# Detection of Diabetic Retina using Vascular Skeleton and its Fractal Dimension

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**Abstract:** The main intention of this work is to reduce retinal disorders in younger generation. Diabetic Retinopathy is most common disease of all diabetic patients caused due to the changes in blood vessels of retina. Retina images are obtained from the fundus camera and graded by skilled professionals. However there is a considerable shortage of expert observers has encouraged computer assisted monitoring. The severity of this disease includes formation of exudates, micro aneurysm and hemorrhages. The retinal blood vessel differs for every individual and this paves the way to use human retinal blood vessels as a reliable way for identifying the person. Compared to other biometric technologies the error rate is smaller because the retina is an internal layer in the eye which is well protected to the changes in the outer environment. The blood vessel structure will stay almost similar in a person's lifespan varying only when any of the ophthalmological diseases are caused. Retinal blood vessel extraction is a major step for identification process which is followed by fractal dimension calculation. Different person's results in different fractal dimension values.

**Keywords**: Diabetic retinopathy (DR), blood vessels, fundus images, exudates, micro aneurysms, image processing, morphological processing, optic disc, disease severity.

## Introduction

Diabetes has turn out to be one of the quickly increasing diseases worldwide. Diabetic Retinopathy is outcome of long standing hyper glycaemia, in which retinal lesions developed that could direct to blindness. Commonly excepted rigorous guidelines for the evaluation of biometric authentication methods for face recognition have enabled the fast progress in the field and similar can be likely in the medical image processing related to diabetic retinopathy detection.

Enhance in blood sugar levels linked with diabetes is the reason of Diabetic Retinopathy(DR). Progressive degenerative syndrome of the retina has an asymptomatic phase that can start long before the beginning of recognized diabetes. Diabetic retinopathy is divided into various stages. The initial signs of DR are micro aneurysms, minute hemorrhages, cotton wool spots, and exudates. These early signs are known as Non proliferative Diabetic Retinopathy (NPDR). There may even be prior indications of diabetic retinopathy. Fluid leaking from the retinal capillaries indicates a additional progression of the disease, this may lead to vision Threatening Diabetic Retinopathy if the leakage is situated in the area of most sensitive vision and is known as Non proliferative Diabetic Retinopathy (NPDR). It is important noting here in advance that certain lesions representing DR, such as the number of micro aneurysms and dot hemorrhages, have been established to correlate with disease severity and likely development of the disease, such lesions have a reasonably well defined appearance and signify useful targets for programmed image detection, and the detection of them provides useful information. It is also important that DR is a treatable disease all through disease development commencing from the preclinical stage, if detected early and treated then significant saving in cost and reduction in the progression of vision loss is possible. As the disease is treatable, detection and monitoring of the disease using fundus photography is beneficial and more efficient detection and cost effective. It would seem that automated image detection of diabetic retinopathy is an engineering solution to a increasing need.

## Methodology

The retinal recognition comprises of various procedures, namely pre-processing, Kirsch's template for vessel extraction, canny edge detection for noise removal and actual edge detection, pruning, fractal dimension calculation using box counting algorithm and Euclidean distance measure for identification. All the mentioned methods are explained in this section. The block diagram description of the whole process is depicted in the below figure 2.

