International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 05 Issue: 08 | Aug 2018 www.irjet.net p-ISSN: 2395-0072

Detection of Microaneurysm in Diabetic Retinopathy: A Review

Ashwini Arvind Kesale[1], Prof. Prashant S. Malge[2]

[1]Master of Engineering, Department of Electronics Engineering, Walchand Institute of Technology, Solapur, Maharashtra, India.
[2]Professor, Department of Electronics Engineering, Walchand Institute of Technology, Solapur, Maharashtra, India

---

Abstract - *Diabetic retinopathy (DR) is a serious complication of diabetes mellitus and one of the major causes of blindness worldwide. As the number of diabetic patients increases, early detection of DR for regular screening can prevent loss of vision and blindness. The very first stage of diabetic retinopathy is microaneurysm, which can predict the progress of diabetic retinopathy, in which blood vessels of the retina are damaged by diabetes that will lead to the reason for blindness. Microaneurysms are reddish in color with a diameter less than 125 µm. The existing trained eye care specialists are not able to screen the growing number of diabetic patients. So there is a need to develop a technique that is capable to detect microaneurysms as a part of diagnosis system, so that medical professionals are able to diagnose the stage of the disease with ease. Thus damage caused by diabetic retinopathy can be prevented by the early detection of microaneurysm in the retina. In this paper, we review the techniques and methodologies used for detection of microaneurysm from diabetic retinopathy (DR) retinal images.*

Key Words: **Diabetic retinopathy, microaneurysm detection, automated detection**

1. INTRODUCTION

DR is a progressive pathology and its severity is determined by the number and the types of lesions present on the retina. As a consequence, there is a need to detect those lesions either for screening DR or for measuring its progression. Microaneurysm (MAs), which are small swellings appearing on the side of tiny blood vessels, are the most frequent and often the first lesions to appear as a consequence of DR. Therefore, within this study we focused on detecting this kind of lesion.

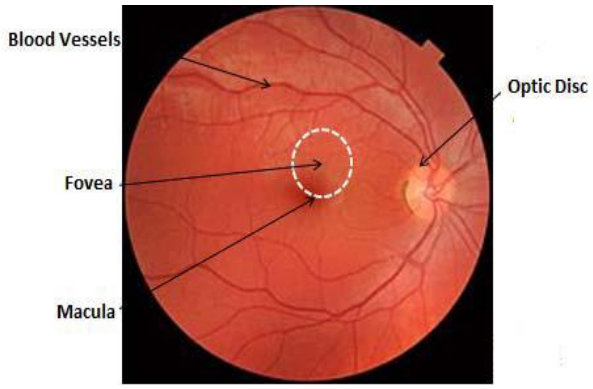

Fig.1. Normal Retinal Fundus Image

Diabetic retinopathy is classified into 4 stages: at the first stage it is Mild Non-proliferative Retinopathy. Second stage is Moderate Non-proliferative Retinopathy. Next is Severe Non proliferative Retinopathy and the final stage is Proliferative Retinopathy [1]. Non Proliferative Diabetic Retinopathy (NPDR) is the earliest of the four stages of DR, when microaneurysm appear as small regions of balloon-like inflammations in the retina's small blood vessels. If DR is identified at this stage it could be treated which prevent blindness. But with the advancement of the disease, the blood vessels that provide nourishment to the retina are blocked, which leads to blindness.

Later on, most of the blood vessels are blocked thereby retina is left without enough blood supply. [2] Proliferative Diabetic Retinopathy (PDR) is the situation which leads to the damage of retinal blood vessels. This causes the secretion of vascular endothelial growth factor (VEGF). VEGF is a substance which causes the abnormal growth of blood vessels on the surface of retina.

These vessels can bleed easily and may also cause retinal traction and detachment. These abnormal blood vessels sometimes grow to the point where they become a threat to the vision even without the person knowing that there is any problem. The different analysis procedures deal with different methods for the earlier detection symptoms.

The earlier detection helps in the treatment of the eye diseases in an effective manner. Different retinal features are blood vessels, optic nerves, macula and vitreous gel as shown in Figure 1. As a result of diabetic retinopathy, different regions on the retina get damaged and lead to loss of vision.

Due to changes in retinal features, new features like microaneurysms, hemorrhages and exudates appear in the retina as shown in Figure: 2. one of the very important steps in automated detection of DR is microaneurysm detection. Microaneurysm belong to the earliest noticeable signs of the presence of DR.

Due to the non-obvious nature of tissues with MAs against the surrounding tissues, it still remains an open issue. In this paper, some of the recent algorithms are being reviewed, which discuss the presently existing methodologies and algorithms.

