Retinal Blood Vessel Segmentation Algorithm for Diabetic Retinopathy using Wavelet: A Survey

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***Abstract*—**Blood vessel structure in retinal images have an important role in diagnosis of diabetic retinopathy. There are several method present for automatic retinal vessel segmentation. For developing retinal screening systems blood vessel segmentation is the basic foundation since vessels serve as one of the main retinal landmark features. The most common signs of diabetic retinopathy include hemorrhages, cotton wool spots, dilated retinal veins, and hard exudates. A patient with diabetic retinopathy disease has to undergo periodic screening of eye. For the diagnosis, doctors use color retinal images of a patient required from digital fundus camera. We present a method that uses Gabor wavelet for vessel enhancement due to their ability to enhance directional structures and euclidean distance technique for accurate vessel segmentation. Retinal angiography images are mainly used in the diagnosis of diseases such as diabetic retinopathy and hypertension etc. In diabetic retinopathy structure of retinal blood vessels change that leads to adult blindness. To overcome this problem automatic biomedical diagnosis system is required. The main stage of diabetic retinopathy are Non-proliferative diabetic retinopathy (NPDR) and proliferative diabetic retinopathy (PDR). Eye care specialist can screen vessel abnormalities using an efficient and effective computer based approach to the automated segmentation of blood vessels in retinal images. Automated segmentation reduces the time required by a physician or a skilled technician for manual labeling. Thus a reliable method of vessel segmentation would be valuable for the early detection and characterization of changes due to such diseases. This article presents the automated vessel enhancement and segmentation technique for colored retinal images. Segmentation of blood vessels from image is a difficult task due to thin vessels and low contrast between vessel edges and background. The proposed method enhances the vascular pattern using Gabor wavelet and then it uses euclidean distance technique to generate gray level segmented image.

Keywords*-Diabetic Retinopathy, Retinal Blood Vessel, Segmentation, Wavele***t.**

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I. Introduction

One of the most important diseases that causes blood vessels structure to change is diabetic retinopathy that leads to adults blindness. Diabetic affects almost 31.7 million Indian, and has associated complications such as vision loss, heart failure and stroke. Diabetic disease which occurs when the pancreas does not secrete enough insulin or the body is unable to process it properly. This disease affects slowly the circulatory system including that of the retina. As diabetes progresses, the vision of a patient may start to deteriorate and lead to diabetic retinopathy. Diabetic retinopathy (DR) is a common cause of blindness among the diabetic population. Despite various advances in diabetes care over the years, loss of vision is still a potentially devastating complication in people with diabetes. The risk of severe vision loss can be reduced significantly by timely diagnosis and treatment of DR.

Blood vessel structure in retinal images have an important role in diagnosis of diabetic retinopathy. There are several method present for automatic retinal vessel segmentation. For developing retinal screening systems blood vessel segmentation is the basic foundation since vessels serve as one of the main retinal landmark features. The most common signs of diabetic retinopathy include hemorrhages, cotton wool spots, dilated retinal veins, and hard exudates. A patient with diabetic retinopathy disease has to undergo periodic screening of eye. For the diagnosis, doctors use color retinal images of a patient required from digital fundus camera. We present a method that uses gabor wavelet for vessel enhancement due to their ability to enhance directional structures and euclidean distance technique for accurate vessel segmentation.

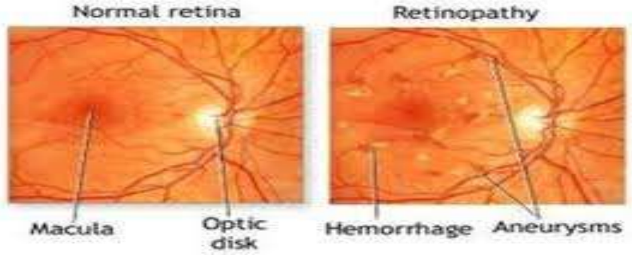

Figure1.1 Difference between normal and diabetic retina

Diabetic Retinopathy:

