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Fundus Vessel Segmentation Technology Based on Image Recognition

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Abstract. The lower part of the eye is filled with abundant blood vessels, in the normal course of infusion of blood vessels, and the reason for this phenomenon is various eyeground vessels, for example, diabetes retinopathy, retina venous obstruction, hypertension retinopathy, hyperoptic retinopathy, etc. If the bleeding volume is small, people don't need to look for a doctor, but eyeground can be self-relieved. If, however, the hemorrhage in the blood vessel is extensive and hard to heal, it may be necessary to make a new diagnosis and operation. So it is of great importance to treat and recover the entire eyeground. The objective of eyeground image segmentation is to extract the blood vessels from complicated fundusimages. This method can offer non-invasive, high resolution data of retinal blood vessels to assist in the correct and reliable diagnosis of eye diseases. This article gives a brief introduction to some of the technology of segmentation, and discusses the features of them. The purpose of this article is to provide the reader with an insight into how this area develops and to become familiar with the techniques used to segment the vessel.

Keywords: Vessel Segmentation; Image Segmentation; Retinal Fundus Image; Medical Imaging.

1. Introduction

Retinal vessels are one of the most important structures in the eye and have a wide range of clinical applications and diagnostic significance. Through the observation and analysis of blood vessels in the fundus, ophthalmologists can understand the patient's eye health. However, the deep blood vessels of the eye can only be observed noninvasively through the retina. The structural and characteristic changes of blood vessels in the fundus reflect the effects of ophthalmic diseases such as cataract. Cataract is one of the leading causes of vision loss worldwide. The study of retinal blood vessels is an important method for the treatment of cataract. It is a common ocular disorder characterized by progressive opacification of the lens and decreased vision. Cataract patients gradually develop blurred vision, difficulty in seeing details, reduced contrast and color fading. If left untreated, it can lead to severe vision loss and blindness. However, retinal vessel segmentation can play a role in the treatment of cataract. Before cataract surgery, the fundus vessel segmentation technique helps the physician to assess the condition of the retina and retinal vessels of the patient. By analyzing features such as vessel density, abnormal vessel dilatation, and leakage, it is possible to determine whether other retinopathy is present so that appropriate measures can be taken during surgery. Segmentation technology provides real-time retinal vascular information during cataract surgery. This helps ophthalmologists accurately locate and manipulate to avoid damage to the retina and blood vessels. Despite the importance of fundus vessel segmentation in ophthalmology, such as diagnosis and monitoring of diabetic retinopathy and early diagnosis and assessment of macular degeneration, there are still some dilemmas and challenges.

Fundus vessels have complex morphology and structure, including branching, crossing and overlapping. This makes it challenging to accurately segment the vascular network, especially in lesion and marginal regions. It may be difficult for existing algorithms to precisely partition these complex vascular structures. Fundus diseases can lead to pathological changes of retinal blood vessels, such as vascular dilatation, vascular blockage and leakage. These changes can affect the accuracy of vessel segmentation and increase the difficulty in the segmentation process. In addition, there may be problems such as noise and low contrast in fundus images, which can also interfere with the results of vessel segmentation. In order to train and evaluate fundus vessel segmentation algorithms, a large amount of labeled data, that is, manually labeled accurate vascular regions, is required. However, the labeling of fundus images is a time-consuming and technically demanding task, requiring manual labeling by an ophthalmologist. This limits the amount and quality of labeled data available for algorithm training. In clinical practice, real-time and efficiency are essential for fundus vessel segmentation techniques. However, some segmentation algorithms may require a long computation time and cannot meet the requirements of real-time performance. In addition, the efficiency of processing large-scale fundus image data is also a challenge, especially in automated screening and large-scale studies. The generalization performance of fundus vessel segmentation algorithms refers to their stability and accuracy across different datasets, different devices, and different pathological conditions. Due to the diversity and complexity of fundus images, the robustness of the algorithm is still an issue, and better generalization ability is needed to adapt to different practical application scenarios.

