BIOSCIENCES BIOTECHNOLOGY RESEARCH ASIA, March 2017. Vol. **14**(1), 483-488

An Automated Detection of Microaneursym to Facilitate Better Diagnosis of Diabetic Retinopathy

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http://dx.doi.org/10.13005/bbra/2468

(Received: 13 February 2017; accepted: 02 March 2017)

Diabetic retinopathy is the commonest cause of vision loss in most of the cases. Microaneursyms are small balloon like swellings that appears in the blood vessels of retina. Appearance of microaneursym indicates the first stage of diabetic retinopathy. Many researchers have actively involved in detecting the micro aneurysms in order to diagnose the disease as early as possible to prevent vision loss. This will further assist the ophthalmologists in investigating and treating the disease more efficiently. This review focuses on automatic detection of micro aneurysm. The standard database such as STARE, DRIVE, DIARETDB1, DIARETDB2, Retinopathy on line challenge(ROC) data base and private database such as Messidor, Moorefield's, Mashhad were used by the researchers for testing the algorithm. The performance parameters like Sensitivity, Specificity, Precision, Accuracy, Area under Curve, Competition Performance Measure were used to measure the performance of various algorithms.

Keywords: Diabetic, algorithms, Microaneursym.

Presently in India, diseases related to food habits and life style is being increasing day by day and this is the reason for diabetes also. If the problems related to diabetes increases, it harms nerves and give rise to heart problems.

The dangerous effect of diabetes is seen on eyes. Researches in the area of detection and prevention of vision loss in diabetic patients is supported by institutes like The National Eye Institute (NEI) Diabetic eye disease refers to a group of eye problems that people with diabetes may face as a complication of diabetes. If the patient's blood sugar level is not maintained it may lead to severe vision loss or even blindness. Fig - 1 represents the scene viewed by person with normal Vision and by a person with diabetic retinopathy. It is therefore more essential to diagnose as early as possible before it turns out to be dangerous.

Diabetes affects the walls of blood veins and weakens the veins carrying oxygen to the retina. The retina is the back part of the eye and is made up of cells, which are sensitive to light. The retina is fed by a network of blood vessels. The wall of the blood vessels become fragile, weak and starts leaking blood around them. Sometimes, before the walls actually break, the weakened area can be seen to have ballooned out dots called as microaneursym. If they break, the amount of blood which leaks out is fairly small, and the symptoms may be blurring of a few areas or floating spots in front of the eyes. They may well disappear without treatment and later the blood vessels may stop carrying blood permanently, and the cells in the

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retina will die from lack of nourishment. This kind of loss of sight is gradual and permanent. When old blood vessels close down, new but abnormal ones will grow to take their place. They are unable to nourish the retina properly, and may grow into the transparent inner part of the eye, and further affect vision.

Diabetic retinopathy can be detected by dilating pupil and viewing through split lamp bio microscopy, fundus fluorescein angiography (FFA), ophthalmoscopy or fundus photography, optical coherence tomography (OCT). Fundus photographic images are used in detecting diabetic retinopathy.DR has been identified and classified into different stages according to the severity level of the disease.

Automatic screening of DR from fundus images can be done by segmenting the anatomical structures like segmentation of blood vessels, segmentation of optic disk and localisation of macula or segmenting manifestations like identification of exudates or detection of micro aneurysms and dot hemorrhages grouped as red lesions

At the earliest stage the presence of microaneursyms are observed and it is reported as Mild Non proliferative Retinopathy (Mild NPDR). As the disease progresses the number of microaneursyms increases further and there may be a blockage in some blood vessels that nourish the retina. This stage is identified as moderate Non proliferative Retinopathy (Moderate NPDR). Sluggish retinal circulation that appears in the next stage is called as venous beading which is identified as severe Non proliferative Retinopathy (Severe NPDR). In the advanced stage, the signals sent by the retina for nourishment triggers the growth of new blood vessels. Those new blood vessels are abnormal and fragile due to which they leak blood that may result in severe vision loss and even blindness can result. This condition is called proliferative retinopathy (PDR).

The ophthalmologist looks at the retina for the primary signs of the disease such as swellings in blood vessels, leaking blood vessels or any other damages in blood vessels, damages to nerve tissue and fatty deposits in retina

Survey on Detection of Micro aneurysms

Micro aneurysms in Retinal image are the first symptom for the prevalence of the Diabetic retinopathy. Micro aneurysms are focal dilatations of retinal capillaries and they appear as small round dark red dots on the retinal surface.

