AUTOMATED SEGMENTATION OF FLUORESCENT AND FUNDS IMAGES BASED ON RETINAL BLOOD VESSEL

P.Sumitra, P.Ponkavitha, K.S.Saravanan and S.Karthika

Department of Computer Science and Applications
Vivekanandha College of Arts and Sciences for Women (Autonomous)
Elayampalayam, Tiruchengode

ABSTRACT

Measurements of retinal blood vessel morphology have been shown to be related to the risk of cardiovascular diseases. The wrong identification of vessels may result in a large variation of these measurements, leading to a wrong clinical diagnosis. In this paper, we address the problem of automatically identifying true vessels as a post processing step to vascular structure segmentation. We model the segmented vascular structure as a vessel segment graph and formulate the problem of identifying vessels as one of finding the optimal forest in the graph given a set of constraints. We design a method to solve this optimization problem and evaluate it on a large real-world dataset of 2,446 retinal images. Experiment results are analyzed with respect to actual measurements of vessel morphology. The results show that the proposed approach is able to achieve 98.9% pixel precision and 98.7% recall of the true vessels for clean segmented retinal images, and remains robust even when the segmented image is noisy.

KEYWORDS

Ophthalmology, optimal vessel forest, retinal image analysis, simultaneous vessel identification , vascular structure

1. INTRODUCTION

Biological Machine Engineering (BME) is the application of engineering principles and design concepts to medicine and biology for healthcare purposes (e.g. diagnostic or therapeutic). This field seeks to close the gap between engineering and medicine. It combines the design and problem solving skills of engineering with medical and biological sciences to advance healthcare treatment, including diagnosis, monitoring, and therapy.

Therapeutic medical devices ranging from clinical equipment to micro-implants, common imaging equipment such as MRIs and EEGs, regenerative tissue growth, pharmaceutical drugs and therapeutic biological . Subdisciplines of biomedical engineering can be viewed from two angles, from the medical applications side and from the engineering side. A biomedical engineer must have some view of both sides. As with many medical specialties (e.g. cardiology, neurology), some BME sub-disciplines are identified by their associations with particular systems of the human body, such as:

1.1 Cardiovascular technology - which includes all drugs, biologics, and devices related with diagnostics and therapeutics of cardiovascular systems.

1.2 Neural technology - which includes all drugs, biologics, and devices related with diagnostics and therapeutics of the brain and nervous systems.

1.3 Orthopaedic technology - which includes all drugs, biologics, and devices related with diagnostics and particular aspects of anatomy or physiology. A variant on this approach is to identify types of technologies based on a kind of path physiology sought to remedy apart from any particular system of the body, for example:

1.4 Cancer technology - which includes all drugs, biologics, and devices related with diagnostics and therapeutics of cancer.

2. OVERVIEW

In this project we implemented a novel technique that utilizes the global information of the segmented vascular structure to correctly identify true vessels in a retinal image. We model the segmented vascular structure as a vessel segment graph and transform the problem of identifying true vessels to that of finding an optimal forest in the graph. An objective function to score forests is designed based on directional information. Our proposed solution employs candidate generation and expert knowledge to prune the search space. We demonstrate the effectiveness of our approach on a large real-world dataset of 2446 retinal images. We introduce a novel vessel enhancement technique based on the matched filters with multi wavelet kernels (MFMK). We identify kernels separating vessels from clutter edges and bright, localized features (e.g., lesions).For noise attenuation and vessel localization, we apply a multistate hierarchical decomposition, which is particularly effective for the normalized enhanced image. This process performs an iterative segmentation at increasing image resolutions, locating smaller and smaller vessels. A single scale parameter controls the level of detail included in the vessel map. We show a necessary condition to achieve the optimal decomposition, deriving a rule to identify the optimal number of the hierarchical decomposition. Our method does not require pre-processing and training it can therefore be used directly on images with different characteristics. In addition, it relies on adaptive thresholding so that no numerical parameter is tuned manually to obtain a binary mask.

3. LITERATURE SURVEY

3.1 Some links between extreme spanning forests, watersheds and min-cuts

Min-cuts (graph cuts) and watersheds are two popular tools for image segmentation, which can both be expressed in the framework of graphs and are well suited to computer implementations. Informally, a cut in a connected graph is a set of edges which, when removed from the graph, separates it into several connected components. Given a set of nodes or sub graphs called markers, the goal of these operators is to and a cut for which each induced component contains exactly one marker and which best matches a criterion based on the image contents.In this paper, we present some results about the links which exist between these different approaches. Especially, we show that extreme spanning forests are particular cases of watersheds from arbitrary markers and that min-cuts coincide with extreme spanning forests for some particular weight functions[1].