2. Fundus Vessel Segmentation Technology

In this article, author present a new method to segment the blood vessels with the aid of fundus photos [1]. This method can get a good result on the normal and abnormal retina images. Furthermore, it has a much smaller computation time compared to the majority of other supervised and unsupervised approaches. In this paper, author use an adaptive global threshold to extract the vessel pixels from the morphology enhancement of the negative green surface in every eyeground image. This algorithm begins with an initial primary vessel estimation, and then applies an adaptive global threshold approach to the current vessel estimation, which will be applied to the current vessel estimation, until the stopping criterion is met. The main characteristic of this method is a new stopping rule, as shown in Figure 1,which computes the first three derivatives of the variation in ship estimation. This standard is helpful in ending the vessel adding process and keeping the segmentation precision. The proposed method can be used to deal with both normal and abnormal retina, and it can be used to detect and increase the size of the lesion. There is, however, one disadvantage of this approach: Because of the area growth activity, small micro-aneurysms near blood vessels are usually classified as part of the vessel section. The purpose of this paper is to integrate the proposed approach into decision-making, and to achieve better results in the treatment of abnormal retina with a minor vascular lesion.

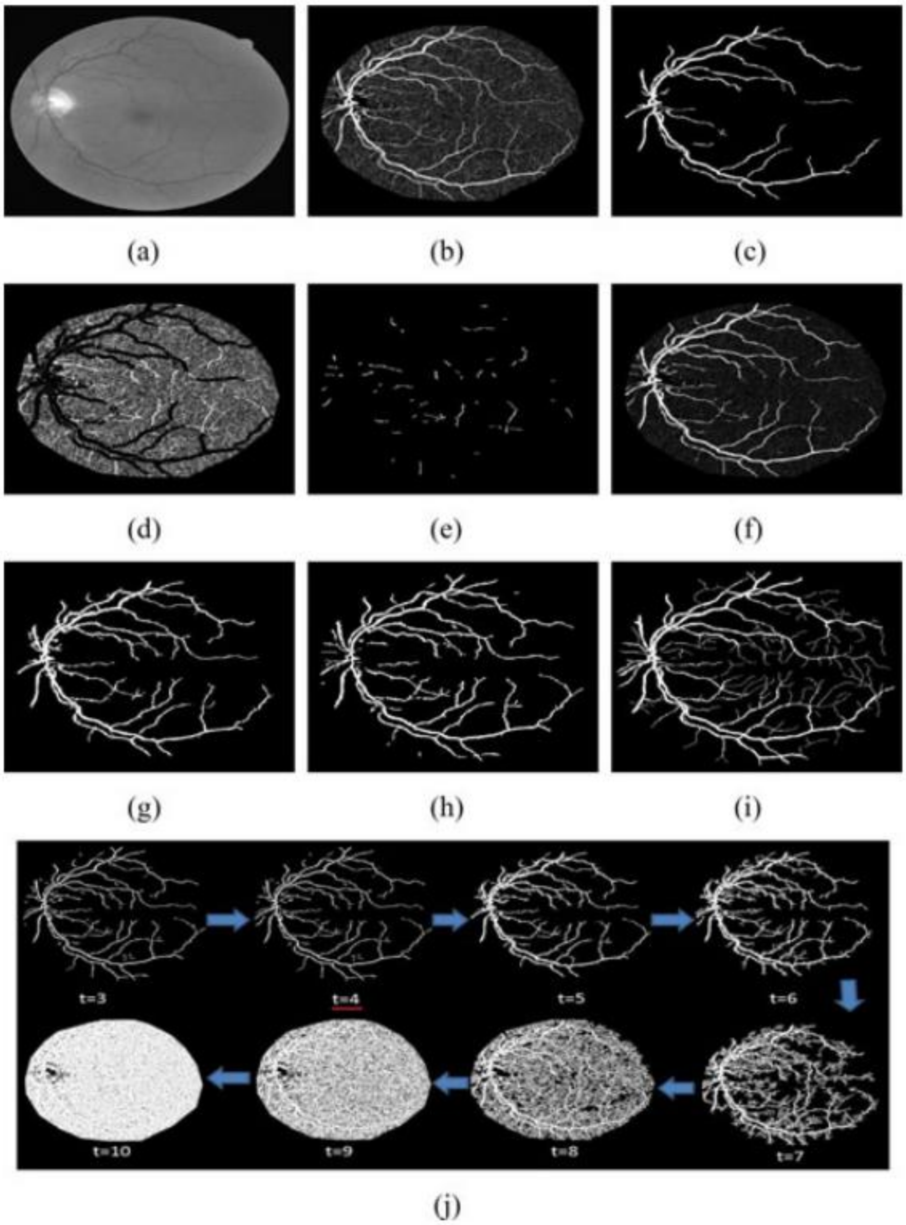

Fig. 1. Intuitive result presentation of the iterative algorithm using the stopping rule [1].

In this article, author present a new hierarchical approach to segment the retina from eyeground [2]. This framework makes use of pre-processing, characteristic extracting and postprocessing to increase the precision of RVR. The core of this framework is a cascade classification network, which employs a series of high performance Mahalanobis distance classifiers to generate high non-linear decision boundaries. Different from other non-linear classifiers, the neural network is trained by a single pass feedback procedure, which can be used to improve the performance of the model. Experiments show that this framework performs better than other approaches on image segmentation and other performance metrics over a wide range of public databases, as shown in Figure 2. Moreover, it can be used to detect the pathology of various kinds of lesions, so it can be used in computer aided diagnosis of ocular diseases. Hierarchical neural networks are widely used in the field of medical image recognition, which can be used in many applications.

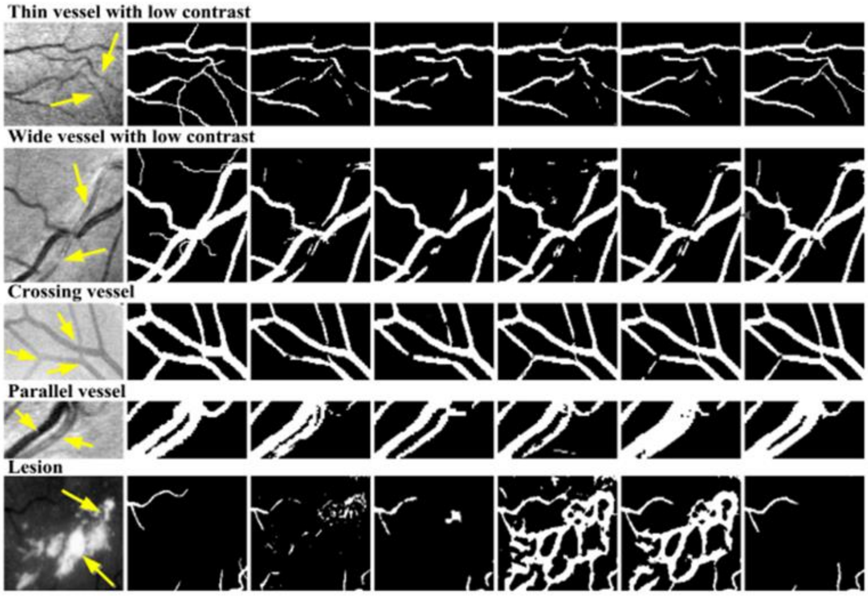

Fig.2. Comparison of the results of the proposed algorithm with other algorithms in complex conditions [2].