MAs are characterized by Intensity, size and shape. Intensity: They have luminous isolated peaks, i.e. they are much brighter than the background and they are disconnected from the network of blood vessels. Size: The diameter of a MA lies between 10 and 100 ¼m, and to the maximum of 125 ¼m. Shape: They are almost circular in shape.Fig-2 represents the fundus image of a patient with DR at different stages with their symptoms.

Sopharak, B. et al [1] in their work proposed a system with pre processing stage that includes noise removal, contrast enhancement and shade correction followed by detection and removal of Vessels, exudates and optic disc to have an effective detection of Micro aneurysms. The candidate MAs are detected by using a set of optimally adjusted mathematical morphology. The best features from a feature set of 18 features are proposed to distinguish MA pixels from non-MA pixels. Finally Classification is done using Naive Bayes Classifier. The overall sensitivity, specificity, precision, and accuracy of the proposed system are 84.82%, 99.99%, 89.01%, and 99.99%, respectively.

M.U.Akram et al [2] have proposed a technique for automatic and accurate detection of MAs from colored retinal images. The technique includes three stage in which candidate region extraction is the first stage followed by formation of feature vectors and classification. Mathematical morphology, contrast enhancement technique and Gabor filter bank are applied in the candidate region extraction phase .The pixels related to blood vessels are eliminated to enhance the detection of MA effectively. Feature vectors are formed from gray level, color, shape and statistical based features. They are further enhanced by supervised local Fisher discriminant analysis (LFDA). LFDA-GMM and SVM classifiers are combined to form a hybrid classifier in a weighted probabilistic framework to obtain better decision in the classification. The overall sensitivity, specificity and accuracy of the proposed system are 98.64%, 99.69% and 99.40% respectively.

Kedir M. Adal et al [3] proposed an a technique that uses Scale-Adapted Blob Analysis

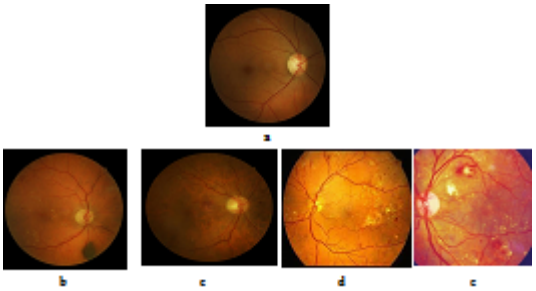
and Semi-Supervised Learning for automating the detection of Micro aneurysms. The singular value based contrast enhancement technique is used as a preprocessing step .In Feature extraction stage ,the features such as Scale-Space Features, Speeded Up Robust Features (SURF), Radon-Transform Features were calculated . Support Vector Machines (SVM), K-Nearest Neighbor (KNN), Nave Bayes, and Random Forest classifiers are employed in the classifier stage. In order to increase performance efficiency optimal classifier-feature pair was tried out. Images from Retinopathy Online Challenge (ROC) and the University of Tennessee Health Science Center (UTHSC) private database are used for experimentation. The performance evaluation results show that Radon and SURF features coupled with SVM and KNN classifiers outperform the other classifier-feature pairing.

Balint Antal [4] proposed an effective ensemble based micro aneurysm detector. They have considered several preprocessing methods such as gray level transformation, local histogram equalization, Vessel Removal and in painting, vignette correction. For candidate extractions the algorithms such as diameter closing, top-hat transformation, circular Hough-transformation, matching multiple Gaussian masks cross-section profile analysis were considered. In the proposed work they first apply the preprocessing method to the input image and then the candidate extractor is applied to the result. An ensemble E is a set of è'preprocessing method, candidate extractoré' or shortly è'PP;CEé' pairs. In the proposed Ensemble creation process all ensembles E from an ensemble pool E is evaluated and the best performing one E_{best} T E is selected based on the Euclidean distance d from c which is smaller than a predefined constant. Best performance of the proposed method 76% sensitivity and 88% specificity is achieved at the threshold of 0.9.

