International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 03 Issue: 02 | Feb-2016 www.irjet.net p-ISSN: 2395-0072

A SURVEY ON EARLY STAGE DETECTION OF MICROANEURYSMS

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Abstract - Diabetic Retinopathy (DR) is namely damage to the retina caused by complications of diabetes in human eyes that will gradually lead to blindness, when they are not detected in the early stages. A microaneurysms is a tiny aneurysm, or swelling, in the side of a blood vessel which can rupture the retina.These microaneurysms 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. The presence of microaneurysms and retinal hemorrhages in the retina is the earliest sign of diabetic retinopathy and also there are various other severe levels of DR such as PDR and NPDR.The presence of microaneurysms can be detected by various detection methods. Early detection of microaneurysms can help to reduce blindness. In this paper we review the techniques, algorithms, and methodologies used for detection of microaneurysms from DR retinal images.

Key Words: *Microaneurysms, Hemorrhages.*

1. INTRODUCTION

Diabetes is a medical form of metabolic diseases in which a person has high blood sugar [26]. Serious long-term complications include damages to retina. At present 41 million people in India are affected by diabetes. Diabetic Retinopathy (DR) is retinopathy due to by complications of diabetes, which can eventually lead to blindness [7]. Figure 2 (A) and 2 (B) shows the vision of a normal person and the vision of a person affected by DR. It is calculable that 210 million people have diabetes mellitus worldwide of that concerning 10- 18% would have DR. Figure 3 (A) and (B) shows the retina of a normal person and person affected by DR [23]. Hence to prevent vision loss, early diagnosis of DR is very important. The longer period a person has diabetes the higher his / her chances of developing DR. And, the 4 stages of DR are as the Mild NPR,Moderate NPR, Severe NPR and Proliferative Retinopathy are based on the effect of microaneurysms. Figure 4 (A) and 4(B) shows the retina of a Non-proliferative and Proliferative DR. In this case the Normal eye is thus now compared to the DR affected eye. Microaneurysms are the first signs of DR. Figure 3 (B) shows the microaneurysms (red dot) [23]. Retinal Hemorrhages is a complaint of the eye in which blood loss occurs in the blood vessels of the retina [16].

Microaneurysms are small growth that forms on the side of the optic disk blood vessels and are caused by increased RBC aggregation and blood viscosity. Clinically,they are similar to retinal hemorrhages due to the similar shape and size. Microaneurysms are thus generally having size of about 12 - 100μm,as they are mainly lesions and hence smaller in size.

Detection of retinal hemorrhages helps to progress an automatic screening system which may promptly detect sight-threatening DR and eye disease [26]. Early detection and diagnosing aids in prompt treatment.Such an automated diagnostic tools are going to be notably useful in health camps particularly in rural areas in developing countries wherever an outsized population laid low with these diseases goes unknown. Automated detection of lesions in retinal images may be a crucial step towards economical early detection, or screening, of enormous at-risk populations, especially, the detection of microaneurysms, typically the first primary symptom of diabetic retinopathy (DR), and also the detection of drusen, the hallmark of age-related degeneration area unit of primary importance. Automated detection of diabetic retinopathy (DR) is very important for permitting timely treatment, and thereby increasing accessibility to and productivity of eye care suppliers. Some of the methodologies have been described for detection of microaneurysms.

2.VARIOUS METHODS USED IN DETECTION OF RETINAL HEMORRHAGES

Early detection of DR is a significant, because treatment methods can slow down the evolution of the disease. Most treatment methods are based on laser technology. The existing methods of hemorrhage detection can be divided into 2 consequent stages: red lesion applicant extraction and classification. First stage of detection requires image preprocessing to lessen noise and advance contrast. Second stage involves the red area of the picture are extracted and segmented to be the candidate of red lesion [1]. The overall process of
microaneurysms detection is as shown in figure 1.

The resulting subclasses review the researches based on their central methodologies involved in the detection of Microaneurysms.

