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Review Paper on Segmentation of Retinal Blood Vessels through Wavelet Filter Method

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Abstract : With the advancement of CAD (Computer Assisted Diagnosis) Image Processing in Medical Field has created its own niche. Retinal Blood Vessels are highly complicated with low contrast and of very thin diameter which often causes failure in diagnosis of exact abnormalities. However, many researchers have worked on enhancement and segmentation of Retinal Blood Vessels through various methods over the course of time. For example Segmentation of Retinal Blood vessels through Morlet wavelet, Gabor wavelet, Wavelet transforms along with sharpening filters etc. Such tools can also help tremendously in diagnosis of early signs of diabetes, heart problems and cardiovascular diseases too. Here, we intend to use wavelet filter method for segmenting the Retinal Blood Vessels. Diabetic Retinopathy which may result into gradual loss of eye sight along with glaucoma can be diagnosed more effectively through Wavelet Filter Method. Through this research we can effectively improve the pattern of very thin and less visible vessels. We take Monochromatic RGB retinal image as an input image. Next thresholding helps to create the Binary masks of vessels segmentation. While masking all the pixels related to Blood Vessels is assigned 1 and 0 to non vessel pixels. This method is specially used for its directional selectiveness ability to diagnose fine tuned to particular frequencies. We have evaluated the segmentation of RBV images through Wavelet Filter Method on publicly available DRIVE database.

Index Terms— CAD (Computer Aided Designing), DR (Diabetic Retinopathy), DRIVE (Digital Retinal Images for Vessel Extraction) Database, Gabor Wavelet, Image Processing, Retinal Blood Vessels, Wavelet Filter Method

1 Introduction

Before direct clinical applications proper diagnosis for the concerned treatment is really important. Majority of the diseases related to Choroid and Retina can be diagnosed with the help of retinal Image Processing. Diabetic Retinopathy (DR) is one such disease in which CNV (Choroidal Neovascularisation) occurs in Choroid and takes a portion of blood supplying the retina. As the blood reaching retina reduces it starts affecting the sight of the Patient. Moreover, Retinal Blood Vessels have measurable changes in branching angles, diameter and length as an outcome of disease[1], [2]. Hoover [3] proposed the segmentation of vessels using matched filters, where the second derivative of Gaussian functions convolves with the image. Gaussian functions at multiple scales can be applied to detect the vessels with various radii. Segmentation of Retinal Vessels could detect the amount of false positive outcomes in detection of microaneurysm. DR can also cause abnormalities like beadings or venous looping. So detection is critical for prior treatment because in maximum cases it can cause blindness too. Retinal Blood Vessels (RBV) are very thin and of low contrast and of very less width of either orange red or deep red filaments [4]. CAD (Computer Assisted Diagnosis) has played a pre-eminent role in diagnosis of abnormalities of RBV [5]. Imaging the RBV and its segmentation can assist tremendously for the treatment of DR. Many probabilistic filter methods have shown lucrative results in segmentation of Blood Vessels. Various methods such as continuous wavelet transform [6], Morlet wavelet [7], Gabor wavelet [8], Sharpening filters, Wavelet methods [9] etc. have contributed a lot in research for segmenting Retinal Blood Vessels for treatment of Diabetic Retinopathy. Nayak, Kaur, C., M.L., & Kumar, M.S. (2015) surveyed the algorithm of retinal BV segmentation for retinopathy of diabetes using wavelet. Gabor wavelet is effective to enhance the vessel, contrast at the same time eliminates the noise. Such technique is selected since it has potential to detect related features and tune to particular frequencies. Moreover, it could adjust specific to the frequency, noise in the background could be filtered. Issue with segmentation of BV is that vascular pattern visibility is not good particularly for vessels which are thin. Therefore, it is significant for enhancing the vascular pattern. Apart from these, it was noted that Gabor wavelets have capability of directional selectiveness. So, in this research we have focused on Segmentation of retinal blood vessels through Wavelet Filter Method.

