Advances and Applications in Mathematical Sciences
Volume 18, Issue 9, July 2019, Pages 909-917

EFFICIENT IDENTIFICATION AND CLASSIFICATION OF BLOOD VESSELS AND EXUDATES IN RETINAL IMAGES FOR DIABETIC RETINOPATHY ANALYSIS

P. B. CHANDA and S. K. SARKAR

Department of Computer Science and Engineering
Kalyani Government Engineering College
Kalyani, West Bengal, India

Department of Electronics and telecommunication Engineering
Jadavpur University
Kolkata, West Bengal, India
E-mail: pramitcse@gmail.com,
su_sircir@yahoo.co.in

Abstract

Today, Retinopathy is one of the major concern for diabetic patients are responsible for color blindness for the abrupt changes part of the retinal area of particular patients. Diabetic retinopathy images are slightly deviated from the fundus images by some component such as microaneurysm, hemorrhages, exudates, cotton wool spots and variations in blood vessels etc. Due to presence of these features in retinal area might occurs the loss of vision. The main objectives are to efficiently segmentation of blood vessels and detect the different areas of abnormalities present in the retina like optic disk, exudates etc. The RGB green channel retina images are used for segmentation methods. In this work, we present the approach of blood vessel segmentation using computer intelligence by edge based segmentation and vessel detection using morphological processing. There method efficiently use the adaptive threshold based segmentation for detecting the optical nerve, blood vessel and exudates, abnormalities are present in retina images for primary detection of diabetic retinopathy. Here, our results achieve more than 90% accuracy rates of classification of datasets like DIARECTDB0, DIARECTDB1.

1. Introduction

Diabetes is a type of chronic end organ disease that basically reason for happening for lack of sufficient secretion of accurate insulin pancreas region [1]. Physical inactivenes, aging, family history, hypertension and extension of

2010 Mathematics Subject Classification: 68U01, 68U10.
Keywords: retinal images, diabetic retinopathy analysis.
Received January 7, 2019; Accepted January 27, 2019

levels of obesity are bigger causes of diabetics [2]. Already a large no of people in all over the world are suffering with this disease. It is already predicted by the experts doctors that, the disease will be enhanced to all most 40-50 million by 2030 [3]. Diabetes not only alter condition the circulatory system of human, but also the optical disk region. Diabetic retinopathy (DR) is a kind of disease where the retinal vessel's are damaged for leakage of fluid from region of blood vessels into the retinal location.

The identification of blood vessels is very urgent task in the applications domain of image processing in ophthalmology [4]. Segmentation methods are here normally required to detect blood vessels for utilizing the contrast between the retinal vessels area and the background area located in region. The major techniques are used to segment the vessels in images of the retina including are matched filtering [5], tracking vessels [6], neural networks [7], morphological operations. In the particular work, we present a technique of extraction of blood vessel which is based on matched filtering method and adaptive histogram equalization method of detection of haemorrhages and classify the retinal cases with higher accuracy of classification. The main motivation of this work are detection of blood vessels, haemorrhages, exudates, Optical Disk Area.

1.1. Optical Disk

The Optic disc (OD) is the most important parts of the retina. OD is the one of the brightest region of retinal having elliptical in nature in which it appears orange pink with the brightness with a pale area in center region. The blood vessels are emanating out from the OD.

1.2. Blood Vessel

The retinal blood vessels are usually referred to arteries and veins. Then artery and central vein normally appear near each other in the nasal side of the optical disc center. Blood vessels are more clearer in the green component region. The processes are used to detection of blood vessels as identification of edges; and the other is rough knowledge regarding the position of optical disk area. The landmarks for locating the optic disk, the fovea (central vision area), and lesions are detected in blood vessels area. As a result of systematic or local ocular disease, the blood vessels can have measurable abnormalities in diameter and color [9, 10].