B Zhang et al [5] proposed a two stage algorithm in which the first step is detection of micro aneurysms in coarse level and confirming the presence of true micro aneurysms as fine tuning in the second stage. Correlation coefficient for each pixel is calculated in coarse level candidate detection by applying a sliding neighborhood filter with multi-scale Gaussian kernels to the fundus image. Gaussian kernel is preferred since micro aneurysms are circular in nature and expected to produce maximum correlation. The regions having a higher coefficient are more likely to be true micro aneurysms. The range of the coefficient is from 0 to 1.In the fine level micro aneurysms classification, the author has used features based on shape, grayscale pixel intensity, color intensity, responses of Gaussian filter-banks, and correlation coefficient values. Totally 31 features are calculated for each candidate. A discrimination table is created with minimum and maximum value for each feature of true micro aneurysms. Using this table candidate whose feature values are greater than maximum or less than minimum can be eliminated. The MSCF algorithm performs better in DIARETDB1 with that of ROC Database.

B Antal et al [6] proposed an Simulated annealing-based search algorithm to select the optimal combination of preprocessing method, candidate extractor pair. Various preprocessing

Fig. 1. Normal Vision and the same scene viewed by a person with diabetic retinopathy



a-Normal fundus; b-Mild PDR; c-Moderate NPDR; d-Severe NPDR; e-PDR

Fig. 2. Stages of Diabetic Retinopathy and their symptoms

techniques such as Walter– Klein contrast enhancement, Contrast limited (CL) adaptive histogram equalization, and vessel removal and extrapolation were used. Five different techniques were considered for candidate extraction. Then simulated annealing is used to select an optimal combination of preprocessing and candidate extraction pair. A pair that has minimum number of false positives is considered to be an optimal combination. The success of simulated annealing lies in the selection of energy function. Centroids of micro aneurysms are selected manually by clinical experts to find the ground truth. Then if the Euclidean distance of the centroid of a candidate is lesser than the manual value, it is regarded as a true positive (TP), otherwise it is a false positive (FP).Sensitivities obtained for Retinopathy Online challenge,DIARETDB1 and Moore fields databases are 74.47%,98.2% and 95.6% respectively

M. Tavakoli et al [7], proposes a complementary method for automated detection of micro aneurysms detection .The algorithm first involves in detection of the optic nerve head and vascular tree. Top-hat transformation and averaging filter were applied to remove the back ground in preprocessing step. In the main stage the whole preprocessed image is divided into sub-images, and then the vascular tree is segmented and masked by applying Radon Transform (RT) in each sub-image. RT is integral of an image over straight lines in specified angle. The proposed algorithm is more powerful and less sensitive to noise than other algorithms because the process of integration omits the intensity variations due to noise. A multi overlapping sliding window is applied to find objects on border of sub-images. The window size (n) has a direct effect on the extraction accuracy. Optimum value of n results in good lesion detection. Maximum diameter of the biggest MA

Table 1. Image processing techniques adapted by various researchers in detecting Microaneurysms with their results

S. No	Author	Year	Image processing techniques adapted	Database	Results % Se	Sp	P	A
1.	Sopharak *et al*	2013	optimally adjusted mathematical morphology + Naive Bayes Classifier	45 Real time images	84.82	99.99	89.01	99.99
2.	M. U.Akram et al	2012	Filter banks+ hybrid classifier	DIARETDB0 & DIARETDB1	98.64	99.69	-	99.40
3.	K M. Adal et al	2014	Scale-Adapted Blob Analysis and Semi-Supervised Learning	ROC & UTHSC private database	56		CPM- 0.364	
4.	B Antalet al	2010	Ensemble based micro aneurysm detector	Messidor database	76	88	AUC 0.90_0.01	
5.	B Zhang et al	2010	MSCF& dynamic thresholding	ROC &DIARETDB1	71.3	-	-	-
6.	B Antalet al	2012	Simulated annealing-based search algorithm	ROC DIARETDB1 Moorefields	74.47 98.2 95.6	-	-	-
7.	M. Tavakoli et al	2013	Radon Transform and multi overlapping window.	Mashhad Local Database from Tehran	94 100	75 70		
8.	I.Lazar et al	2013	Local Rotating Cross-Section Profile Analysis+ Naive Bayes Classifier	ROC & Moorefields	-	-	-	-

Se = Sensitivity Sp = Specificity P = Precision A = Accuracy
AUC = Area under Curve CPM = Competition Performance Measure

in pixel decides the size of n. n=18, n=10 were selected for MUMS-DB and 2nd-DB respectively. Three different retinal images databases, the Mashhad Database with 120 Fluorescein Angiography (FA)fundus images, Second Local Database from Tehran with 50 FA retinal images and a part of Retinopathy Online Challenge (ROC) database with 22 images are selected for testing the algorithm. Automated DR detection demonstrated sensitivity and specificity of94% and 75% for Mashhad database and 100% and70% for the Second Local Database respectively.

