

# AUTOMATED SEGMENTATION OF RETINAL VASCULATURE



Muder M. Almiyani, Buket D. Barkana, Ph.D.  
The School of Engineering  
University of Bridgeport, CT, USA



## Abstract

Image processing, analysis and computer vision techniques are increasing in all fields of medical science, and are especially applicable to modern ophthalmology. Automated image segmentation processing has the prospective for early detection of many diseases like the diabetes, by detecting changes in blood vessel in the retina images. The focus of this poster is on the automated segmentation of vessels in color images of the retina by describes the development of segmentation methodology in the processing of retinal blood vessel images using the region growing method and the Power-law transformation.

The retina is the only location where blood vessels can be directly visualized non-invasively in vivo. Inspection of the retinal vasculature may reveal hypertension, diabetes, arteriosclerosis, cardiovascular disease, and stroke.

In the same time with suitable feature extraction and automated classification methods, this segmentation method could form the basis of a quick and accurate test for the retina image, which would have many benefits for improved the access to screening people for risk or presence of diseases.

## Retinal Images

Assessment of the characteristics of vessels plays an important role in a variety of medical diagnoses. The focus of this paper is on the automated segmentation of vessels in color images of the retina. These images, also known as fundus images, are acquired by making photographs of the back of the eye. We are interested in vessel segmentation for screening of diabetic retinopathy. About 10% of all diabetic patients have diabetic retinopathy, which is the primary cause of blindness in the western world. Since this type of blindness can be prevented with treatment at an early stage. Knowledge about the location of the vessels can aid in screening of diabetic retinopathy.

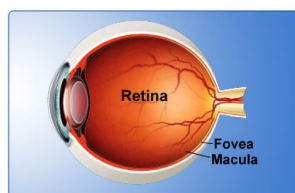


Figure 1: Human eye diagram



Figure 2: Ultra-widefield imaging

The retina can be divided into the central retina and the peripheral retina. The central retina is for clear central vision. The peripheral retina is for peripheral vision. Optus is the leading provider of devices for diagnosing and treating diseases and conditions presenting in the retina of the eye.

In our method we use the DRIVE (Digital Retinal Images for Vessel Extraction) database that has been established to enable comparative studies on segmentation of blood vessels in retinal images.

## Automatic Image Segmentation

Automatic image segmentation is a prominent objective in image analysis. It can be defined as the classification of all the picture elements or pixels in an image into different clusters that exhibit similar features. Various techniques have been proposed in the literature where color, edges, and texture were used as properties for segmentation. Using these properties, images can be analyzed for use in several applications including medical imaging analysis, video surveillance, image retrieval, and object classification. *Segmentation is one of the most important and difficult procedures in medical analysis due to the complex nature of vascular structure, the acquisition faults, the low-contrasted regions or the anatomical background noise.*

Recent developments in image processing relevant to ophthalmology last two decades include the progress being made towards developing automated diagnostic systems for conditions, such as diabetic retinopathy and age-related macular degeneration. These diagnostic systems offer the potential to be used in large-scale screening programs with the potential for significant resource savings as well as being free from observer bias and fatigue.

Accurate segmentation is considered as a key step in achieving that goal. Image segmentation techniques can be classified into four main categories: i) Pixel-based, ii) boundary-based, iii) region-based, and iv) hybrid techniques which is a combination of boundary and region criteria. In this study, we use a region-based segmentation method.

## Proposed Algorithm

We propose an automatic image segmentation algorithm to detect blood vessels in Retinal Images.

The algorithm contains two major stages: (a) Image enhancement and (b) Image segmentation. Conventional low-pass filter is used as a noise reduction method. To enhance the contrast between blood vessels and soft tissues, we apply power-law transformation.

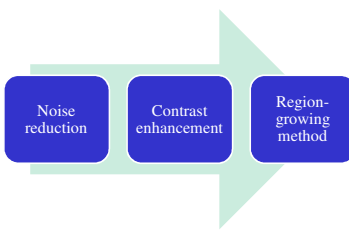


Figure 3: Block diagram of the proposed algorithm

### Region-growing method

Image segmentation stage uses region growing method to extract vessels structures. A region of interest (ROI) is determined by automatically selecting two points on the Retinal Images image. This helps to restrict and constrain the region-growing to within the ROI. A seed point for the region growing algorithm is automatically defined at the centre of the ROI. In parallel, the average pixel intensity in the neighboring region is calculated and is defined as the initial feature metric. Consequently, a search is conducted to determine the pixel which has the least intensity difference from the initial average intensity. The determined pixel is then added to the region. The process of region-growing method is given at Figure 5.

### Power-law transformation

Power-law transformation is useful for such a contrast manipulation. Power-law transformation can be defined as  $s = cr^\gamma$ , where  $c$  and  $\gamma$  are positive constants. Power-law curves with fractional values of  $\gamma$  map a narrow of dark input values into a wider range of output values, with the opposite being true of higher value of input level. Figure 4 shows a Retinal Images. Since the image is not predominantly grey we convert it to gray image, an adjustment of gray levels is desirable. This can be accomplished by a power-law transformation with a fractional exponent.

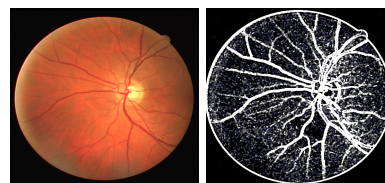


Figure 4: (a) An original Retinal Images  
(b) Enhanced image.

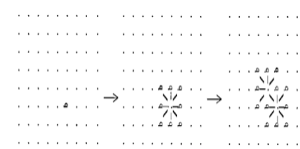


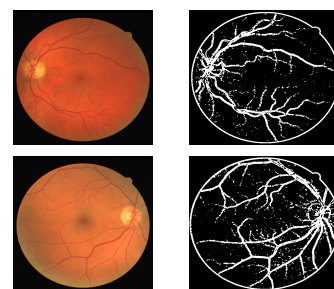
Figure 5: The process of region growing method. Seed locations for segmentation for MRA image of blood vessels in the brain; the segmented image with region growing method.

## Experimental Results

Retinal images of humans are used in the diagnoses of diseases by ophthalmologist. To build an expert system that is able to perform the diagnoses task we need to use digital retinal images. By imaging the retina of a person with a special camera, then using image processing and pattern recognition techniques to analyze that retina we can make a specific diagnoses decision. The segmentation is the key to various visualization techniques and to the quantification.

Our database has 40 images has been divided into a training and a test set, both containing 20 images. The proposed algorithm is implemented in MATLAB. In this poster we have proposed an automatic image segmentation algorithm to detect blood vessels in Retinal Images. The benefit of this algorithm is that it provides a parameter-free environment to allow no user intervention. Image denoising and vessel enhancement are useful both to improve the display and to help the segmentation. In order to improve the region-growing method, contrast enhancement is applied by power low transformation. Figure 6 shows our results on some of the test images.

In the future, we plan to extend our algorithm into to be directed toward improving the tracking and measurement of center lines of small vessels and the ability to detect low-contrast vessels that are not apparent.



(a) (b)  
Figure 6: (a) An original Retinal Images  
(b) Segmented images