1.3. Exudates and Microannuams

The exudates detection was achieved by dividing the segmentation process into two parts; first by rough exudates segmentation and fine exudates segmentation. The purpose of this stage is to estimate the size and position of the exudates in the fundus image. The lesions like Microannuam As (MAs) and several exudates are bright area can be identified from the retina images. The exudates are looking as brighter in the particular image. Adaptive histogram equalization is required several times on image and extraction of the exudates is done by segmentation method.

2. Proposed Methodologies

Here, the technique used different steps as like as-

A. Image Pre-Processing

Image pre-processing is the initial step in automated retinal pathological diagnosis. It includes techniques like contrast enhancement, gray/green component, image de-noising, etc. In case of binary image, foreground regions is represented by white pixels, background is denoted by white black pixels. In case of Gray scale image, the value of pixels are in between 0 to 255 with gray level intensity value.

1. Image Intensity Conversion

Green pixels of the vessels region are denoted by RGB image and background part like the region which is noise full is marked with red and blue pixels. Blood vessels are more darker for the gray scale image, The image intensity conversion is done in green Channel areas.

2. Image Filtering

In cases of retinal image the noises are very high, so removal of noise is necessary for working with it. One of the effective method of filtering is medial filtering as it can filter out the outliers easily. Salt and pepper noise can be easily removed with this approach. Median filtering is used for reducing noise problem. This approach focuses on difference of Gaussians is utilized for increasing the edges visibility and other information exists in a filter image after reduction of larger noise frequency. Here Gaussian filter is required for removing Gaussian noise that is in the particular dataset.

3. Histogram Equalization

Some times some regions of particular images might appear brighter more rather than other region. Quality improvement of the image is done by histogram equalization. Image contrast can be changed by Adaptive Histogram equalization method which is dynamic in nature and intensity can be altered using this technique. The very tiny region of pixels, as noisy considered, is reduced after applying morphological operations. After using this method the image will be high contrast. In this case, the better histogram might taken from fundus image with the contact from the expert. The next step is to perform histogram specification for normalize the color region of fundus image.

4. Image Segmentation

Morphological method is a technique of considering a fixed size value of gray scale image and after that to classify each of the image pixel by checking whether it belongs this threshold value as below or higher. Here processing of normalized input image is done in two levels, first input image is dilated by structural element creation then subtraction of dilated image is done from normalized input image, calculated maximum value is taken to resulting image. Here the thresholding based segmentation is done using Otsu Thresholding method. Here, the segmentation objectives for exudates segmentation from the retinal area and vessel segmentation using some morphological operations. Also optical disk region is also important part of this work. So segmenting the OD is important part of the work. So, different holes in the retinal area are segmented by morphological segmentation.The Steps are provided in figure below. Those are given serially stepwise.

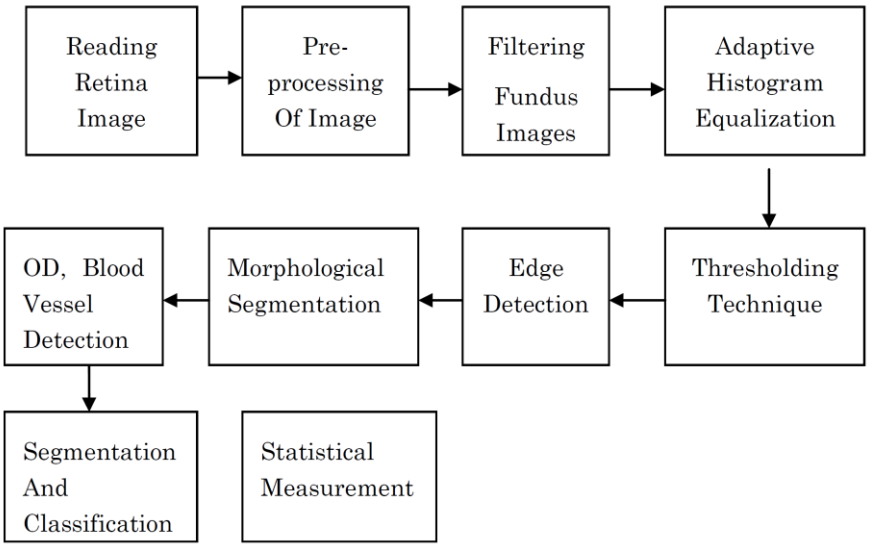


Figure 1. Proposed Methodology.