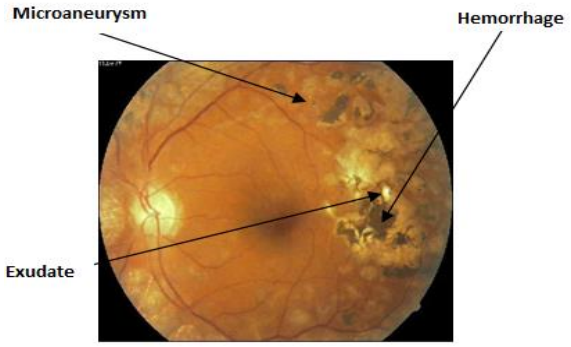

Fig2. Retinal Fundus Image Containing DR Lesions

2. CURRENT METHODOLOGIES USED IN MICROANEURYSM DETECTION

Automated system made the work of ophthalmologists at easier. It also helped to reduce the cost of detecting DR without compromising on accuracy and efficiency. Digital methods suggested by different researchers have opened wide opportunities in the field of ophthalmology. Several automated measures were developed to prevent the blindness due to diabetic retinopathy.

The process of detection of microaneurysm is as shown in the block diagram of figure 3:

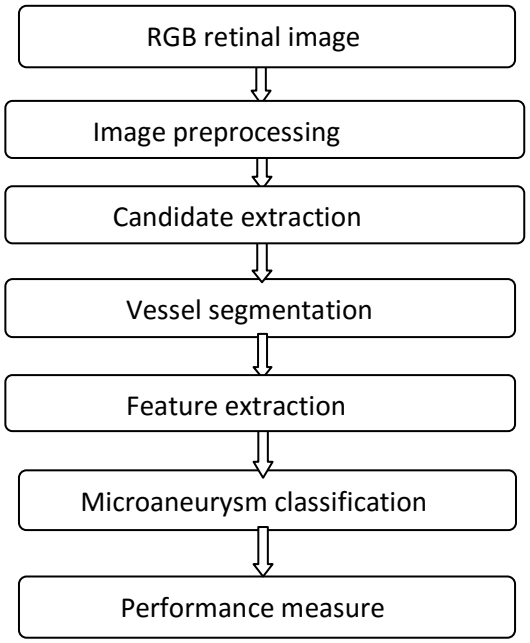

Fig 3: Block Diagram of Microaneurysm detection process

Initial stage needs image pre-processing to reduce the noise, and for image enhancement. The Image pre-processing is done on the green color plane of RGB image so that microaneurysms have the higher contrast with the background in green color plane. Image pre-processing is performed to minimize the varying intensity effect in the background throughout the image. Then, the required microaneurysm candidate regions are detected. After that, algorithms for the segmentation of blood vessels are utilized to decrease false positives in the pre-processed image. Finally, feature analysis is performed for extraction and then selection of features.

In the second stage, algorithms for classification are used for categorizing these features into MA candidates and non-MA candidates which are normal and abnormal respectively. Finally, the probability is projected for each candidate using a classifier to represent microaneurysms. This detection process ensures the probability of finding the possible occurrence of blindness.

3. RELATED WORK DONE IN DETECTION OF MICROANEURYSM

Zhang et al. [3] proposed a new approach which is based on multi-scale correlation filtering (MSCF) and dynamic thresholding. This consists of two levels coarse level and fine level detection. Microaneurysm candidate detection is called as coarse level and true microaneurysm classification is called as fine level. The images are obtained from two of the public datasets ROC (Retinopathy Online Challenge) and DIARETDB1 database for processing.

Tsuyoshi et al. [4], proposed a technique focusing on Eigen value analysis which used a Hessian matrix. The microaneurysm candidate regions were detected by Eigen value analysis with the usage of HM in green-channeled retinal fundus images following image pre-processing. For individual candidate region a group of features were considered. False positive candidates were eliminated by comparing with an accepted standard value. By making use of ANN classifier based on PCA the extracted regions were sorted to microaneurysms or false positives. The results showed 73% accuracy in MA detection, while testing on retinopathy online challenge (ROC) database, with eight false positives for each individual retinal image.

M. Usman Akram et al. [5] proposed a method for early detection of DR. The early finding of microaneurysms (MAs) is a critical step for early detection of diabetic retinopathy because they appear as the first sign of disease. A three-stage system has been proposed for early detection of MAs using filter banks. In the first stage step of, the system extracts all the possible candidate regions in which MAs are presented. Based on the following of properties such as color, shape, intensity and statistics features the candidate region is classified based on MA or non-MA. Here the hybrid classifier which adds up Gaussian Mixture Model (GMM) and support vector machine is used which improves the accuracy for classification level. The retinal images are taken from an openly available retinal image databases for processing and higher accuracy is achieved compared to another methods.