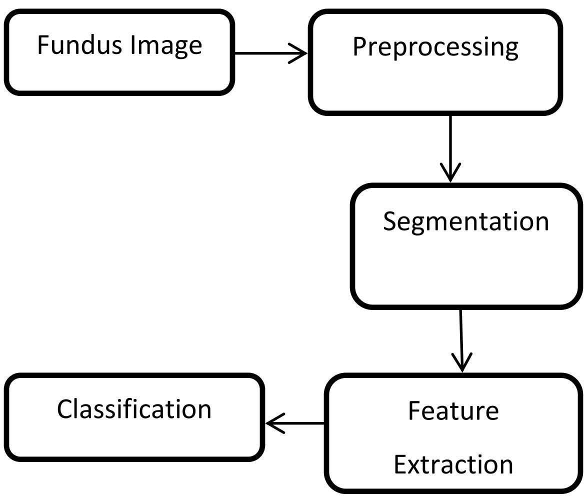

Fig -1: The Detection of Microaneurysms Process

2.1 Pre-Processing

Preprocessing method [2] is very important which is used to reduce the noise, enhance the poor contrast and lighting effects. The most frequently used method nowadays for the preprocessing step is the mainly basic morphological method. Thus preprocessing approach is needed to correct the imperfections like lighting variations, poor contrast and noise reduction which will be very much useful for the further processing of the image.Thus, below are some of the other preprocessing techniques discussed by which the retinal images can be enhanced for further processing.

Shivaram et al. [15] used image arithmetic and mathematical morphology methods to sense the presence of red lesions and the blood vessels. The preprocessing step used here is same morphological operations. The output of the result is compared with ophthalmologists' ground-truth images pixel by the pixel. Specificity, Sensitivity and predictive value obtained are 99.89, 89.49 and 98.34 respectively.

(A) (B)

Fig -2: (A) Vision of a normal person and (B) Vision of a person with DR.

Kande et al. [1, 8] proposed a detection method for microaneurysms in early, based on the pixel by classification. Morphological operation is used as a preprocessing step which is used to improve the retinal image for additional processing. Red lesion candidates are identified by using the matched filter and the morphological top-hat transformation method. Classifier used is Support Vector Machine (SVM) to categorize red lesion areas and non- red lesion areas with 89 retinal images. They were selected erratically from 3 databases namely STARE [23], DIARETDB0, and DIARETDBI [6]. This methodology realized a sensitivity of 100% and specificity of 91 %.

Zhang and Fan [27] presented an line of attack for spot lesion detection algorithm using the multi scale morphological processing. Here also morphological operations are used for preprocessing the retinal images. Blood vessel and over-detection were unconcerned by scale-based lesion validation. An algorithm was verified on 30 retinal images that were selected at random and sensitivity and predictive value obtained are 84.10% and 89.20% respectively.

2.2 Segmentation

Li Tang et al. [18] proposed a unique method where the novel image is thus segmented i.e. the splat is produced where the retinal hemorrhages is detached from the retinal background. Here the segmentation algorithm used here is Watershed Segmentation. The gradient of Magnitude is calculated for vessel improvement so that it will be stress-free to segment the retinal hemorrhages.

Kamowski et al. [17] proposed morphological reconstruction for segmentation of retinal lesion. At variety of scales the segmentation is performed using ground-truth data. They produced a "lesion population" feature vector from each image to classify normal or abnormal classes and tabulate.

2.3 Feature Extraction

Li Tang et al. [18] proposed a method where
splats are formed with their connected feature vectors and reference standard labels, a classifier can then be trained to detect objective objects. In this study, features are extracted based on two approaches namely pixel based approach and the spat wise features. From that particular features that are necessary for classification purposes are nominated.

(A) **(B)**

Fig -3:(A) Retina of a normal person and (B) Retina of a person affected by DR.

An approach has been proposed by Gardner et al. [11] which uses a back propagation neural network to detect diabetic features. The images were allocated into squares of 30x30 and 20x20 pixels used as training data and test data. Then the extracted features from each square are used to classify "normal", or "vessel", or "exudate", or ''hemorrhage''.

Usher et al. [25] also used a neural network approach for feature extraction. After preprocessing step has been carried out, the next step is hemorrhages/microaneurysms were removed and obtained using recursive region growing and the adaptive intensity thresholding in conjunction with a "moat operator", edge enhancement image operator. Sensitivity for the detection of any the hard or soft exudates and/or hemorrhages/ microaneurysms in the retinal image was 95.10% and specificity is 46.30%.

Garcia et al. [10] used morphological and region growing method to extract color and shape based features and logistic regression for selection process of the extracted features. Neural network classification: multilayer perceptron, radial basis function, support vector machine, and the high majority voting were used to detect red lesions and clasify. Garcia et al. [9] noticed red lesions by means of multilayer perceptron neural network. The procedure was tested on 50 images with a set of 29 features that describe the shape and other color notaion of image regions. Using a lesion based criterion, they touched a mean sensitivity of 86. 1 %.

2.4 Classification

After the functioning of feature extraction, the main process of classification is carried out. And many forms of classification networks are designed and used in various constrains. Let us have a study on various classification techniques used in classifying the severity of the disease such as mild, moderate and severe.