2.1 Proposed System

To implement the system of vessel screening it is very crucial to find accurately the pattern of vascular. To get an effective Segmentation Results through Wavelet Filter Method we take a monochromatic Red, Green and Blue Retinal Image as an Input Image. Wavelet filter method is used for enhancing the pattern of vascular particularly less and thin vessels are improved using wavelet filter method [10]. The continuous wavelet transform $T\Psi(b,\theta,a)$ is defined in terms of the scalar product of 'f' with the transformed wavelet $\Psi b,\theta,a$ using equation

$$T_\Psi(b,\theta,a) = C_\Psi^{-\frac{1}{2}}\langle \Psi_b,\theta,a|f\rangle = C_\Psi^{-1/2} a^{-1}\int \Psi*(a^{-1}r_{-\theta}(x-b))f(x)d^2x$$

….1

where f ∈ L2 is an image represented as a square integral (i.e., finite energy) function defined over R2 and ψ ∈ L2 be the analyzing wavelet Cψ, ψ, b, θ and 'a' denote the normalizing constant, analyzing wavelet, the displacement vector, the rotation angle, and the dilation parameter respectively. It is easy to implemented wavelet transform using the fast Fourier transform algorithm. Fourier wavelet transform is defined using equation 1.

$$T\Psi(b,\theta,a) = C_\Psi^{-\frac{1}{2}} a \int \exp(jkb)\hat{\Psi}^*(ar_{-\theta}k)\hat{f}(k)d^2k$$

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The 2-D Gabor wavelet is defined as

$$\Psi G(x) = \exp(jk_0x)\exp\left(-\frac{1}{2}|Ax|^2\right)$$

..….3

where k0 is a vector that defines the frequency of the complex exponential and A = diag[ε−1/2, 1], ε >1 is a 2×2 diagonal matrix that defines the elongation of filter in any desired direction. For each pixel, for considered scale value, the Gabor wavelet transform Mψ (b, a)is computed using equation 3 , for θ spanning from 0 to 170 degrees at steps of 10 degree and the maximum is taken

$$M_\Psi(b,a) = \max \theta |T_\Psi(b,\theta,a)|$$

….4

This gives us the enhanced vascular pattern for the retinal image. Histogram for the enhanced retinal image is calculated. Otsu algorithm assumes uniform illumination so the weighted within-class variance is

$$\sigma_w^2(t) = q_1(t)\sigma_1^2(t) + q_2(t)\sigma_2^2(t)$$

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Where the class probabilities are estimated as:

$$q_1(t) = \sum_{i=1}^{t} P(i)\; q_2(t) = \sum_{i=t+1}^{I} P(i)$$

…6

The class means are given by:

$$\mu_1(t) = \sum_{i=1}^{t} \frac{iP(i)}{q_1(t)}\; \mu_2(t) = \sum_{i=t+1}^{I} \frac{iP(i)}{q_2(t)}$$

…7

The individual class variances are:

$$\sigma_1^2(t) = \sum_{i=1}^{t} [i - \mu_1(t)]^2 \frac{P(i)}{q_1(t)}$$

…8

$$\sigma_2^2(t) = \sum_{i=t+1}^{I} [i - \mu_2(t)]^2 \frac{P(i)}{q_2(t)}$$

…9

We need to do is just run through the full range of t values [1,256] and pick the value that minimizes $\sigma_w^2(t)$. After getting the threshold the hard thresholding is done by converting all the values below the threshold to 0 and all the values greater than threshold is represented as 1. So

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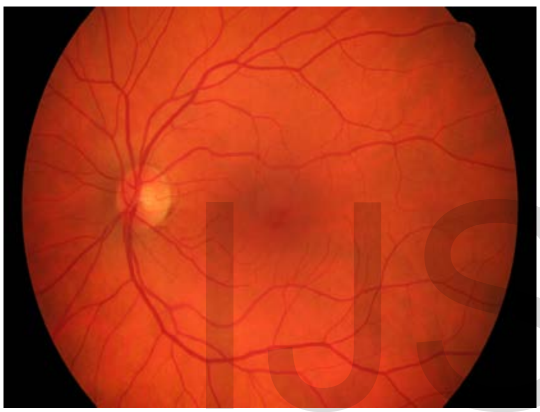
the resulting binary image will consist of the segmented blood vessel.