In this paper, author present a new method for detecting blood-vessel in eyeground images, which is based on mathematical morphology, space dependence and curvature [3]. The rough division process searches for broad and narrow vessels, whereas the refinement process separates the connected and long real vessels from the vessel-like ones. Consideration should be given to the local aspects associated with the deformation of the blood vessel, for example, the CVR and the noise of the vessels, which together influence the detection of the vessel net. Results indicate that this approach is superior to most modern approaches on DRIVE and STARE in both sensitivity and precision. This approach is robust and suitable for dealing with retina defects and anomalies, as it is capable of detecting a more complete vascular tree while retaining essential characteristics of the vascular network. These results indicate that this approach could be applied to automatic biometric identification of retina, which is based on a vessel tree. In order to reduce the subjective and expert bias in the performance assessment, a neutral reference, known as the Average Observer, was employed to balance the difference between the two observers. Balanced precision, which combines sensitivity with specificity, is employed to give a more precise evaluation of the approach's overall performance. Research shows that this approach's performance is restricted by the false-positive rate. In the future, the emphasis will be placed on the measurement of vessel diameter in order to enhance the performance of the system, enhance the specificity and decrease the number of false-positive results. In addition, the authors will continue to explore its possibilities for DR and ARMD monitoring and for retinal biometric applications.

In this paper, author propose a new layer of image matrix for RVR, which is based on image matching technology [4]. The authors stress that there has been little prior work on the extraction of the retina, primarily because it is difficult and time consuming to create a user defined triangle for vessel segmentation by hand. In order to solve this problem, author present an automatic generation method based on regional characteristics of blood vessels, which is based on the classification of vessel pixels. The proposed model has been assessed on open data sets (DRIVE, STARE, CHASE _ DB1) and has shown the effectiveness and efficiency of vessel segmentation. Experiments indicate that the precision of the segmentation is 96.0%, 95.7% and 95.1%, and the mean time is 10. 72 sec, 15. 74 sec, 52. 71. The results show that the proposed method has higher competition than other methods of segmentation.

In this article, author present a new approach to accurately segment retina blood vessels, which is a new approach to overcome the difficulties of RVR [5]. There are 3 phases in the process: pre-treatment, primary treatment and post treatment. In pre-processing phase, author use Gauss Filter to get a smooth gray scale. "There are two parts to the primary processing phase. A first arrangement utilizes a group of filters (optimal top-cover, homomorphism, and middle) to partition rough vessels, while a second arrangement utilizes an additional group of filters (optimum top-cover, homomorphism, and matching) and a multi-level cross entropy Harris Eagle optimization (MCET-HHO) for fine vessel segmentation. Lastly, the paper uses the morphology of the image to do the post processing. A number of experiments were carried out in two public databases. Experiments using performance measures demonstrate that our algorithm achieves better performance than other state-of-the-art algorithms for retinal blood vessel segmentation.

This paper presents a new kind of mixed depth segmentation method which can increase the precision of blood-vessel segmentation [6]. The major contributions include: (1) In order to overcome the difficulty of neglecting the relation of thickness and thickness in eyeground images, a multi-task segmentation network was presented. Both the thickness and the thickness of the blood vessels were detected simultaneously in order to improve the relativity of the blood vessels in the different segmentation networks. (2) To guarantee the efficiency of the algorithm, a new kind of efficient loss function was developed to deal with the unbalance of the thickness and thickness of vessels. (3) Based on the above, author put forward a method of merging the two kinds of vessels and get the final segmentation. Experiments on a number of open data sets show that this algorithm performs better than other approaches in the field of eyeground, particularly for small-vessel segmentation.

In this paper, author present a new approach to segment and classify the RVA [7]. In this paper, author propose a new approach based on the convolution of the convolution neural network, which can extract the vasculature from the ground of the eye and differentiate it into an artery or a vein. The approach is composed of two major steps. Firstly, the classification of arterial, arterial, and venous was performed by convolution neural networks. Then, a graph is applied to the whole blood vessel network in order to obtain the global structure. Our CNN model, which is built on the U-Net framework, is capable of detecting different kinds of environmental characteristics, and can differentiate the retina from the others (choroid, optical disk borders, and nerve fibres), thus decreasing the risk of false alarm. Furthermore, author present a new method of vessel tag propagation, which can be used to mimic the nature of blood flow in a vascular network. Furthermore, they have demonstrated that their methodology can be applied to compute a new arterial vein rate (AVR), a worldwide measurement of AVR, which can more accurately trace blood vessel alterations due to diabetes retinopathy, which has a huge potential for searching for particular blood vessel markers beyond the optical disk.

