Original Article

Diabetic retinopathy - microaneurysm early diagnosis and prognosis assessment

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Abstract

Objective: To detect microaneurysms in retinal fundus images involving the selection of green channel of retinal fundus image illumination smoothing of retinal fundus image by bi-cubical interpolation blood vessel detection. **Materials and Methods:** Prospective randomised study retinal fundus images of 25 diabetic patients subjected to Rotational cross-sectional profile analysis on the regional maximum pixels and the peak properties are measured. The statistical parameters like mean standard deviation, co-efficient of variation of feature set are calculated. The microaneurysm candidates are estimated by comparison of distribution from the values of mean and standard deviation with the training set obtained from various datasets. **Applications:** The final MA candidates obtained can be used to diagnose developments in the earlier stages of diabetic retinopathy.

Keywords: Rotational cross-sectional analysis – Regional maximum – Classification of ma candidates.

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INTRODUCTION

Diabetes mellitus is a metabolic disease and a common lifestyle disorder affecting people of any age group and the retinal complications are one of the common causes for preventable blindness in adults[1]. A retinal microaneurysm is a tiny area of blood vessel protruding from an artery or vein in the retina of the eye. They may rupture and leak blood into the retinal tissue surrounding it, which may lead to further bleeding in the retina, vitreous, progressing to detachment of retina and visual loss, if not detected and treated at an earlier stage. The earlier stages in detection of the diabetic retinopathy is thus important to prevent blindness in diabetic patients as India is the diabetic capital of the world[2]. Currently the microaneurysm evaluation is manually performed and is subject to individual evaluation by ophthalmologists. There are three images from which microaneurysm can be detected: Fundus photograph, OCT and HRT. OCT and HRT have limited depth penetration and lack true color data. The fundus of the eye reveals the surface of the retina with its blood vessels and nerve fibres. In this process we detected the microaneurysm[3] from fundus images by involving the selection of green channel of retinal fundus image illumination smoothing of retinal fundus image by bi-cubical interpolation blood vessel detection.

MATERIAL AND METHODS

The study includes 25 cases of Diabetic patients, who attended the Outpatient in department of Ophthalmology, Melmaruvathur adiparasakthi institute of medical sciences from March 2015 to April 2016. Informed and written consent was obtained from all the patients.

Inclusion Criteria

1. Patients with diabetic retinopathy
2. Patients with clear media and Micro aneurysm

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Exclusion Criteria

1. Patients with mature cataract
2. Patients with CRVO. secondary Glaucoma, proliferative vitreo retinopathy etc
3. Other ocular pathologies like Micro Ophthalmos, Retinopathy of Maturity, Ectopialentis.
4. History of any ocular injury

Study Design

This is a Prospective, randomised, observational study of Diabetic patients attending the OPD between the period of March 2015 to April 2016 were selected randomly - criteria applied. Patients were randomly selected and examined by single ophthalmologist. Anterior segment examination was followed by the recording of initial visual acuity and the best corrected visual acuity. IOP was measured for all the cases using Applanation tonometer. Full mydriasis was obtained using homatropin 2% in young patients and phenylephrine 10% in adults. Fundus was examined with direct ophthalmoscope, indirect ophthalmoscope, 90D and B- SCAN was done in few cases. The media, disc, vessels, macula and the surrounding retina were examined. The periphery was was examined with indentation method. The various fundus changes and pathological lesions were noted. following which Fundus photograph was taken with high resolution retinal camera.

