Retinal Blood Vessels Segmentation of Ultra-Widefield View Retinal Images in Application of Detection of Diabetic Retinopathy at Early Stage

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Introduction

Ultra-wide field of view allow examination not only the central retinal area, but also peripheral zones. UWF imaging covers 82% greater retinal area (200°) against 45° in conventional cameras, allowing more clinically relevant diabetic retinopathy to be detected.[1,2].The use of Ultra-wide field(UWF)imaging has revealed potentially important clinical findings in the periphery of diabetic eyes beyond the seven standard Early Treatment of Diabetic Retinopathy Study(ETDRS) filed ,and the clinical significance of these finding are continuing to be investigated.Initial studies utilizing nonmydriatic UWF imaging for screening of diabetic retinopathy found that there was a 94% sensitivity compared to the clinical exam, and follow-up recommendations corresponded to clinical recommendations at a rate of 82%.[1]

The changes in retinal blood vessels serve as a bio-marker for identification of many disorders such as diabetic retinopathy, hypertensive retinopathy, retinal artery occlusion, retinal vein occlusion. Also, other diseases such as stroke, hypertension, glaucoma and diabetes produce noticeable alterations in the retinal blood vasculature.[3] These diseases usually change reflectivity, tortuosity and patterns of blood vessels. For example, hypertension changes the branching angle or tortuosity of vessels and diabetic retinopathy can lead to neovascularization i.e., development of new blood vessels [3].These modifications in vascular network would lead vision degradation or even vision loss. Diagnosing these disorders at early(initial) stage can prevent the vision loss to a greater extent. [4]

Research scope

Retinal blood vessels (vasculature structure) carries important information which is used by ophthalmologist to analyze, detect and diagnose a variety of retinal pathologies such as Diabetic Retinopathy, Glaucoma, Hypertension, Age-related Macular Degeneration, Brain related diseases or Heart-stroke, among others. The clinical analysis of the conditions of retinal vascular is tedious work and prone to errors, Advances in image processing and analysis reduces the workload while providing ophthalmologists with high accuracy diagnosis of the eye related diseases. Retinal blood vessels segmentation plays a crucial role in diagnosis, screening, treatment and evaluation eye related diseases. In particular on diabetic retinopathy disease blood vessels exhibit abnormalities at early stage which includes vessel diameter alterations, dilation and elongation of main arteries, veins and their branches.

Here we present an algorithm which operates with both ultra-widefield view angiography retinal images in which vessels are lighter than background and fundus images. The algorithm uses pre-processing consisting in extracting the green channel, second, we use CLAHE (contrast limited adaptive histogram equalization) for contrast enhancement, then denoising the image by applying 5 x 5 median filter to smooth the image, followed by Gaussian filter 17x17 window with sigma 1.8. Blood vessels are later enhanced by BCOSFIRE filters, where the filter achieved orientation selectivity by combining the output at a given position with respect to the center of the COSFIRE filter-of center-on Difference of Gaussians (DoG) functions by a geometric mean. Finally, two set of filters which are symmetric and asymmetric COSFIRE filters were configured with different parameters such as sigma0, sigma 1(Gaussian function in the DoG and Gaussian weighting function respectively), length of the filter support and alpha coefficient of weighting function, number of orientations and output responses of these two filters were combined to get single blood vessels enhanced image. Enhanced images were obtained at number of orientations 12 and 24 for symmetric and asymmetric filtering, respectively. A fully segmented image was obtained after thresholding applied to blood vessels enhanced.