García et al. [6], proposed a technique to extract a subset to distinguish the red lesions from the image background .An MLP (Multilayer Perceptron) classifier was

utilized to get the final segmentation of retinal lesions. The database having 100 images were considered for the study. From them 50 images were used to get examples for training the classifier. The method's performance was evaluated using the other set of 50 images. These images had variable color, brightness, and quality. A lesion based criterion was followed, and they obtained a mean sensitivity value of 86.1% and also the mean positive predictive value reached 71.4%. Using an image-based criterion, they could achieve an 80.0% mean accuracy, 60.0% mean specificity and 100% mean sensitivity.

Quellec et al. [7], presented a digitalized system to detect MAs by using sub-bands of the wavelet transformed images and matching a lesion template with it. Optimization was done using genetic algorithm process. This was followed by Powell's direction set for the effective detection of MAs. Evaluation was done by an expert where in 120 retinal images were analyzed and the optimal wavelet was compared with different conventionally existing wavelets already available for analysis. The images belonged to three different modalities: viz. color photographs, green filtered photographs and angiographs. Relying on imaging modality, MAs were detected with a sensitivity of 89.62%, 90.24%, and 93.74% respectively and positive predictive values of 89.50%, 89.75% and 91.67% respectively.

Spencer et al. [8] used morphological processing which detects microaneurysms present in fluorescein angiograms. After preprocessing stage, a bilinear top-hat transformation and matched filtering are used to provide an initial segmentation of the images. Then Thresholding is used to produce a binary image that contains candidate microaneurysms. Then a novel region-growing algorithm results in the final segmentation of microaneurysms.

Frame *et al.* [9] produced a list of features like shape features and pixel-intensity features on each candidate. After that the classifier is used to classify each candidate as microaneurysm and non-microaneurysm by using these features.

Niemeijer *et al.* [10] used a hybrid approach to detect the red lesions by combining the prior works by Spencer *et al.*[8] and Frame *et al.* [9] with two important new contributions. Their first contribution is the use of new red lesion candidate detection system which is based on pixel classification. Blood vessels and red lesions are separated from the background by using this technique. Remaining objects are considered as possible red lesions after removal of vasculature. Their second contribution is the addition of a large number of new features to those proposed by Spencer-Frame. Then k-nearest neighbor classifier is used to classify the detected candidate objects. The images for the dataset are taken from the hospital. This method has achieved 100% sensitivity and 87% specificity but the time required is more for initial detection of red lesions.

BalintAntal et al. [11] announced two approaches to the improvement of microaneurysm detector ensembles. First, an approach to handpicked a set of preprocessing methods for a microaneurysm candidate extractor thus to enhance the detection performance in color fundus images is provided. The performance of the candidate extractor with each preprocessing method is measured general of about in six microaneurysm categories. They are near vessel, in the macula, periphery, obvious, regular and subtle. The best performing preprocessing method for each category is selected and organized into an ensemble-based method. The openly existing DIARETB1 database images are used for testing purposes. Second, an adaptive weighting procedure for microaneurysm detector ensembles is presented. The foundation of the adaptive weighting approach is the spatial location and the image contrast of the many detected microaneurysm. During training, the presentation of ensemble members is restrained with respect to this contextual information, which serves as a basis for the default optimal weights assigned to that the detectors. Moreover, again the proposed approach outperformed all of their investigated individual detectors.

Kedir et al.[12], modeled a microaneurysm detection system for finding blobs or interest regions from a retinal image. An automatic local-scale selection technique was formulated for MA detection. For the characterization of the regions containing blob different scale-adapted region descriptors were defined. A semi-supervised learning technique was developed, in which a few non-automated learning examples were considered. Few manually labeled and a considerable amount of unlabeled retinal color fundus images were considered for evaluation. The system was overviewed using an ROC competition database. A Competition Performance Measure (CPM) of 0.364 was obtained using the database.

Hatanaka et al.[13], developed a digital schematic by considering twenty five different cases. Earlier image preprocessing attempts were carried out and the candidate regions for microaneurysms were spotted by making use of a double ring filter. Automatic extraction of blood vessels was made and if any potential false positives were detected, they were removed by the computer based systems developed for the study. One hundred twenty six image features were considered positively for the study from which 28 were chosen by making use of principal component analysis methods. The candidates obtained were effectively classified finally into MAs or false positives by the already available artificial neural network combined with the existing rule-based methods. The achievement rate of the proposed approach was 68% by considering 15 false positives for each individual image.