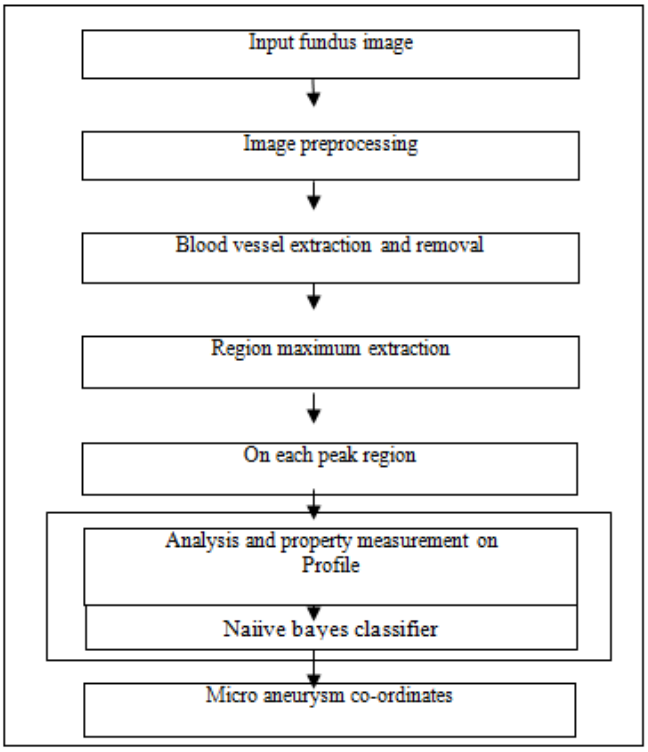

Figure 1: Work flow of proposed algorithm

The retinal images obtained from the high resolution retinal camera with suitable image quality are alone chosen for the detection. Images with dimension 3857 X 2588 pixels are alone used. The inverted green channel image convolved with then Gaussian mask then local maximum regions are extracted. The cross–sectional[4] scanning is done. Then properties of the profile are calculated. From the statistical properties the feature set. Based on naive Bayes classifier the microaneurysm are extracted.

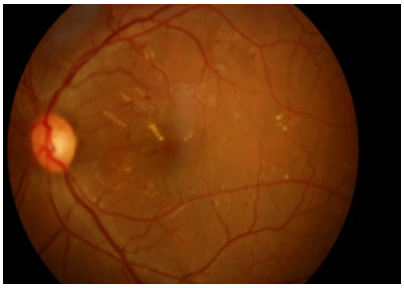

Figure 2 Colour retinal fundus image having microaneurysms

Inverted green channel

Color of each pixel consists of three components namely red, blue, green and intensity value of individual pixel. The green channel used to distinguish between the blood vessels[5] and other neighboring structure, so the green channel is used for further stages in computation. Where I is the original image, C (x, y) and L (x, y) are the contrast and illumination deviations of the pixel located in location (x, y), respectively, k1 and k2 are constant coefficients. L and C are estimated through sampling the original image.

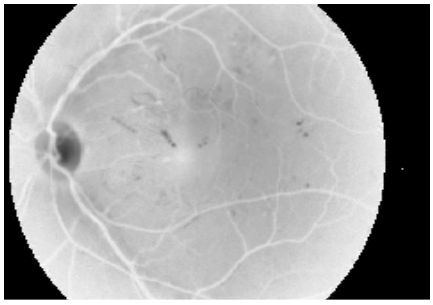

Figure 3: Green Channel retinal fundus image where the blood vessels and red colour regions are enhanced

Owing to the circular structure of the OD region in the retinal images, The interpolated surface is smoother than corresponding surfaces obtained by bilinear interpolation or nearest-neighbor interpolation. Images re sampled with bi-cubic interpolation are smoother and have fewer interpolation artifacts. Bi-cubic interpolation to calculate the mean and the standard deviation of the remaining pixels in the retinal images. To recognize the pixels in the background for the threshold.

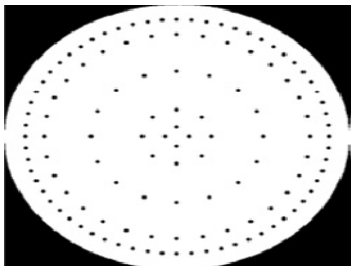

Figure 4: Non uniform sampling grid

Improved morphology

The improved morphology function is proposed to extract the blood vessels from the background of the retinal images[6]. For input image I and structuring element SE.