Diabetic retinopathy is a chronic progressive, potentially sight-threatening disease of the retinal microvasculature associated with the prolonged hyperglycaemia and other conditions linked to diabetes mellitus such as hypertension. Diabetic retinopathy is a complication of diabetes mellitus. Diabetes mellitus is a condition in which the blood sugar level is elevated because the body is unable to use and store sugar. This high sugar content damages blood vessels in the body over time and can affect a variety of body organs such as the eyes, heart, and kidneys. Diabetes affects the eyes by causing deterioration of blood vessels in the retina. Breakdown of retinal blood vessels may result in fluid leaking into the center of the retina (macular edema) or abnormal blood vessels that grow on the surface of the retina (neovascularization) which can bleed and scar. This can lead to loss of central and possibly peripheral vision.

A simple example of a diabetic retinopathy is shown below:

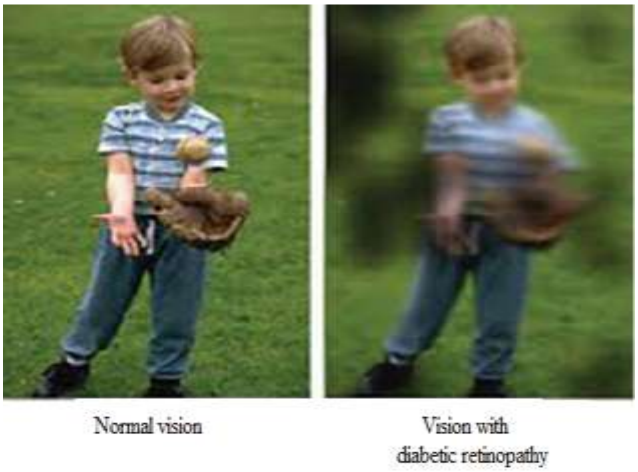

Figure1.2: Difference between normal vision and vision with diabetic retinopathy

Stages of Diabetic Retinopathy:

The diabetic retinopathy has 4 stages.

- Mild non-proliferative retinopathy
- Moderate non-proliferative retinopathy
- Severe non-proliferative retinopathy
- Proliferative retinopathy

Mild non-proliferative retinopathy is the earliest stage.in this micro aneurysms occur. They are small areas of balloon-like swelling in the retina's tiny blood vessels. The next stage is moderate non-proliferative retinopathy. As the disease progresses, some blood vessels that nourish the retina are blocked. The third stage is severe non-proliferative retinopathy. Many more blood vessels are blocked, depriving several areas of the retina with their blood supply.These areas of the retina send signals to the body to grow new blood vessels for nourishment. The advance stage is proliferative retinopathy. At this advanced stage, the signals sent by the retina for nourishment trigger the growth of new blood vessels.

II. METHODOLOGY

Blood vessel structure in retinal images have an important role in diagnosis of diabetic retinopathy. There are several method present for automatic retinal vessel segmentation. Below table1 shows the summary of blood vessel segmentation. For developing retinal screening systems blood vessel segmentation is the basic foundation since vessels serve as one of the main retinal landmark features. The most common signs of diabetic retinopathy include hemorrhages, cotton wool spots, dilated retinal veins, and hard exudates. A patient with diabetic retinopathy disease has to undergo periodic screening of eye. For the diagnosis, doctors use color retinal images of a patient required from digital fundus camera. The present study is aimed to develop an retinal blood vessel segmentation technique. We present a method that uses gabor wavelet for vessel enhancement due to their ability to enhance directional structures and euclidean distance technique for accurate vessel segmentation.