3. Results and Analysis

In this section we have presented the experimental result and evaluated the performance of the proposed method. The proposed method is implemented in the MATLAB15 in windows 7 environment.

A. Image Quality Parameter

In the experimental phase we have used the parameter PSNR (Peak Signal to Noise Ratio) for calculating the difference between the cover image and Segmented image. The PSNR for an image of size NxN is given as follows:

$$PSNR = 10 \log10 (255^2/MSE) \quad (dB)$$

$$\text{where } MSE=(1/N*N)\ \Sigma\Sigma\ (xij - x'ij\ )2.$$

Here, the bar chart shows the image quality parameters given as psnr, mse, ssim. Those statistical parameter are used to show the images performance level.

Table 1. Image Quality Parameters.

Original Image	PSNR	MSE	SSIM
Image013.png	58.374	2.946	0.9905
Image032.png	57.8166	3.8075	0.9859
Image025.png	59.0762	4.804	0.9897
Image026.png	55.1799	8.7973	0.97326

Here the plot of several images shows the statistical parameter's of different images are illustrated given below.

Figure 2. Image Quality Parameters.

This graph shows that the PSNR and SSIM values are high and MSE values are much lower for image quality measurement. So, the performance for first and second images are very good quality purposes.

Here, some cases of diabetic retinopathy are used which are shown given below. These retinal images are consisting with several abnormalities of features. All of the cases are basically shows individually several Vessels, Exudates and shape of optical nerve region. Here different cases of retinal fundus images are given from several datasets of retinopathy.

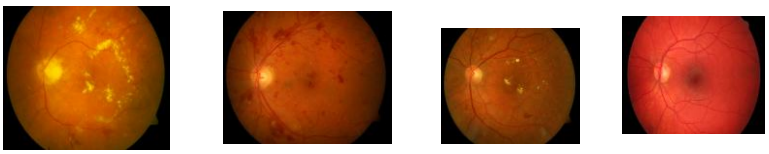
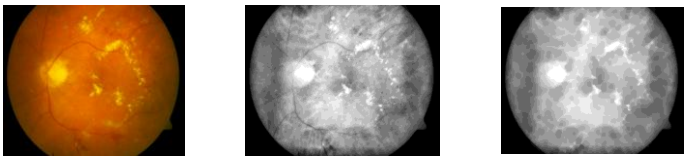
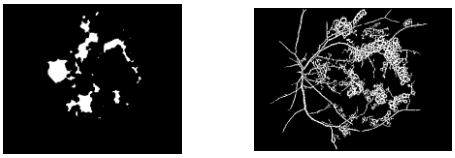


Figure 3: Case 1 Case 2 Case 3 Case 4

Here for the particular cases of retinopathy is given below:-



(a) (b) (c)



(d) (e)

Figure 4. (a) Input Image (b) Adaptive Threshold Image (c) Morphological Image (d) Optical Disk And Exudates (e) Blood Vessels And Abnormalities.

Table 2. Classification Accuracies Based On Feature Extraction.

Cervical Stages of Images	Sensitivity (%)	Specificity (%)	Accuracy (%)
Image 1	87.78	89.66	91.116
Image 2	80.09	91.12	90.09
Image 3	90.612	91.03	92.417
Image 4	89.993	86.091	90.107

The accuracy is measured with confusion matrix for supervised classification of data. The Sensitivity, Specificity, Accuracy parameter shows better classification accuracy with supervised learning methods with more than 90% of accuracy rates. Here the Accuracy of third image is more than 92% for higher accuracy rates more than other images used in datasets used like as DRIONS, DIARECTDB0, DIARECTDB1.