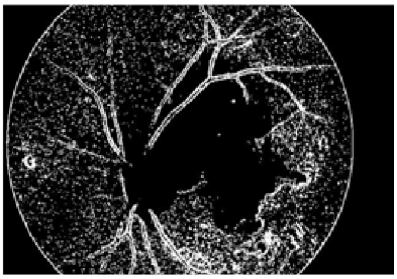

Figure 5: Detected blood vessel of retinal fundus image

Region Maximum

The local region maximum extraction is the process of extracting the pixels with higher intensity in the retinal fundus image[7].

Analysis and property measurement on each profiles

The profile analysis is done iteratively over the all the candidate pixels and with two discrete line segments of different orientations corresponding to the pixel and its values are stored. From the obtained profiles middle value of the cross-sectional profile is taken as the maximum intensity, P[C] the maximum region and the discrete line were taken based upon the central maximum candidate pixel.

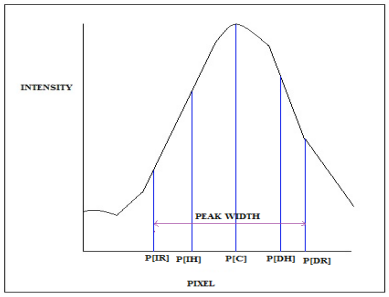

Figure 6 Analysis across the peak candidate pixel locations

Let P be a profile and P[i] denote its i^{th} value. Once the peak analysis are located, Maximum regions are taken as candidates. The figure 4.1 shows the sample peak analysis. Then final peak is represented by start of pixel locations (P[IR]), (P[IH]), and end of peak analysis[8] by (P[DH]), (P[DR]). The central peak is taken to be central pixel P[C] the peak analysis was done only along the peak pixel. Let P be a profile and P[i] denote its i^{th} value. A rising peak is defined as the increase in pixel values along the peak. Then it is compared with the neighbouring profile values the increasing peak P[IR] and decreasing peak P [DR]. Then the start and decrease of the peak is given by P[IH] and P[DR]. From the central value is compared with the neighbouring pixel value and if the difference between the two pixels is above certain value then the pixel is considered to be the P [IR] and P [DR]. From the above measured peak properties[9] are stored. Once a peak is detected the following properties are calculated.

The peak width is the difference between the start and end pixel:

Pw = P [DR]-P [IR]

The top width is the size of the gap between the increasing and decreasing ramp:

Tw =P[DH]-P[IH]

The increasing peak height: Iph=P [P [IH]]-P[P[IR]]

The decreasing peak height: Dph = P [P [DH]]-P[P[DR]]

The increasing peak slope: SIp=Iph/ (P [IH]-P[IR])

The decreasing peak slope: SDp=Dph/(P[DR]-P[DH])

The peak height (PH) is calculated as the difference between the intensity of the central pixel and a baseline that connects the start and end of profile[10].

PH=P[C]-(P[P[DR]]-P[P[IR]])/Pw.(center-[IR])+P[P[IR]]

The value of peak width corresponds to the extension of the structure in the considered direction. The top width measures how large the maximum area of the structure. The heights and slopes of the increasing and decreasing peak analysis provide information about the distinction from the surroundings, and the sharpness of the intensity transition[11].

Naïve bayes classifier

From the calculated statistical measures of the peak properties, five sets of array that contain the values of the corresponding peak properties as obtained by scanning. The increasing and decreasing peak height values are stored in IPH and DPH. The increasing and decreasing peak slope values are stored in IRS AND SPS respectively. The TW, PW and PH sets contain the top width, peak width and peak height values respectively. Let mean (μ), standard deviation ($\underline{\sigma}$) and coefficient of variation (cv_T) of the values in set T, where the coefficient[12] of variation is ratio of standard deviation and mean, that is $cv = \mu/\underline{\sigma}$. Then we consider a feature set for classification F= μ_{PW}, $\underline{\sigma}_{PW}$, μ_{TW}, $\underline{\sigma}_{TW}$, $\underline{\sigma}_{RS}$, CV_{PH}, CV_{PH}. The value of $\underline{\sigma}_{PW}$ gives a good measure of extension of candidate object. The value of $\underline{\sigma}_{TW}$ shows the symmetric of candidate object. Naïve bayes classifier is a classisifier based on all model parameters class priors and feature

probability distributions can be approximated with relative frequencies[13] from the training set. These are maximum likelihood estimates of the probabilities. μ_c be the mean of the values in x associated with class c, and let σ_c^2 be the variance of the values in *x* associated with class c.