3.2 Watershed cuts: minimum spanning forests and the drop of water principle

In order to compute the watershed of a digital image, several approaches have been proposed. Many of them consider a gray scale digital image as a vertex-weighted graph. One of the most popular consists of simulating a flooding of the topographic surface from its regional minima. The divide is made of “dams” built at those points where water coming from different minima would meet. Another approach, called topological watershed , allows the authors to rigorously define the notion of a watershed in a discrete space and to prove important properties not guaranteed by most watershed algorithms . We propose a linear-time algorithm to compute the watershed-cuts. As far as we know, the proposed algorithm is the most efficient existing watershed algorithm both in theory and practice. Finally, we illustrate the use of watershed-cuts for application to image segmentation and show that, in the considered cases, they are able to improve the quality of the delineation in watershed-based segmentation procedures[2].

3.3 Unsupervised Curvature-Based Retinal Vessel Segmentation

Automatic segmentation of the vessel tree from color retinal images has received much attention recently given its important role in image registration and in disease identification such as in diabetic retinopathy and hypertension. Techniques ranging from multi-level thresholding to model-based have been proposed. In the latter, information about the vessel morphology such as linearity, coloring, circular cross section, etc., are used to construct feature sets which are used for either supervised classification or to devise filters for detection. In the course of our experiments, we discovered that the ground truth markings in the DRIVE dataset tended to be over segmented at times, perhaps as a sign of the above problem, in which case the vessel thickness obtained prior to the last dilation step in our algorithm was found to be closer to the true vessel thickness as detected by a Canny detector[3].

3.4 Automatic Grading of Retinal Vessel Caliber

New clinical studies suggest that narrowing of the retinal blood vessels may be an early indicator of cardiovascular diseases. One measure to quantify the severity of retinal arteriolar narrowing is the arteriolar-to-venular diameter ratio (AVR). The manual computation of AVR is a tedious process involving repeated measurements of the diameters of all arterioles and venules in the retinal images by human graders. Consistency and reproducibility are concerns. To facilitate large-scale clinical use in the general population, it is essential to have a precise, efficient and automatic system to compute this AVR. This paper describes a new approach to obtain AVR. The starting points of vessels are detected using a matched Gaussian filter. The detected vessel filter. A modified Gaussian model that takes into account the central light reflection of arterioles is proposed to describe the vessel profile. The width of a vessel is obtained by data fitting. Experimental results indicate a 97.1% success rate in the identification of vessel starting points, and a 99.2% success rate in the tracking of retinal vessels. The accuracy of the AVR computation is well within the acceptable range of deviation among the human graders, with a mean relative AVR error of 4.4%. The system has interested clinical research groups worldwide and will be tested in clinical studies[4].

3.5 Retinal Vascular Tree Morphology: A Semi-Automatic Quantification

Quantitative analyses of retinal blood vessels from fundus images have usually been studied in terms of individual bifurcations, measuring a few of the most clearly visible bifurcations in an image. Most of these studies have focused mainly on diameter measurements although others also included midline detection and tortuosity measurements .Those studies that have characterized continuous blood vessel trees from retinal images, by means of image processing techniques, have been mainly focused on the detection process rather than the measurement of geometrical or topological properties a semi-automatic method to measure and tabulate geometrical data as well as connectivity information from continuous retinal vessel trees is presented. Data are extracted from binary images obtained from a previously developed segmentation method. The procedure consists of a semi-automatic labelling of the skeleton trees followed by an automatic procedure for measurement and generation of tabulated data for further analysis. Several geometrical and topological indexes are extracted. The methods are validated by comparison with manual measurements and applied to a pilot study of ten normal and ten hypertensive subjects and differences between groups in the morphological properties are investigated[5].

4. METHODOLOGY APPLIED

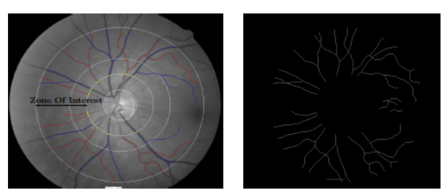
- Pre processing
- Vessel tracking
- Seed point extraction
- Segmented retinal vessel morphology
  Graph cut algorithm

4.1 Preprocessing

- Preprocessing of an image is done to reduce the noise and to enhance the image for further processing.
- To improve the image and the image quality to get more accuracy and pixel precision in segmenting the Retinal blood vessel.