I.Lazar et al [8] proposed a micro aneurysm detection method in which the inverted green channel of a fundus image is considered as the input image to highlight MAs, hemorrhages and the vasculature as bright structures in the image. The method for the detection of MAs on retinal images is based on the principle of analyzing directional cross-section profiles centered on the candidate pixels of the preprocessed image. The local maxima of the preprocessed image are considered to reduce the number of pixels to be processed. Peak detection was applied on each profile and a set of values that describe the size; height and shape of the central peak are calculated. The statistical measures of these values as the orientation of the cross-section changes constitute the feature set used in a classification step to eliminate false candidates. A formula to calculate the final score of the remaining candidates was proposed based on the obtained feature values. Various classifiers, such as k-nearest neighbor (kNN), and support vector machines (SVMs) with different kernel functions and naïve Bayes (NB) classifier have been used .Naïve Bayes (NB) classifier seems to produce better results.

CONCLUSION

Occurrence of micro aneurysms is the first sign of presence of diabetic retinopathy. The main objective of detecting micro aneurysms is to diagnose the diabetic retinopathy at an earlier stage, which will prevent many diabetic patients from severe vision loss. Automatic detection system will be of great help to the ophthalmologist to concentrate on those patients who really have the threat of the disease. Table-1 shows the results of various Image processing techniques adapted by researchers in detecting Micro aneurysms. The algorithm considered for review mostly work on fluorescein angiography or color images taken on patients with dilated pupils, in which the MA and other retinal features are clearly visible. Efforts are to be taken to work with non dilated pupils, so that examination time and effect on patients will reduced. However, the quality of these images will be a challenge for the researchers for detecting MA. Detection of micro aneurysms that are in smaller in dimensions is difficult as they are removed during preprocessing step. The standard database such as STARE, DRIVE, DIARETDB1, DIARETDB2, Retinopathy on line challenge(ROC) data base and private database such as Messidor, Moorefield's, Mashhad were used by the researchers for testing the algorithm. The performance parameters like Sensitivity, Specificity, Precision, Accuracy, Area under Curve, Competition Performance Measure were used to measure the performance of various algorithms. A direct comparison on the performance of the methods is not possible because of authors have tested their algorithm with different databases.

REFERENCES

1. Sopharak, B. Uyyanonvara, and S. Barman D "Automatic Microaneurysm Quantification for Diabetic Retinopathy Screening", *World Academy of Science, Engineering and Technology,* **78**; 2013- pg 06-20
2. M. U Akram et al," Identification and classification of micro aneurysms for early detection of diabetic retinopathy", *Pattern Recognition* (2012)
3. Kedir M. Adal et al ," Automated Detection of Micro aneurysms Using Scale-Adapted Blob Analysis and Semi-Supervised Learning", *Computer Methods and Programs in Biomedicine*, 2014: pg 1-22.
4. Balint Antal, , and Andras Hajdu, "An Ensemble-based system for Micro aneurysm Detection and Diabetic Retinopathy Grading", IEEE transactions on biomedical engineering
5. B Zhang et al," Detection of micro aneurysms using multi-scale correlation coefficients", *Pattern Recognition*, 2010; **43**; 2237–2248.
6. B. Antal, A. Hajdu ," Improving micro aneurysm detection using an optimally selected subset of candidate extractors and preprocessing methods", *Pattern Recognition*, 2012; **45**: 264–270.
7. M. Tavakoli et al, "A complementary method

for automated detection of micro aneurysms in fluorescein angiography fundus images to assess diabetic retinopathy", *PatternRecognition,* 2013; **46**: 2740–2753

8. I.Lazar et al , "Retinal Micro aneurysm Detection Through Local Rotating Cross-Section Profile Analysis", *IEEE Transactions on medical imaging,* 2013; **32**(2).

9. Don't Lose Sight of Diabetic Eye Disease (NIH Publication No. 04-3252) and Diabetic Retinopathy: What You Should Know (NIH Publication No. 03-2171).