Automatic Detection of Retinal Venous Beading and Tortuosity by using Image processing Techniques

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ABSTRACT
For the automatic detection of retinal venous beading and to calculate tortuosity of extracted retinal blood vessels. Venous beading represents focal areas of venous dilation and thinning of the venous walls. Venous beading is most easily comprehended as changes in the vascular caliber of the veins of the vascular arcades. This algorithm proceeds through three main steps 1. Preprocessing operations on high resolution fundus images 2. Simple vessel segmentation techniques formulated in the language of 2D Median Filter for retinal vessel extraction 3. Detection of Venous beading and Tortuosity from extracted blood vessels. Performance of this algorithm is tested using the fundus image database(300Fundus Images) taken from Dr. ManojSaswade,Dr.Neha Deshpande and online available databases diaretdb0, diaretdb1 and DRIVE. This algorithm achieves accuracy of 98% with 0.92 sensitivity and 0 specificityfor Saswadedetabase,for diaretdb0 accuracy 95% with 0.95 sensitivity and 0 specificity, for diaretdb1 accuracy 96% with 0.96 sensitivity and 0 specificity,and for DRIVE database 98% accuracy with 0.98 sensitivity and 0 specificity.

Keywords
Blood Vessels, Venous Beading, Tortuosity.

1. INTRODUCTION
Venous beading are included as they are the most predictive for progression to Proliferative Diabetic Retinopathy, and Tortuosity is early symptoms of diabetic retinopathy.The prevalence of Diabetic Retinopathy in the Chennai Urban Rural Epidemiology (CURES) Eye Study in south India was 17.6% significantly lower than age-matched western counterparts. However, due to the large number of diabetic subjects, DR is likely to pose a public health burden in India [1]. Proposed algorithm shows Automatic detection of venous beading and tortuosity of retinal blood vessels. In this algorithm we have used the Image Processing techniques for extraction of the retinal blood vessels and then classification is based on venous beading and tortuosity to see whether the images are normal or abnormal, if the image does not have venous beading and tortuosity then it is called as normal otherwise it is abnormal image. Tortuosity is early symptom of Diabetic retinopathy whereas venous beading is most easily comprehended as changes in the vascular caliber of the veins

of the vascular arcades. Image processing techniques can help in extractions of blood vessels and calculate venous beading and tortuosity. The proposed algorithm shows the automatic detection of venous beading and tortuosity of retinal blood vessels this algorithm has 3 stages, shown in the figure 1. In first stage preprocessing is done to remove the background noise from input fundus image. Blood vessels are highlighted and extracted in the second stage and in the third stage calculate venous beading and tortuosity of extracted blood vessels for the classification in to normal or abnormal.

2. METHODOLOGY
Firstly we have performed the preprocessing operation on high resolution fundus images. In the preprocessing high resolution color fundus image is taken. Green channel is extracted from RGB image, because green channel shows high intensity as compare to red and blue respectively. After green channel extraction histogram equalization is done for enhancement of image, after histogram equalization image is enhanced but noise gets added, thus to remove the noise, 2D Median filter is used. After performing the 2D Median filter, blood vessels are extracted using some image processing techniques and threshold function. Then morphological thinning is performed for extracting the centerline of the extracted blood vessels. Centerline extraction calculates its diameter. Normal diameter range for retinal blood vessels is 25mm. If diameter of centerline blood vessels is equal to length or length*5 then it is called as venous beading[2]. After calculation of venous beading, tortuosity is calculated. For observing the result we have taken the images and formed a database from Dr. ManojSaswade and Dr. NehaDespande (300 images), images from online databases diaretdb0, diaretdb1, STARE and DRIVE.

2.1Preprocessing
The Preprocessing is done to remove noise from the background and to enhance the image. We have taken out green channel, because green channel shows high intensity as compare to red and blue[4]. As shown in figure 2.Green channel is extracted from the high resolution fundus image mathematical formula for finding green channel is as follows.