TABLE I. BLOOD VESSEL SEGMENTATION SUMMARY

S.No.	Year	Author	Methodology
1	2006	Joao V. B. Soares, Jorge J.G. Leandro,	Supervised Classification
2	2008	A.Osareh and B.Shadga	Gabor Wavelet+Gaussian mixture mode
3	2010	C. Siddalingaswamy, K. Gopalakrishna Prabhu	Entropic Thresholding
4	2012	M. Usman Akram , Shoab A. Khan	multilayered thresholding technique
5	2012	S. Muthu Lakshmi	Supervised Method
6	2013	E. Annie Edel Quinn, K. Gokula Krishnan	Curvelet Transform
7	2013	Renoh C Johnson, Veena Paul, Naveen N, Padmagireesan S	Curvelet Transform
8	2014	Nafeela Jahan.N	Neural Network
9	2014	C.R.Dhivyaa, K.Nithya and M.Saranya	AM-FM Method
10	2014	Sneha Purusharthi, Bhakti Kurhade	Support Vector Machine

Gabor Wavelet:

The problem with blood vessel segmentation is that the visibility of vascular pattern is usually not good especially for thin vessels. So, it is necessary to enhance the vascular pattern. Here we have used gabor wavelet to enhance the vascular pattern and thin vessels. Gabor wavelets have directional selectiveness capability. They act as low level oriented edge discriminators and also filter out the background noise of the image. Since vessels have directional pattern, so Gabor wavelet is best option due to its directional selectiveness capability of detecting oriented features and fine tuning to specific frequencies.

The Gabor wavelet having following merits

- Reduce noise in single step by adjusting the different frequencies
- Gabor wavelet has the capability of detecting oriented features and tuning to specific frequencies.
- Different scales of gabor transform allow us to detect vessels with various thicknesses. The pixels of image are viewed as objects that are represented by feature vectors so statistical classifiers can be applied for segmentation.
- The Gabor transform enhance the vessel contrast and filter out the noise. It is used in different scales and makes it possible to segment vessels of different orientations.

The Gabor wavelet is the most popular complex wavelet used in practice, which mother wavelet is defined as:

$$\psi_m(x) = \exp(jk_0 x)\exp(-\frac{1}{2}|Ax^2|) \qquad (1)$$

Euclidean distance is used for the false edge detection. In our project classification is based on the pixels. Each pixel is categorized as vessel or non-vessel. Two widely known measurements are used for evaluation of his method :sensitivity and selectivity. The true positive fraction (TPF), also called sensitivity, is determined by dividing the number of pixels correctly classified as vessel pixels (TP) by the total number of vessel pixels in the ground truth.

$$Sensitivity = \frac{TP}{TP + FN} \qquad (2)$$

Specificity is determined by dividing the number of pixels correctly classified as background pixels (TN) by the total number of background pixels in ground truth.

$$Specificity = \frac{TN}{TN + FP} \qquad (3)$$

Where false negative (FN) appears when a pixel in a vessel is segmented in the non-vessel area,and a false positive (FP) when a non vessel pixel is segmented as a vessel pixel.True positive (TP) and true negative (TN) when a pixel is correctly segmented as a vessel or non vessel. The accuracy of the binary classification is defined by

$$Accuracy = \frac{TP + TN}{P + N} \qquad (4)$$

Where P and N represent the total number of vessel and non-vessel pixels in the segmentation process. The accuracy shows the degree of conformity between the output and the manual of original image. Thus, the accuracy is strongly related to the segmentation property and shows how proper are the segmentation method. For this reason it is used to evaluate and compare different methods. Gabor wavelet is more accuracy from the other vessel detection method.The Gabor transform enhance the vessel contrast and filter out the noise. It is used in different scales and makes it possible to segment vessels of different orientations.

III. RESULT AND CONCLUSION

The Gabor wavelet is efficient in enhancing vessel contrast, while filtering out noise. Gabor wavelet is chosen, because it has the capability of detecting oriented features and tuning to specific frequencies. Since it can adjust to the frequency, background noise can be removed. The problem with blood vessel segmentation is that the visibility of vascular pattern is usually not good especially for thin vessels. So, it is necessary to enhance the vascular pattern. Normally matched filters and gabor filters are used for this purpose but here we have used gabor wavelet to enhance the vascular pattern and thin vessels. Gabor wavelets have directional selectiveness capability. They act as low level oriented edge discriminators and also filter out the background noise of the image. Since vessels have directional pattern, so Gabor wavelet is best option due to its directional selectiveness capability of detecting oriented features and fine tuning to specific frequencies. Euclidean distance is choosen for false edge detection.

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