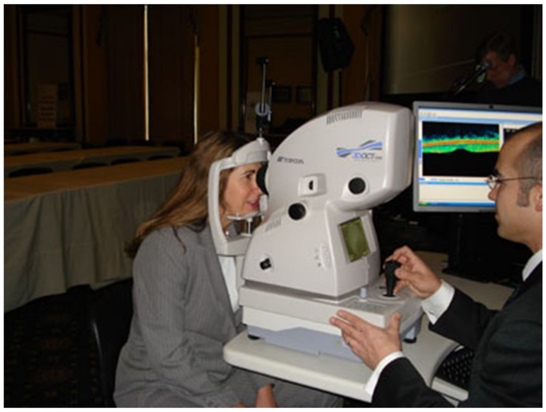

Figure 1.Reinal Scanning

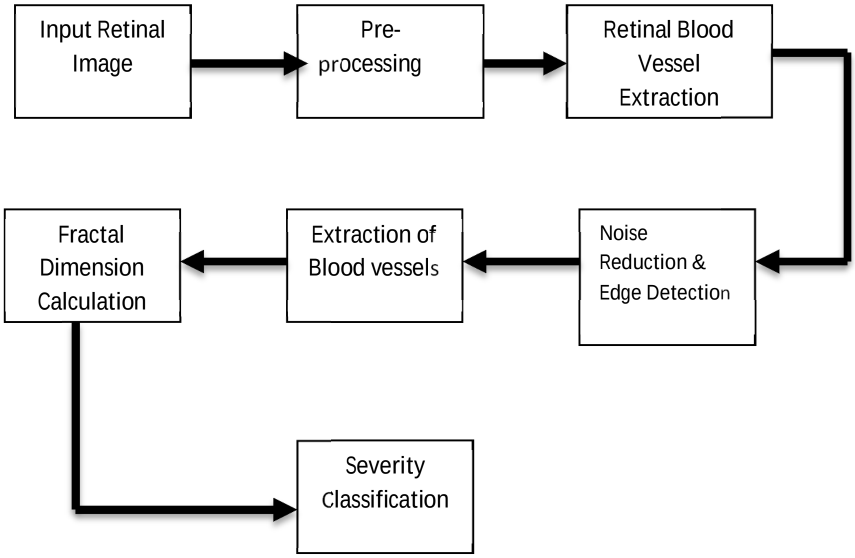


Figure 2.Block diagram for detection of Diabetic Retina

**Kirsch's templates**

The Kirsch operator takes only one kernel mask and rotates it in the increments of 45 degrees through all 8 available and possible directions. The eight templates are shown in the figure 3. The magnitude of the edge in the retinal blood vessel is calculated as the maximum magnitude across all possible directions. Each and every pixel of the retinal image will use these 8 masking to make convolution which has great response to a certain edge direction. The maximum value of all 8 directions is considered as output. The mask which has greatest response constitutes the direction of the edge in blood vessel structure. The retina blood vessel is the irregular structure and determining the branch points can be done efficiently using these templates.

$$\begin{bmatrix}-3 & -3 & 5\\ -3 & 0 & 5\\ -3 & -3 & 5\end{bmatrix} \quad \begin{bmatrix}-3 & 5 & 5\\ -3 & 0 & 5\\ -3 & -3 & -3\end{bmatrix} \quad \begin{bmatrix}5 & 5 & 5\\ -3 & 0 & -3\\ -3 & -3 & -3\end{bmatrix} \quad \begin{bmatrix}5 & 5 & -3\\ 5 & 0 & -3\\ -3 & -3 & -3\end{bmatrix}$$

$$\text{East } M_0 \quad \text{North East } M_1 \quad \text{North } M_2 \quad \text{North West } M_3$$

$$\begin{bmatrix}5 & -3 & -3\\ 5 & 0 & -3\\ 5 & -3 & -3\end{bmatrix} \quad \begin{bmatrix}-3 & -3 & -3\\ 5 & 0 & -3\\ 5 & 5 & -3\end{bmatrix} \quad \begin{bmatrix}-3 & -3 & -3\\ -3 & 0 & -3\\ 5 & 5 & 5\end{bmatrix} \quad \begin{bmatrix}-3 & -3 & -3\\ -3 & 0 & 5\\ -3 & 5 & 5\end{bmatrix}$$

$$\text{West } M_4 \quad \text{South West } M_5 \quad \text{South } M_6 \quad \text{South East } M_7$$

Figure 3.Kirsch's templates in all possible directions

**Box Counting Algorithm**

Minkowski dimension or box counting dimension is the efficient and relatively simple method for calculating the fractal dimension of the image. It is effectively used for irregular shapes where the calculation of object dimensions with numerical formulas or by determining the slope is irrelevant. If N (b) is the number of boxes of side length r required to cover the desired surface of the image where the fractal dimension need to be determined, then the box counting dimension is defined as:

$$Dimension = \lim_{b \to 0} \frac{\log N(b)}{\log \frac{1}{b}}$$

A grid mesh is applied on the retinal blood vessel image and the box which contains the blood vessel information is chosen for calculating the fractal dimension. The steps for calculating the fractal dimension using box counting approach is depicted below:

Step 1: The dimension of the image is increased by the factor of power of 2, by padding the retinal image by background pixels

Step 2: The box size is set to ‘b’

Step 3: If the box contains at least one object pixel is determined and no of such boxes of size ‘b’ are determined and termed as N (b)

Step 4: If the value of ‘b’ is greater than 1, step 3 is repeated and ‘b’ is reduced to half of its value i.e., b/2

Step 5: The points log N(b) and log (1/b) is calculated and the line is fitted by least squares method using these points

Step 6: The slope of the above fitted method gives fractal dimension

## Implementation

*A. Pre-processing*

The retinal image is converted to gray scale for ease of processing and resized for 512*512 for maintain even resolution across all of the images in the database.

