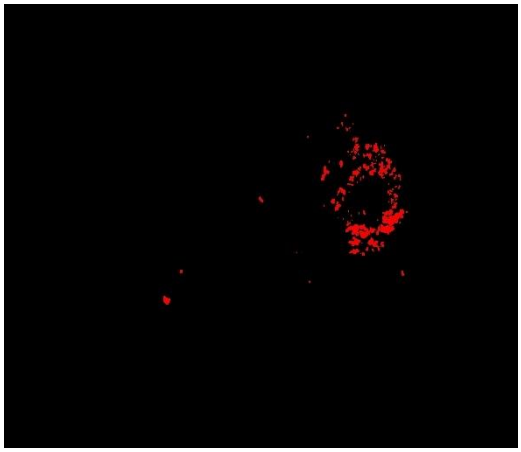

Figure: 3 Exudates in colour retinal fundus image

Following the extraction of exudates, blood vessel removal is performed. To improve contrast, an RGB image is first transformed to a grey channel. Principal component analysis (PCA) is used for greyscale conversion. Principal component analysis (PCA) is a statistical technique that creates a set of values for correlation and dependence variables from a set of observations of potentially associated variables using an orthogonal transformation. A strong technique for data analysis is PCA [9], [10]. Dimensional reduction is its primary application. In this case, a 3-dimensional matrix (RGB) is converted to a 2-dimensional matrix (gray).CLAHE is also utilized to improve contrast. CLAHE is mostly used to improve retinal images with low contrast. A transformation function is obtained for each neighborhood pixel in the case of CLAHE using a contrast-limited approach. The primary purpose of CALHE is to stop ADHE from amplifying noise excessively [8]. By averaging the improved image and deducting it from the improved image, background is removed. The image is transformed to binary scale and retinal blood vessels are extracted following background elimination. Figure 4 displays the final image.

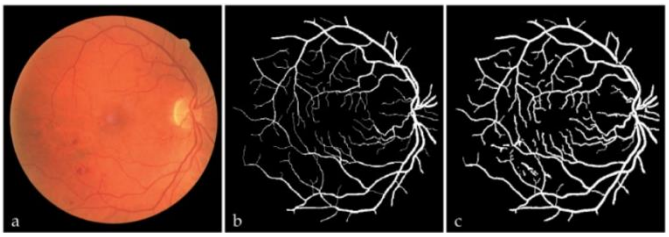

Figure: 4 Extraction of retinal blood vessels

The two processes of localization and detection are used to segment the optic disc. We start by creating a template by extracting the (80x80) pixel optic disc and blurring the image using a (6x6) window. Additionally, we keep the histograms of the color components—such as red, blue, and green—after extracting them. Every image in the database is subjected to this procedure, and an average is produced.

A pre-processed image has been utilized to locate the fovea. Since the fovea has a greater area than other structures, less than 25 pixels are removed using the basic morphological process. Fovea localization is crucial because it lowers the possibility of misdetectingmicroaneurysms. Each image has a different section. By removing the exudates, blood vessels, optic disc, and fovea from the pre-

processed image, a microaneurysm was found in the fundus image. In Figure 5, an extracted microaneurysm is displayed.

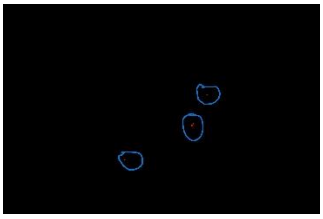

Figure: 5 an extracted microaneurysm

B. Feature Extractions

The area of the microaneurysm and the number of MAs that have been retrieved from fundus images are two characteristics of microaneurysms. The total number of white pixels in the microaneurysm extracted image, as displayed in Figure5, is used to compute the area of the microaneurysm. The number of discontinuities from white to black pixels is used to determine the number of microaneurysms.

C. Classification

For DR detection, the SVM classifier has been employed. SVM divides the image into two groups, such as healthy eye and DR eye. The SVM classifier's parameters were determined using the microaneurysm's characteristics. Bladimir Vapnik's learning theory is the source of SVM. Convex functions that never become trapped in the local maximum are the objective function in SVM.The form of the separating hyperplane is known as the optimal hyperplane, and the optimization problem's objective function solely depends on the inner products of two vectors rather than the input vector's dimensionality. Because of this, it is possible to create separate hyperplanes in high-dimensional environments, including infinite-dimensional ones [11].

Two input features, such as the area and number of MAs, were used to train the SVM parameters. The criteria for classifying DR is the average number and area of microaneurysms. SVM parameters were trained using a linear kernel with fivefold validation. New testing data is fed into the SVM classifier once it has been trained, and the results are improved.

D. Result

A total of 110 pictures, both normal and pathological, were extracted from the DIABETDB1 database. Of them, fifty-two photos are used as testing samples and fifty-eight eye images are used as training samples with fivefold validation. MATLAB R2015a has been used for simulation. The sensitivity and specificity of the suggested DR detection method are used to assess its accuracy.The suggested system's sensitivity and specificity have been calculated to be 95.21% and 91.36%, respectively. The results of the suggested DR detection scheme and the detection system by Sarni Suhaila Rahim et al. [3] are contrasted in Table 1. The suggested approach improves specificity and sensitivity.