4. Conclusion

This work is based on image segmentation technique as morphological and adaptive threshold based segmentation has developed a methodology for primary stage of diagonosis of Diabetic Retinopathy. Here the main objectives are based on the quantity of exudates, Optical Disk, Blood Vessels identification in particular retinal image. This methods can detect exudates, Optical Disk, Blood Vessels successfully for identifying features. This method can be able for detecting fovea for several datasets. Here, operation like mathematical morphology are used for detecting lesson of blood vessels more accurately. Overall the image quality parameter obtained by using this technique are good and SSIM values near about 1 which yields better quality results for images. The methods yields more than 90% accuracy rates of properly identification of retinopathy diseases with extraction of vessels and exudates.

References

[1] M. D. Abramoff, M. K. Garvin and M. Sonka, Retinal imaging and image analysis, IEEE Reviews in Biomedical Engineering 3 (2010), 160-208.

[2] www.diabetes.org.uk,

[3] S. Wild, G. Roglic, A. Green, R. Sicree and H. King, Global prevalence of diabetes: Estimates for the year 2000 and projections for 2030, Diabetes Care, 27 (2004), 1047-1053.

[4] O. Faust, R. A. U., E. Y. K. Ng, K.-H. Ng and J. S. Suri, Algorithms for the automated detection of diabetic retinopathy using digital fundus images: A review, Jnl. Medical System 36 (2012) 145-157.

[5] G. Quellec, M. Lamard, P. M. Josselin, G. Cazuguel, B. Cochener and C. Roux, Optimal wavelet transform for the detection of microaneurysms in retinal photographs, IEEE Transactions on Medical Imaging 27 (2008), 1230-1241.

[6] J. Staa, M. D. Abràmoff, M. Niemeijer, M. A. Viergever and B. Van Ginneken, Ridge-based vessel segmentation in color images of the retina, IEEE Transactions on Medical Imaging 23(4) (2004), 501-509.

[7] A. Hoover and M. Goldbaum, Locating the optic nerve in a retinal image using the fuzzy, IEEE Transactions on Medical Imaging 22(8) (2003), 951-958.

[8] B. Kochner, D. Schuhmann, M. Michaelis, G. Mann and K. H. Englmeier, Course tracking and contour extraction of retinal vessels from color fundus photographs: most efficient use of steerable filters for model based image analysis, Proceedings of the SPIE, The International Society for Optical Engineering, San Diego, CA, 1998.

[9] C. nthanayothin, J. F. Boyce, H. L. Cook and T. H. Williamson, Automated localisation of the optic disc, fovea, and retinal blood vessels from digital colour fundus images, British Journal of Ophthalmology 83 (1999), 902-910.

[10] D. Selvathi, N. B. Prakash and Neethi Balagopal, Automated detection of diabetic Retinopathy forearly diagnosis using Feature Extraction & support vector machine, International Journal of emerging technology and advanced Engg. 2(11) (2012), 103-108.

[11] Q. Li, J. You and D. Zhang, Vessel segmentation and width estimation in retinal images using multiscale production of matched filter Responses, Expert Systems with Applications 39-9 (2012), 7600-7610.

[12] Y. Hatanaka, T. Nakagawa, Y. Hayash, A. Fujita, Y. Mizukusa, M. Kakogawa, K. Kawase, T. Hara and H. Fujita, CAD scheme for detection of hemorrhages and exudates in ocular fundus images, in Proc. SPIE Medical Imaging 2007: Computer-aided Diagnosis, San Diego, 2007, vol. 6514, pp. 65142M-1-65142M-8.

[13] A. D. Fleming, K. A. Goatman, S. Philip, G. J. Williams and G. J. Prescott, The role of haemorrhage and exudate detection in automated grading of diabetic retinopathy, Br. J. Ophthalmol 94(6) (2010), 706-711.

[14] Nidhal Khdhair EI Abbadi and Enas Hamood Al Saadi, Bood vessel extraction using mathematicalmorphology, Journel of Computer Science 9(10) (2013), 1389-1395.