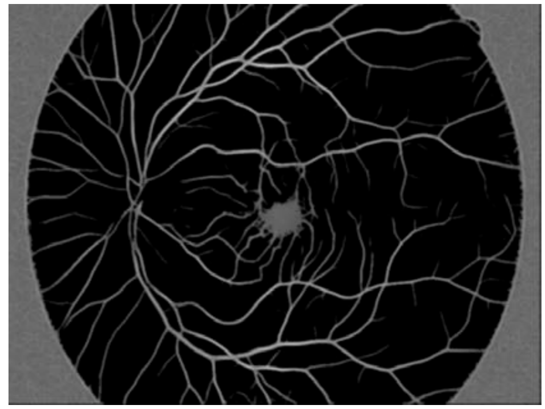
3 Experimental Outcomes

This method is adopted specially because of its directional selectiveness potential to detect related features along with the fine tuned to particular frequencies [11]. This method has also helped us to enhance the thin vessels as well as vascular patterns [10]. The MATLAB implementation for the input image gives following enhanced images from Left to Right. The images are tested on publicly available DRIVE databases.

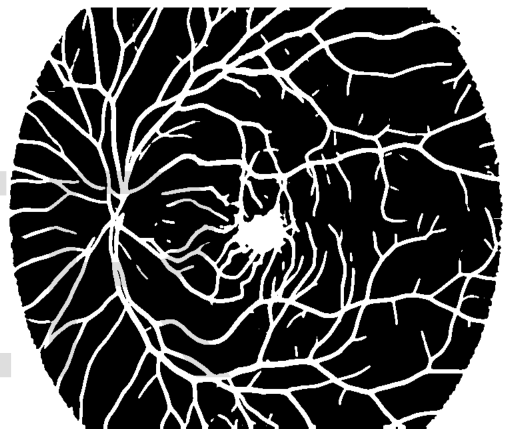
STEP 1 – RGB INPUT IMAGE



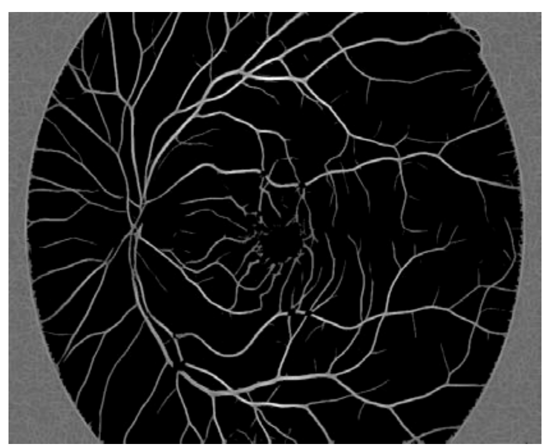
STEP 2 - SMOOTH IMAGE



STEP 3 - Gradient magnitude



STEP 4 - Gradient magnitude



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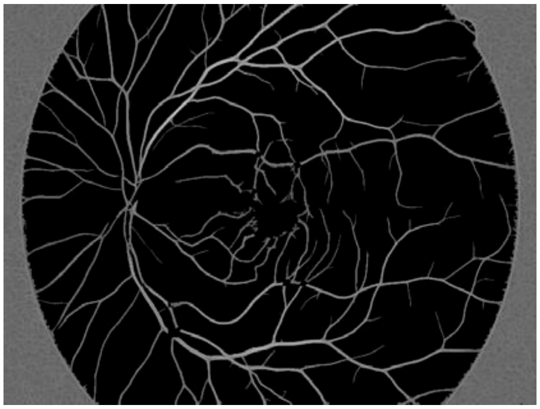
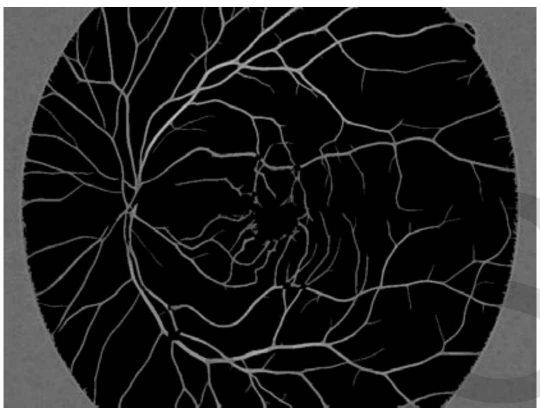
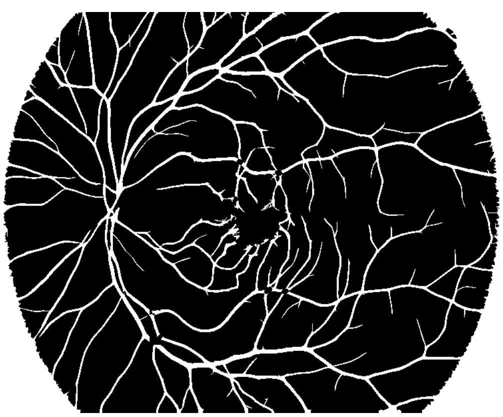
STEP 5 - Opening-by-reconstruction (Iobr)