	Sarni Suhaila Rahim et al. method		Proposed method
	RBF kernel SVM	Polynomial kernel SVM	Linear kernel SVM
Sensitivity	0.81	0.80	95.21
Specificity	1	0.55	91.36

Table 1 compares the outcomes of the suggested approach with the Sarni Suhaila Rahim et al. method.

4. Conclusion

An enhanced method for accurately determining the quantity and area of microaneurysms in order to detect diabetic retinopathy was given in this research. The suggested diagnostic technique is superior for detecting non-proliferative diabetic retinopathy, as evidenced by the obtained values of sensitivity and specificity. This paper's next step is to suggest a method for detecting proliferative diabetic retinopathy by using aberrant blood vessels and cotton wool as characteristics from colour fundus pictures.With the use of Feed Forward Neural Network, Radial Basis Function Neural Network and SVM, the DR detection system could be expanded to multiclass diabetic retinopathy classification, specifically to distinguish between proliferative, mild non-proliferative, moderate non-proliferative, severe non-proliferative, and healthy diabetic retinopathy.

REFERENCES

1. Segio B. Junior and D. Welfer, “Automatic Detection of Microaneurysms Ang Haemorrhages in Color Eye Fundus Images,” Southeast Asian J Trop Med Public Heal., vol. 34, no. 4, pp. 751–757, 2003.
2. S. S. Rahim, C. Jayne, V. Palade, and J. Shuttleworth, “Automatic detection of microaneurysms in colour fundus images for diabetic retinopathy screening,” Neural Comput. Appl., vol. 27, no. 5, pp. 1149 1164, 2016.
3. E. Ricci and R. Perfetti, “Retinal blood vessel segmentation using line operators and support vector classification,” IEEE Trans. Med. Imaging, vol. 26, no. 10, pp. 1357–1365, 2007.
4. A. Sopharak, B. Uyyanonvara, and S. Barman, “Fine Microaneurysm Detection from Non-dilated Diabetic Retinopathy Retinal Images Using a Hybrid Approach,” vol. II, pp. 6–9, 2012.
5. K. M. Adal, D. Sidibé, S. Ali, E. Chaum, T. P. Karnowski, and F. Mériaudeau, “Automated detection of microaneurysms using scale adapted blob analysis and semi-supervised learning,” Comput. Methods Programs Biomed., vol. 114, no. 1, pp. 1–10, 2014.
6. W. Zhou, C. Wu, D. Chen, Y. Yi, and W. Du, “Automatic Microaneurysm Detection Using the Sparse Principal Component Analysis-Based Unsupervised Classification Method,” IEEE Access, vol. 5, pp. 2563–2572, 2017.
7. R. A. Welikala et al., “Automated detection of proliferative diabetic retinopathy using a modified line operator and dual classification,” Comput. Methods Programs Biomed., vol. 114, no. 3, pp. 247–261, 2014.
8. B. Antal and A. Hajdu, “Improving microaneurysm detection in color fundus images by using context-aware approaches,” Comput. Med. Imaging Graph., vol. 37, no. 5–6, pp. 403–408, 2013.

9. Sharad Kumar Yadav, Shailesh Kumar, Basant Kumar, and R.Gupta "Comparative Analysis of Fundus Image Enhancement in Detection of Diabetic Retinopathy." Humanitarian Technology Conference (R10 HTC), 2016 IEEE Region 10, 21-23 Dec. 2016
10. A. Deka and K. K. Sarma, "SVD and PCA features for ANN based detection of diabetes using retinopathy," Proc. CUBE Int. Inf. Technol. Conf. - CUBE '12, no. April, p. 38, 2012.
11. S. S. Rahim, V. Palade, J. Shuttleworth, and C. Jayne, "Automatic Screening and Classification of Diabetic Retinopathy Fundus Images," Commun. Comput. Inf. Sci., vol. 459 CCIS, no. Dm, pp. 113–122, 2014.
12. Logistic Regression for Machine Learning," Machine Learning Mastery, 06-Apr-2019. [Online]. Available: https://machinelearningmastery.com/logistic regression-for-machine-learning/.
13. L. Chen and L. Chen, "Support Vector Machine Simply Explained," Towards Data Science, 07-Jan 2019. [Online]. Available: https://towardsdatascience.com/support-vector machine-simply-explained-fee28eba5496
14. M. Shamsujjoha, and T. Bhuiyan, "A Content-based Image Retrieval Semantic Model for Shaped and Unshaped Objects", Journal of Computer Engineering, vol: 18, no: 1, pp:43-60, year: 2016
15. H. Abedy, F. Ahmed, M. N. Q. Bhuiyan, M. Islam, M. N. Y Ali, and M. Shamsujjoha "Leukemia Prediction from Microscopic Images of Human Blood Cell Using HOG Feature Descriptor and Logistic Regression", 16th Int'l Conf. ICT & Knowledge Engineering, pp: 1-6, year: 2018