

# Epidemiology And Control Of Hypertension: Papers And Discussions From The 2d International Symposium

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## An Image Analysis Framework for the Early Assessment of Hypertensive Retinopathy Signs

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**Abstract.** This paper presents a framework for the detection and measurement of retinal vessels in funduscopy images. The proposed method segments retinal vessels, enabling the actual measurement of the vessel diameter. A Graphical User Interface (GUI) further supports a number of methods for the automatic and interactive measurement of vessel diameters at any selected point or region of interest. In addition, it provides methods for editing the vessel representation in order to recover from possible segmentation misclassifications. All the above steps are integrated into a clinical application capable of supporting vascular risk stratification in persons with hypertension. The performance of the segmentation is assessed on two publicly available DRIVE and STARE datasets. The experimental results show that the method can achieve a high accuracy on both datasets with very low computational cost, being comparable or slightly better than widely used supervised and unsupervised methods.

**Keywords:** Retinal images; vessel segmentation; vessel enhancement filtering; vascular measurements; retinal image toolkit

### I. INTRODUCTION

The retina provides an open and accessible window for studying the microcirculation in the human body. Retinal vessels can be easily visualized with non-invasive techniques providing valuable information in patients of hypertension and cardiovascular diseases [1]. For many years physicians used to perform traditional funduscopy, which provides an overview of the retina and vitreous of the eye, by the use of a direct or indirect ophthalmoscope or with a slit lamp. However, all of the above mentioned methods present several important drawbacks; in particular, they are prone to operator bias, since image recording is not feasible, and do not permit the assessment of more sophisticated measurements of retinal vessels, such as the diameter of the vessels [2]. In addition, prior medical mydriasis is required, and presence of specially trained examiners is necessary. These important drawbacks have been counterbalanced by the development of advanced fundus cameras (mydriatic or non-mydriatic), allowing thus the accurate, objective, and repeatable representation of retinal blood vessels, and providing further insights in the diagnosis, classification and surveillance of retinopathy signs [3].

Detecting and measuring the spatial properties of the vessel network through automated techniques is a challenging task. From the perspective of the image processing, much effort has been devoted for segmenting the retinal vasculature and extracting its anatomical characteristics, such as width, length etc. A number of vessel detection and measurement techniques have been suggested in the literature (analytically described in [4]). In summary, the proposed approaches can be classified in two broad categories: i) methods that segment vessels from the image as a first step to estimate retinal structure, and ii) methods that track the vessel boundaries to extract their shape. The entire pool of the techniques that belong to the first category is generally further divided into two subgroups. In the first group, pixel-processing based techniques, such as local and global thresholding [5, 6], region growing [7] and matched filtering [8], fundamentally identify the vessel regions before extracting the available vasculature geometrical knowledge. More computationally intensive techniques based on 2D wavelet transforms [9], Gabor Wavelets mixed with classification [10], supervised learning [11-14] and active contours [15] may be also employed in this category. The second subgroup includes tracking methods [16, 17] that focus on the identification of the vascular network without the need to apply any segmentation step. Given an initial position, the vessel detection is achieved by tracking their boundaries. Fuzzy C-means clustering [18] has been effectively used since the extraction of the vasculature requires no prior assumptions about the characteristics and the edge information of the vessels.

The presented approach involves two separate modules. The first includes the detection and measurement of vessels in retinal images. The second module provides the ability to validate, edit and represent vessel information in multiple ways, by interactively selecting segments of interest and extracting their statistical information within spatial regions dictated by pertinent medical protocols. In brief, such methods include the automatic segmentation and measurement of a vessel-segment of interest, the computation of statistics across user-defined regions of medical interest, the interactive correction and editing of segmentation results,

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