Marwan D. Saleh et al. [14] presented an approach for automated diagnosis of DR integrated with a user-friendly environment. The grading of the rigorousness level of DR is based on detecting and analyzing the early clinical signs associated with the disease, such as microaneurysms

(MAs) and hemorrhages (HAs). Here some of the features are extracted such as optic disc, fovea, and retinal images for easier subdivision of dark spot lesions in the fundus images. Then it is followed by the classification of the correctly segmented spots into MAs and HAs. Based on the number and location of MAs and HAs, the system quantifies the severity level of DR. From the publically available database, 98 color images are used in order to estimate the performance of the put forth proposed system. From the experimental results, it is found that the proposed system achieved 84.31% and 87.53% values in terms of sensitivity for the detection of MAs and HAs respectively. In terms of specificity, the system achieved 93.63% and 95.08% values for the detection of MAs and HAs respectively. Also, the proposed system achieved 68.98% and 74.91% values in terms of kappa coefficient for the detection of MAs and HAs respectively.

Wenhua *et al*. [15] proposed a method to detect the microaneurysms using SVM (Support Vector Machine) in retinal fundus images. In this method, first of all a generalize histogram algorithms are used to enhance the images. Then blood vessels and any object which is too large to be a red lesion are removed. Then finally, extraction of microaneurysm is performed and its result is given as the input to the SVM to classify the microaneurysms. The images are taken from Clemson and STARE database. This system has achieved an accuracy of 90%. For the detection of red lesions like microaneurysms, this approach is a desirable approach.

Streeter *et al.* [16] proposed a microaneurysm detection method using region growing algorithm in color fundus images. After the preprocessing, the blood vessels are removed. Then thresholding and region growing algorithm is applied by taking a candidate seed image. After region growing, the features are extracted. The dataset for this method was created by scanning non-mydriatic retinal images from slide film using a Nikon LS-2000 scanner. This system has achieved 56% of sensitivity at 5.7 false positives per image.

Rukhmini et al.[17], prepared a two stage algorithm MA detection. In the first stage image pre-processing and fractal analysis of retinal vascular structure were performed. The effectiveness of the digital screening program was increased to higher degrees. Since fractal analysis improved the differentiation of abnormal images from the normal images the initial step proved more effective. The second phase was planned to obtain a typical shape of microaneurysm. Since the abnormal retinal image goes through canny edge detection and morphological reconstruction the second step also proved effective. The proposed method was experimented on a group of 89 color fundus images. A specificity of 82.1% and an operating sensitivity of 89.5% were got by applying the algorithm on retinal image.

Kamel *et al.* [18] proposed a neural network approach for automatic detection of microaneurysms in retinal angiograms. The main purpose of using neural network is that it is able to detect the regions that contain the microaneurysms and reject other regions. So to achieve this goal, the image is divided into several regions or windows. To classify the input patterns into their desired classes, LVQ (Learning Vector Quantization) is used. From a grid of smaller image windows, the input vector of the neural network is derived. According to a novel multistage training procedure, the presence of microaneurysms is detected in these windows.

Usher *et al.* [19] also used neural network to detect the microaneurysms. First of all preprocessing is done. After preprocessing, microaneurysms are extracted using recursive region growing and adaptive intensity thresholding with “moat operator” and edge enhancement operator. The images for the result evaluation are taken from the hospital. For this method, the sensitivity of detecting the microaneurysms is 95.1% and specificity is 46.3%.

4. CONCLUSIONS

Automatic detection of microaneurysm presents many of the challenges. The size and color of microaneurysm is very similar to the blood vessels. Its size is variable and often very small so it can be easily confused with noise present in the image. So there is a need of an effective automated microaneurysm detection method so that diabetic retinopathy can be treated at an early stage and the blindness due to diabetic retinopathy can be prevented. In this paper, some existing methods are reviewed to give a complete view of the field. On the basis of this work, the researchers can get an idea about automated microaneurysm detection and can develop more effective and better method for microaneurysm detection to diagnose diabetic retinopathy.

REFERENCES

[1] National Eye Institute, National Institutes of Health, “Diabetic Retinopathy: What you should know. http://www.nei.nih.gov/health/diabetic/diabeticretino.pdf

[2] http://www.retinaphysicians.com/proliferative-diabetic-retinopathy.php

[3] Bob Zhang, Xiangqian Wu, Jane You, Qin Li, Fakhri Karray, “Detection of microaneurysms using multi-scale correlation coefficients”, Elsevier, Pattern Recognition pp. 2237–2248, 2010.