Yuji et al. [12, 28] proposed a methodology to detect hemorrhage using density analysis, rule-based method in this paper. Gray level grouping based on contrast enhancement was implemented here to improve the contrast of the green channel in early step [21]. Then candidate red lesions were feature extracted by thus employing automatic seed generation. The k Nearest Neighbor (K-nn) [14] and Gaussian Mixture Models (GMM) classifiers were used hand in hand together and called Hybrid classifier was used to classify true red lesions from non-red lesions of image. Thus ,the best sensitivity obtained was 87% with 95.53% specificity.

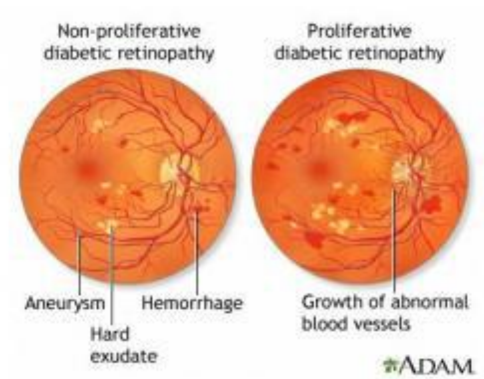

Fig -4: Retina of Non-proliferative DR and Proliferative DR.

Tang et al. [18] proposed the frequently used classification technique based on K-nn classifier. Here initially the splat is produced and for that the features are extracted based on the pixel based approach and splat wise features. And from that the particular features are extracted that will be hence necessary for the classification purpose. Then the classification process is made use throughout using the K-nn classifier. The databases they trained here are STARE and Messidor databases.

Zhang and Chutatape [28] proposed the bottom-up strategy for discovery of bright lesions and the top-down strategy in dark lesions detection. In hemorrhage detection, the vessel hemorrhages are located in the ROI firstly by manipulative the confirmation value of every pixel by means of SVM. The kernel PCA and PCA are used to select features. SVM Classifier with kernel yields 90.6% true positive while with PCA it is 89.1 %.

3. VARIOUS METHODS IN DETECTION OF MICROANEURYSMS

The earliest symptom of diabetic retinopathy is the microaneurysms. Hence it is significant to detect its occurrence in the retina of diabetic patients for early management. It is very minor in size and appears red in color in the retina. It is very parallel to the dot hemorrhages. It is also the bodily strength among all of the capillary walls. Below are the various techniques which can be used to detect the presence of microaneurysms in the retinal images are discussed.

Zhang et al. [4] 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) [13] and DIARETDB1 database [6] for processing.

M. UsmanAkram et al. [19] 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 addsup 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 anyother methods.

Marwan D. Saleh et al. [20] 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 putforth 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.

BalintAntal et al. [2] offered an approach to detect the manifestation of microaneurysms in digital color fundus images. After preprocessing step has been carried out the candidates are extracted and classified based on a innovative approach. Higher flexibility is provided by the a modular prototypical and simulated annealing-based examination algorithm to find the optimal grouping. This technique outclasses the other method that are used.

BalintAntal et al. [3] 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 its 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 is 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 these 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.

Carla Pere et al. [5] proposed a new approach for microaneurysm segmentation based on a multi-agent system model go before by a preprocessing phase to permit construction of the atmosphere in which agents are positioned and interaction, is presented. The proposed method is applied to two available online fundus image datasets and the results are compared to other previously used described approaches. By undergoing the agent interaction Microaneurysm segmentation is emerged now. The final output score of the proposed approach was 0.240 in the Retinopathy Online Challenge. Here they achieved output competitive results, predominantly in detecting microaneurysms close to vessels, compared to more conservative algorithms.

Thomas Walter et al. [24] proposed a novel method for the automatic early detection of microaneurysms in color fundus images. The algorithm used here can be classified into four steps.

Initial step consists of image enhancement, shade correction and image normalization of the green channel. The second step aims at detecting candidates, i.e. all patterns possibly corresponding to MA. This is done by diameter closing and an automatic threshold scheme. After that the features are extracted, which are used in the last step to automatically classify candidates into real MA and other objects; the classification relies on kernel density estimation with variable bandwidth. A database of 21 annotated images has been used to train the algorithm. The algorithm was compared to manually obtain grading of 94 images; sensitivity was 88.5% at an average number of 2.13 false positives per image.

4. CONCLUSION

The automatic detection of the microaneurysms presents a challenging task. It is very hard to detect the microaneurysms from the background due to various contrast variation. Since retinal hemorrhages are in various size,shape and texture it may get confuse with noise, microaneurysms and various objects available in an image. So there are various methodologies and techniques which is used to detect the presence of microaneurysms.

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