**Blood vessel extraction**

Kirsch’s templates in all eight directions are used for extracting the blood vessels. The appropriate condition for determining the blood vessel is established by applying the Kirsch’s templates and then the false edges are removed. Kirsch’s templates will result I broken junctions in blood vessels, these broken edges are determined and fixed by extending the blood vessel in opposite direction till another vessel is detected. The resulting image will contain noise and is removed in next step.

**Canny edge detector**

The canny edge detector is used for detecting the clear edge in the vascular structure. The Gaussian filter is used for removing the noise present in the retinal blood vessel image resulting from last step. The strong edges and weak edges are clearly distinguished in canny edge detection method. The weak edges are considered in the output image only if it is connected to any one of the strong edges. Hence, this method will not get fooled by noise embedded in the image and will detect only true weak edges.

**Fractal Dimension**

The retinal blood vessel structure will contain unwanted circle around the structure resulting from the scanned retinal image. This should be removed for calculating fractal dimension. The circle is removed by using 512*512 all zero pixel image and ‘xor’ing the retinal blood vessel image by selecting the area where the blood vessels present. The fractal dimension is then calculated using the box counting algorithm and these values are stored in the database for recognition process.

**Severity classification**

Diabetic retinopathy is classified on the basis of presence of exudates and micro aneurysms, if only the micro aneurysms is present it is said to be mild, if both exudates and micro aneurysms are present then it is said to be severe, and if both are absent then it is classified as normal stage of DR.

## Experimental Results


Figure 4.Input retinal image


Figure 5.Resized image


Figure 6.Grayscale image

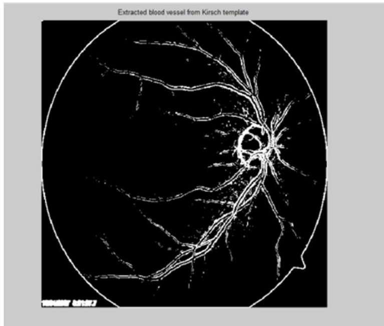


Figure7. Extracted blood vessel from Kirsch's templates

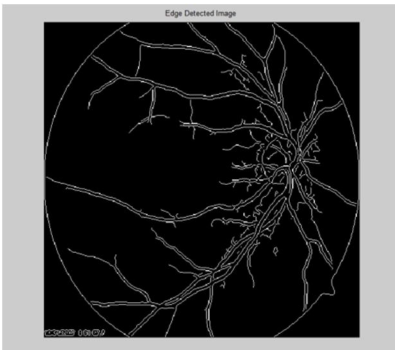


Figure 8.Canny edge detection image

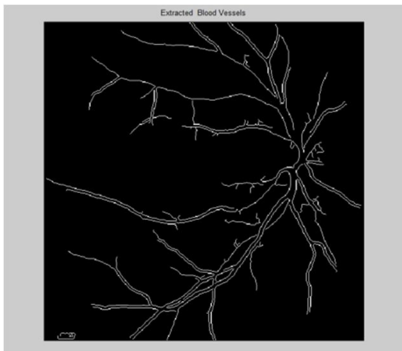


Figure 9. Blood vessel structure after pruning

## Conclusion

The method proposed here is efficient and simple done by applying techniques of image processing. Diabetic retinopathy is classified on the basis of presence of exudates and micro aneurysms, if only the micro aneurysms is present it is said to be mild, if both exudates and micro aneurysms are present then it is said to be severe, and if both are absent then it is classified as normal stage of DR.

This system intend to help ophthalmologists in the screening process to detect symptoms of Diabetic Retinopathy quickly and more easily. This system does not require any user intervention and has consistent performance in both normal and abnormal images.

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