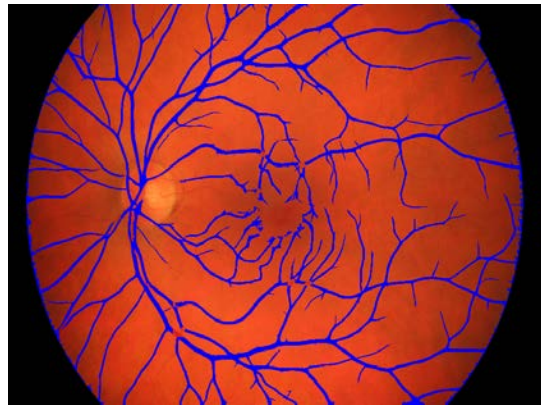
STEP 6 - Opening-closing by reconstruction



STEP 7 - Final segmented image



STEP 8 – RGB FINAL SEGMENTED IMAGE



4 Conclusion

The proposed Wavelet Filter Method used for segmentation of Retinal Blood Vessel is highly effective to handle images under various conditions with satisfactory accuracy rates and reliability for diagnosis of Diabetic Reliability. The problem with vascular patterns is that they are very thin and highly complicated with very low contrast. So, it is very important to use enhancement methods before detection itself as described in this paper for proper diagnosis. Wavelet filter method is adopted because of its directional selectiveness potential to detect related features as well as fine tuned to particular frequencies. Wavelet filter method was adopted in order to enhance the thin vessels as well as vascular patterns.

References

[1] T. Teng, M. Lefley and D. Claremont, "Progress towards automated diabetic ocular screening: A review of image analysis and intelligent systems for diabetic retinopathy," Med. Biol. Eng. Comput., vol. 40, pp. 2-13, 2002.

[2] M. Foracchia, E. Grisam, and A. Ruggeri, "Detection of the optic disc in retinal images by means of a geometrical model of vessel structure," IEEE Trans. Med. Imag., vol. 23, no. 10, pp. 1189-1195, Oct. 2004

[3] A. Hoover, V.Kouznetsova, and M. Goldbaum. Locating blodd vessels in retinal images by piecewise

threshold probing of a matched filter response. IEEE Transactions on Medical Imaging, 19(3):203-210,2000

[4] Leandro J. J. G., Cesar R. M. Jr., Jelinek H. F. (2001), Blood vessels segmentation in retina: preliminary assessment of the mathematical morphology and of the wavelet transform techniques, In SIBGRAPI-01,Florianópolis - SC, IEEE Computer Society Press: 84-90

[5] C. Wu and G. Agam (2007a), "Probabilistic Retinal Vessel Segmentation," in Proceedings of the SPIE (The International Society for Optical Engineering), vol. 6512, March 2007.

[6] Cornforth.D.J et al (2005), Development of Retinal Blood Vessel Segmentation Methodology using Wavelet Transforms for assessment of Diabetic Retinopathy, Complexity international.

[7] Soares.V.B et al (2006), Retinal Vessel Segmentation using the 2-D Morlet Wavelet and Supervised Classification, Retrieved on: 8th July 2015, Retrieved from: http://arxiv.org/pdf/cs/0510001.pdf

[8] Kharghanian.R and Ahmadyfard.A (2012), Retinal Blood Vessel Segmentation using Gabor Wavelet and Line Operator, International Journal of Machine Learning and Computing, vol 2, no 5.

[9] Nayak.C et al (2015), Retinal Blood Vessel Segmentation Algorithm for Diabetic Retinopathy using Wavelet : A Survey, International Journal on Recent and Innovation Trends in Computing and Communication, vol 3, iss 3.

[10] Arnodo.A et al (2000), A Wavelet-based method for multifractal image analysis, I.Methodology and test applications on isotropic and anisotropic random rough surfaces, Eur.Phy.J.A, vol 15, pp: 567-600

[11] Antoine.J.P et al (1993), Image Analysis with 2D continuous wavelet transform, Signal process, vol 31, pp: 241-272.

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