In this paper, author present the ResDO-UNet, which is used to precisely segment the retina blood vessels in the retina [8]. Based on the features of residual learning and U network, ResDO-UNet is used for extraction and recovery of vascular details by means of several remaining blocks and up-sampling levels. The ResDO-conv network is used to represent the strong contextual characteristic, PFB net is used to realize non-linear integration, and AFB net block is used to efficiently express multi-scale characteristics. In addition, a new loss function is proposed to increase the precision of segmentation by integrating cross entropy and Dice loss. Experiments indicate that ResDO-UNet is superior to others on a number of open data sets.

In this article, author present a highly effective and reliable way to segment the retina with the help of the color-eyeground image [9]. The algorithm adopts matching filter and minimal error threshold technology to get the binary vessel tree. In this paper, author have developed 5 kinds of core functions that can be applied to the vasculature of various width classes in common eyeground. This method leads to a reliable segmentation over a range of vessel widths. A major focus of this approach is the ability to separate vascular structures using spectral reflections. Quantitative assessment of the available retina data indicates that the proposed approach is similar to other approaches in the literature. Furthermore, author also present a high resolution eyeground data base which includes the eyeground of normal people, diabetes retinopathy, and glaucoma, as well as hand-tagged Golden Standard Blood Vessel Tree. These results offer a new chance for the researchers who are involved in the field of retina image analysis to assess the performance of vessel segmentation. This data base is open to the public, so that all writers can download and share the results of blood vessel segmentation. The HRF (High Resolution Eyeground (HRF)) database now includes 3 groups of images (Normal Person, Diabetes and Glaucoma Retinal Picture). Our aim is to provide additional gold-standard information to help evaluate vascular segmentation methods for differentiating arterial from venous, arterial, and vascular diameter measurements. Furthermore, author intend to extend this database not only to assess the RVO, but also to assist in the evaluation of other RRS applications, including the diagnosis of glaucoma, disk or macula, and the localization of vascular branches and intersections.

In this thesis, author present FANet (FNN) based on RNN, which is based on RNN [10]. FANet is an extended version of U-Net, which uses SK cells instead of conventional convolution, and combines a light-weight two-way attention module. Furthermore, author apply the method of VFD to improve the contrast and reduce the background noise. This was done in order to get a more distinct vascular signal from the fundus. Furthermore, it is proved by comparison that the proposed method is effective in acquiring multi-scale and long range contextual information, which can enhance the capability of recognition within the model. FANet was able to extract more abundant vascular information than the U-Net base. Our proposed model has been shown to have good performance on three common data sets. It is possible to use more light weight and higher level segmentation structures in order to increase the efficiency of diagnosis.

3. Conclusion

Detecting retinal diseases is tedious, as it requires specialists to painstakingly detect and segment retinal vessels. However, this approach is costly and time-consuming. Therefore, it is necessary to automatically extract and segment blood vessels using artificial intelligence technology for early detection of retinal diseases.

Many researchers have proposed various algorithms to deal with the task of retinal vessel segmentation, which can be divided into two categories: supervised and unsupervised methods. Supervised methods include support vector machine (SVM) -based, neural network (NN) -based, and other methods. Unsupervised methods include matched filtering methods, vessel tracking methods, mathematical processing methods and model-based methods. This article compares these vessel segmentation techniques, using data sets, fundus photography, preprocessing and post-processing methods, and evaluation criteria.

Although these algorithms are very effective in diagnosing retinal diseases, they should not replace the role of retinal experts, but rather aim to reduce their workload. With the advancement of technology, high-resolution fundus cameras can provide better retinal image quality. High-resolution images have higher signal-to-noise ratio and lower distortion. Such segmentation of images can reduce the need for pixel-level vessel identification. The average accuracy of deep learning methods in retinal vessel segmentation task has also reached about 98%, which provides strong evidence for its application in early diagnosis.

This article reviews the application of machine learning (ML) and deep learning (DL) methods in vessel segmentation, and tries to cover all current and existing methods. Choosing an appropriate method for retinal vessel segmentation is challenging, as each has its own advantages and disadvantages.

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