Objectives

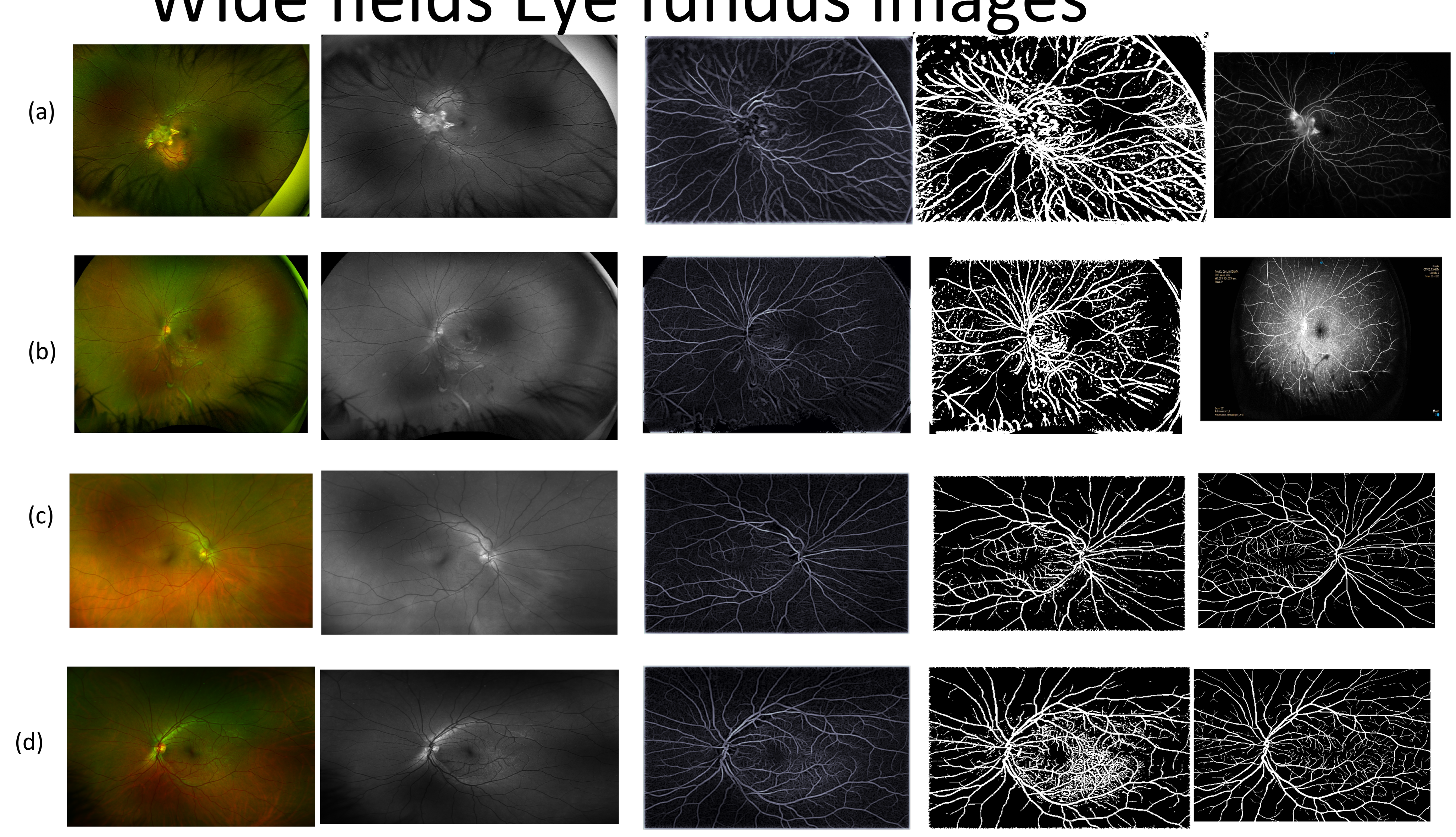
Early diagnosis is crucial in many sight-threatening diseases like glaucoma, hypertension and diabetic retinopathy which cause blindness among working age people.
To develop an inexpensive and high-throughput automated system to screen retinal related diseases (diabetic retinopathy, glaucoma, macular edema)The system will have capability of analyzing and accurately measuring the oxygen saturation in blood vessels, which currently is in high demand.

Methodology

- **Image acquisition**: Eye fundus are obtained with a Optos © ultra wide field camera. The image acquires 200° single-capture retinal image. It uses two laser sources to obtain the image (Red laser: 635 nm, Green laser: 532 nm)
- **Preprocessing**: Extraction of green chanel from input ultra wide field retinal image, applying median filter for denoising, then Gaussian filter follow. CLAHE plays a major role on contrast enhancement of the filtered image.
- **Blood vessels enhancement**: Contrast enhanced image considered as input of the DoG filters, DoG filters gives high responses to the intensity change to the input image.DoG responses at determined positions are used to compute the output of B-COSFIRE filter. The output of B-COSFIRE filter is the weighted geometrical mean of all blurred and shifted DoG responses [5]
- **Segmentation**: We applied local region-based threshold probing, which produce good results because the particular information of retinal vessel network is used.

Results

Wide fields Eye fundus images



(I) Optos© ultra wide field eye fundus | (II) Green channel | (III) Processed green channel | (IV) Final image | (V) Optos© ultra wide field eye fundus angiography

In the figure four different ultra wide field eye images (a trough d) presenting (I) input image , (II) green channel image, (III) vessels enhanced image and (IV) groundtruth from left to right respectively . For comparison in (c) and (d) are ground truth angiographic images .

Using this images we obtained that the proposed algorithm perform well and provides sensitivity = 0.833 , specificity = 0.8738 which are the promising results compared to other algorithms when applied to same kind of images (Ultra-wide field of view) retinal images in order to provide blood vessel distribution.

Conclusion

The proposed algorithms gives us the promising results when it comes about enhancement of the blood vessels and also in segmentation of blood vessels as well. We are still working to know how many numbers of vessels enhancement filters will gives us the best results which will leads to high sensitivity and specificity during segmentation of the blood vessels, especially the thin blood vessels needs more concern so that we will have more details and simplify work of analysis retinal blood vessels for diabetic retinopathy detection at very early stage .

References

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