4.2 Vessel Tracking

- Find starting and ending points.
- In order to identify the vessel profile along the scan line, matched filters are used.



(A) Zone of Interest (B) Line Image
Figure.1.Vessels Tracking

This is a circular ring bounded by two concentric circles of radii 2r and 5r. where r is the radius of the optic disc (OD). Measurements from this zone are used in a number of clinical studies. Each vessel starts from a pixel near the circle of radius 2r. These pixels are called root pixels.

4.3 Seed Point Extraction

- A scan analysis is performed on each of these lines, in order to identify sequences of pixels corresponding to possible vessel profiles.
- Due to the presence in the neighborhood of both vessel" (dark) and non-vessel"(light) pixels. Mean and standard deviation of all the seed points are computed.

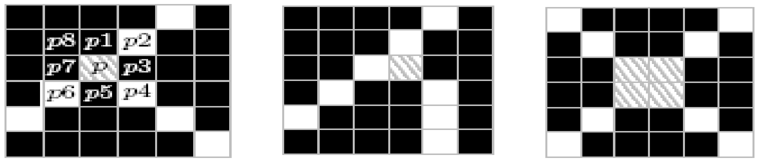


Figure.2.Seed Point Tracking

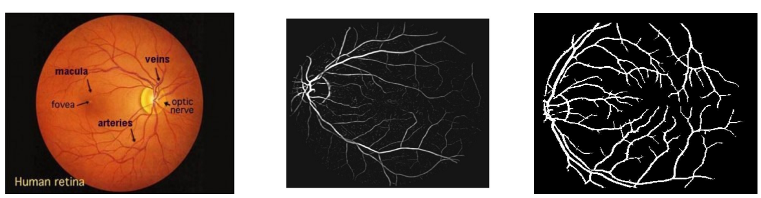
4.4 Segmented retinal vessel morphology

A)Wrong Identification Of I and II B)Correct Identification Of I and II
Figure.3.Vessels Identification

4.5 Segmentation

There are advanced segmentation algorithms in the literature which extends the concepts of graph cuts. Prominent of them are :

4.5.1 Grab Cut: Grab Cuts extends graph-cut by introducing iterative segmentation scheme that uses graph-cut for intermediate steps.
4.5.2 Lazy Snapping: Lazy snapping is an interactive image cut out tool. Lazy Snapping separates coarse and fine scale processing, making object specification and detailed adjustment easy.
4.5.3 Grow Cut: Given a small number of user-labeled pixels, the rest of the image is segmented automatically by a Cellular Automation.



A)Grab Cut B)Lazy Snapping C)Grow Cut
Figure 4.Graph Cut Retina Segmentation

5. Conclusion

Retinal Blood vessel morphology is an important indicator for many diseases such as diabetes, hypertension and cardiovascular, and the measurement of geometrical changes in retinal veins and arteries and is applied to a variety of clinical studies. Two of the major problems in the segmentation of retinal blood vessels namely the presence of a wide variety of vessel widths and inhomogeneous background of the retina have been addressed. A method of automated segmentation for both fluorescent and funds images of the retinal blood vessel has been proposed.

ACKNOWLEDGEMENT

We like to thank all those who gave us their support to complete this paper.

6. REFERENCES

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Authors

Dr.P.Sumitra. received her Ph.D Degree in Computer Science from Mother Teresa Women's University, Kodaikannal, Tamil Nadu, India in the year 2013. She is currently working as a Assistant Professor in Dept of Computer Science, Vivekanandha College of Arts and Sciences for Women, Elayamapalayam, Tiruchengode, TamilNadu,India. She published 17 International Journal papers, 4 papers in International Conference and 10 papers in National Conferences. Her research areas include Image Processing, Data Mining and Artificial Intelligence. She has 13 years 8 Months of teaching experience in self finance institutions.

P.Ponkavitha M.Phil Research Scholar, Department of Computer Science and Applications Vivekanandha College of Arts and Sciences for Women (Autonomous) Elayampalayam , Tiruchengode.

K.S.Saravanan working as a Assistant Professor in Dept of Computer Science & Applications, Vivekanandha College of Arts and Sciences for Women(Autonomous), Elayamapalayam, Tiruchengode, TamilNadu,India.

S.Karthika M.Phil Research Scholar, Department of Computer Science and Applications Vivekanandha College of Arts and Sciences for Women (Autonomous)Elayampalayam , Tiruchengode.