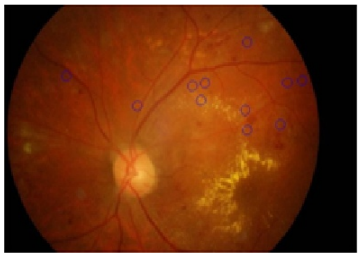

Figure 7: Colour retinal fundus image showing the detected microaneurysm centered by blue colour circles

The study was reviewed by the appropriate ethics committee was been performed in accordance with the ethical standards of the most recent version of the 1964 Declaration of Helsinki.

RESULTS AND OBSERVATION

Performance evaluation methodology

Analysis involves the accuracy of detections in the implemented algorithm when compared with the manual detections of the ophthalmologist, which includes the missed microaneurysm[14] which are left undetected by algorithm and other false detections FD (falsely taken as microaneurysm) and the true microaneurysm as true detections[15] TD of the implemented algorithm.

Sensitivity of algorithm is given by

$$\text{Sensitivity(S)} = \frac{\text{True detection(s)}}{\text{True Positive(s)} + \text{False Positive(s)}}$$

Higher the sensitivity of the algorithm higher is the accuracy of the algorithm.

Table 1: Sensitivity of the proposed method of microaneurysm detections

Fundus Image	Physician Detection	Algorithmic detections without blood vessel removal		Sensitivity
	Total detections	True detections	False detections	Percentage
1	11	9	2	81
2	7	6	1	85
3	15	13	2	86
4	4	3	1	75
5	9	8	1	88
6	11	8	3	73
7	14	10	4	71
8	10	9	1	90
9	12	8	4	66
10	6	6	-	100
11	9	7	2	78
12	10	9	1	90
13	12	11	1	92
14	14	12	2	86
15	10	9	1	90
16	9	7	2	78
17	11	10	1	91
18	9	9	-	100
19	14	12	2	86
20	6	5	1	83
21	4	4	-	100
22	10	9	1	90
23	12	10	2	83
24	10	8	2	80
25	11	10	1	91

Out of 25 patients examined 12% of patients found to be 100 % sensitive, 28% of patients fall in-between 90-95% sensitivity, 36% of patient in the range of 80-90% sensitive, 20% of patients were 70-80% sensitive and only 4% of patient fall under 70% sensitivity which is just 1 case of 25 patients. By observing the results obtained from the 25 patients, the proposed algorithm has more sensitivity than the manual detections.

CONCLUSION

For the detection of microaneurysm the directional cross-sectional analysis is used. Directional cross-sectional

analysis yields the best results in the computation and aids in the diagnosis of microaneurysm significantly from the pixels in the retinal fundus images[16] of the patients. The microaneurysm are extracted by means of local regional maximum pixel. The local regional maximum pixels is followed by cross-sectional profile analysis for property measurement and the final feature set for the classification. This proposed algorithm can distinguish the microaneurysm in the blood vessel bifurcations and other regions which are difficult to make out individually, still some microanuerysm are falsely detected, particularly in the cup disk region and in some vessel crossing regions. It falsely detects the local maximum regions inside the optic disk cup region considering it as an microaneurysm, leading to increase in the number of false positives, so an algorithm must be developed such that the local maximum regions in the optic cup disk regions are neglected and better specificity can be achieved. This is a simple, non invasive procedure, can be used in any patients who are even not fit for fundus fluoresce in angiography secondary to renal impairment or hypersensitive to fluorescein dye etc. This procedure will help the ophthalmologist in grading the diabetic retinopathy accurately and to evaluate the prognosis during follow up. Apart from the Diabetic retinopathy this procedure is helpful in evaluating patients suffering from non diabetic retinopathy such as hypertensive retinopathy, radiation retinopathy, retinal vein occlusion, Aplastic anemia, sickle cell disease etc were microaneurysm is one of the pathogonomic feature.