[4] Tsuyoshi Inoue, Yuji Hatanaka, Susumu Okumura Chisako Muramatsu, and Hiroshi Fujit a, “Automated Microaneurysm Detection Method Based on Eigen value Analysis Using Hessian Matrix in Retinal Fundus

Images" 35th Annual International Conference of the. IEEE EMBS pp.5873-5876, 2013.

[5] M. Usman Akram, Shehzad Khalid, Shoab A. Khan, "Identification and classification of microaneurysms for early detection of diabetic retinopathy", Elsevier, Pattern Recognition pp.107–116, 2013.

[6] María García, Clara I. Sánchez, María I. López, Ana Díez and Roberto Hornero, "Automatic Detection of Red Lesions in Retinal Images Using a Multilayer Perceptron Neural Network", 30th Annual International IEEE EMBS Conference , 2008

[7] Gwénolé Quellec, Mathieu Lamard, Pierre Marie Josselin, Guy Cazuguel, "Optimal Wavelet Transform for the Detection of Microaneurysms in Retina Photographs", IEEE TRANSACTIONS ON MEDICAL IMAGING, VOL. 27, NO. 9, SEPTEMBER 2008.

[8] T. Spencer, J. Olson, K. McHardy, P. Sharp, and J. Forrester, "An image processing strategy for the segmentation and quantification in fluorescein angiograms of the ocular fundus," Comput. Biomed. Res., vol. 29, pp. 284–302, 1996.

[9] A. Frame, P. Undrill, M. Cree, J. Olson and K. McHardy, P. Sharp, and J. Forrester, "A comparison of computer based classification methods applied to the detection of microaneurysms in ophthalmic fluorescein angiograms," Comput. Biol. Med., vol. 28, pp. 225–238, 1998.

[10] M.Niemeijer,B. V. Ginneken, J. Staal, M. S. A. Suttorp-Schulten, and M. D. Abramoff, "Automatic detection of red lesions in digital color fundus photographs," IEEE Trans. Med. Imag., vol. 24, no. 5, pp. 584–592, May 2005

[11] BalintAntal, AndrasHajdu, "Improving microaneurysm detection in color fundus images by using context-aware approaches", Elsevier, Computerized Medical Imaging and Graphics pp. 403– 408, 2013.

[12] Kedir M. Adala,Désiré Sidibéa, Sharib Alia, Edward Chaumb, Thomas P Karnowskic, Fabrice Mériaudeaua, " Automated detection of microaneurysms using scale-adapted blob analysis and semi-supervised learning". Computer Methods and Programs in Biomedicine Volume 114, Issue 1, 2014, Pages 1–10.

[13] Yuji Hatanaka, Tsuyoshi Inoue, Susumu Okumura, Chisako Muramatsu* and Hiroshi Fujita, "Automated microaneurysm detect ion method based on double-ring filter and feature analysis in retinal fundus images", Annual International IEEE EMBS Conference, 2012.

[14] Marwan D. Saleh, C. Eswaran, ―An automated decision-support system for non-proliferative diabetic retinopathy disease based on MAs and HAs detection‖, Elsevier, computer methods and programs in biomedicine pp.186–196, 2011.

[15] X. Wenhua, Y. Faling and C. Guohua, "Detection of Microaneurysms in Digital Fundus Images Based on SVM," IEEE International Conference on Oxide Materials for electronic Engineering (OMEE), 2012

[16] L. Streeter and M. J. Cree, "Microaneurysm Detection in Colour Fundus Images," image and vision computing NZ, pp. 280-285, 2003.

[17] Rukhmini Roy, Srinivasan Aruchamy, Partha Bhattacharjee. "Detection of retinal microaneurysms using fractal analysis and feature extraction technique", International conference on Communication and Signal Processing,pp.469-474, April 2013, India

[18] M. Kamel, S. Belkassim, A. M. Mendonca, A. Campilho, "A Neural Network Approach for the Automatic Detection of Microaneurysms in retinal Angiograms," IEEE Conference, pp. 2695-2699, 2001.

[19] D. Usher, M. Dumskyj, M. Himaga, T. H. Williamson, S. Nussey, J. Boyce, "Automated detection of diabetic retinopathy in digital retinal images: a tool for diabetic retinopathy screening," Diabet Med., vol. 21, pp. 84- 90, 2004.