REFERENCES

1. Vamsi KC, Sujatha P. Study Of Serum Magnesium, Hba1 C and Microalbuminuria in Diabetic Retinopathy. Int J Pharm Bio Sci.2013; 4(3):501 - 09.
2. Antal B, Hajdu A. An ensemble-based system for microaneurysm detection and diabetic retinopathy grading. IEEE Transactions on Biomedical Engineering. 2012; 59(6):1720–26.
3. Cree MJ, Olson JA, McHardy KC, Sharp PF, Forrester JV. A fully automated comparative microaneurysm digital detection system.Eye.1997; 11(2): 622–28.
4. Istvan Lazar, Andras Hajdu. Retinal microaneurysm detection using retinal cross-sectional profile analysis.IEEE Transactions on Medical Imaging.2013; 32(2):400- 7.
5. Mendonca A, Campilho A, Nunes J. Automatic segmentation of microaneurysms in retinal angiograms of diabetic patients, in Proceedings in International Conference in Image Analysis and Processing.1999;12(5):728–33.
6. Niemeijer M, Staal J, Abramoff MD, Suttorp Schulten MA, Van Ginneken B. Automatic detection of red lesions in digital color fundus photographs. IEEE Transactions in Medical Image Processing.2005; 24(5):584–92.
7. Quellec G, Lamard M, Josselin P, Cazuguel G, Cochener B, Roux C. Optimal wavelet transform for the detection of microaneurysms in retina photographs. IEEE Transactions in Medical Imaging, 2008; 27(9):1230–41.
8. Ram K, Joshi GD,Sivaswamy J. A successive clutter-rejection-based approach for early detection of diabetic retinopathy. IEEE Transactions Biomedical Engineering. 2011; 58(3):664–73.
9. Sanchez. CI, Hornero, Mayo A, Garcia M,. Mixture model based clustering and logistic regression for automatic detection of microaneurysms in retinal images in Procedings. SPIE Medical Imaging and Computer Aided Diagnosis.2009; 19(4):500-7.
10. Spencer T, Olson A, McHardy V, Sharp PF. Forrester JV. An image processing strategy for the segmentation and quantification of microaneurysms in fluorescein angiograms of the ocular fundus. Computer Biomedical Research.1996; 29:284–302.
11. Walter T, Massin P, Arginay A, Ordonez R, Jeulin.C, Klein JC. Automatic detection of microaneurysms in color fundus images. Medical Image Analysis. 2007; 11:555–66.
12. Zhang B, Wu X, You J, Li Q, Karray F. Detection of microaneurysms using Multi scale correlation coefficients.Pattern Recognition.2010;43(6):2237– 48.
13. Sivakamasundari,. Kavitha G, Natarajan V, Ramakrishnan S. Proposal of a Content Based retinal Image Retrieval system using Kirsch template based edge detection. Informatics Electronics Vision.2014; 3(2):1-5.
14. Hanung AN, Dhimas AD, Indriana H, Latifah L. Automated microaneurysms (MAs) detection in digital colour fundus images using matched filter. Computer Control Informatics and its Applications.2015;5(5):104-8.
15. Mohammad A, Miad F. Histogram analysis for automatic blood vessels detection: First step of IOP. IEEE International Conference on Electro Information Technology.2015; 6(1):146-51.
16. Sohini RC, Dara I, Sam K, Keshab P. Optic Disc Boundary and Vessel Origin Segmentation of Fundus Images. IEEE Journal of Biomedical and Health Informatics.2015; 99:1.

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