$$g = \frac{G}{(R + G + B)} \qquad (1)$$

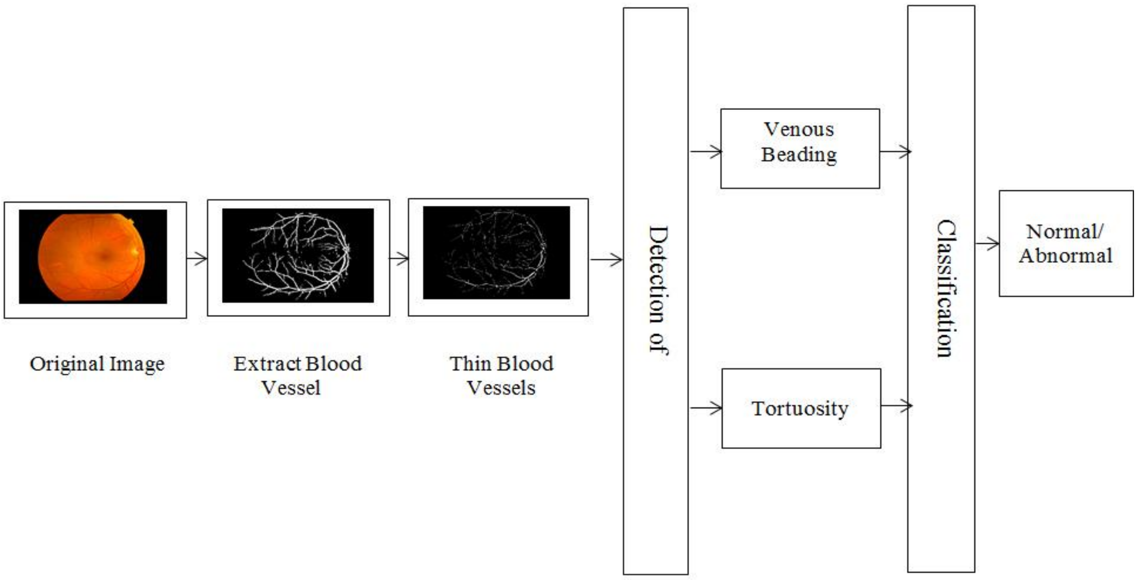


Figure 1: Flow chart for proposed algorithm of automated detection of retinal venous beading and

Here g is a Green channel and R, G and B are Red, Green and Blue respectively.

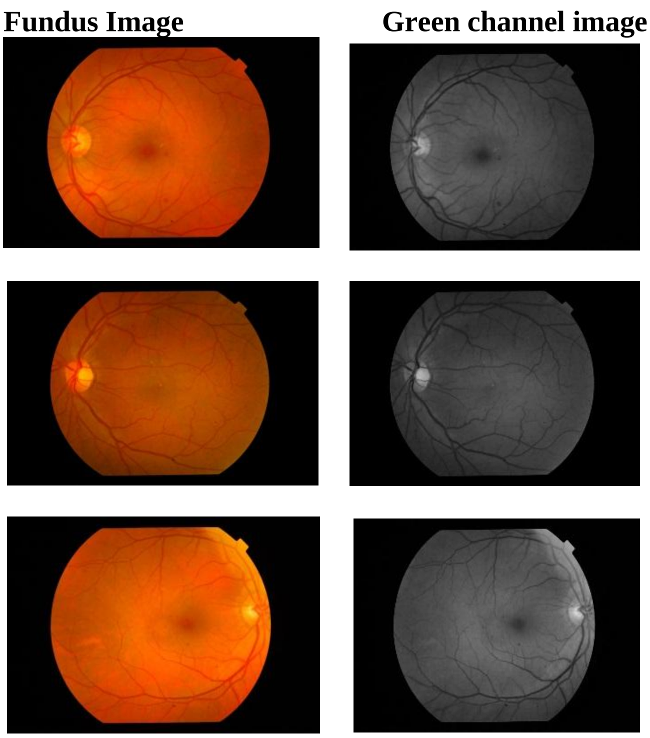


Figure 2: Fundus image and green channel image

2.2 Blood Vessels

2.2.1 Blood Vessels Enhancement

After preprocessing of high resolution fundus images, enhancement is done on processed image, for enhancement following operations are widely use.

Complement function for enhancing the blood vessels of the retina.

$$A^c = \{\omega \mid \omega \notin A\} \qquad (2)$$

Here A^c is a complement, ω is the element of A, ∉ stands for not an element of A and A is set.

Then Histogram equalization function for enhancing the complementary image.

$$h(v) = \text{round}\left(\frac{cdf(v) - cdf_{min}}{(M \times N) - cdf_{min}} \times (L-1)\right) \qquad (3)$$

Here cdf_{min} is the minimum value of the cumulative distribution function, M × N gives the image's number of pixels and L is the number of grey levels. After performing this operation image is enhanced but noise is added to removing the noise 2D Median filter is use 2D median filter for removing noise from the histogram equalized image.

$$y[m,n] = \text{median}\{x[i,j], (i,j) \in \omega\} (4)$$

Here ω Represents a neighborhood centered around location(m,n) in the image.
As shown in the figure 3, we have use the Morphological structuring element for highlighting the blood vessels of the retina.

2.2.1Blood Vessels Extraction

$$I_{dilated}(i,j) = \max_{f(n,m)=true} I(i+n,j+m) (5)$$

$$I_{eroded}(i,j) = \min_{f(n,m)=true} I(i+n,j+m) \qquad (6)$$

Use the Morphological open function for thickening the retinal blood vessels.

$$A \circ B = (A \ominus B) \oplus B \qquad (7)$$

Color Fundus Images **Blood Vessels Enhanced images**

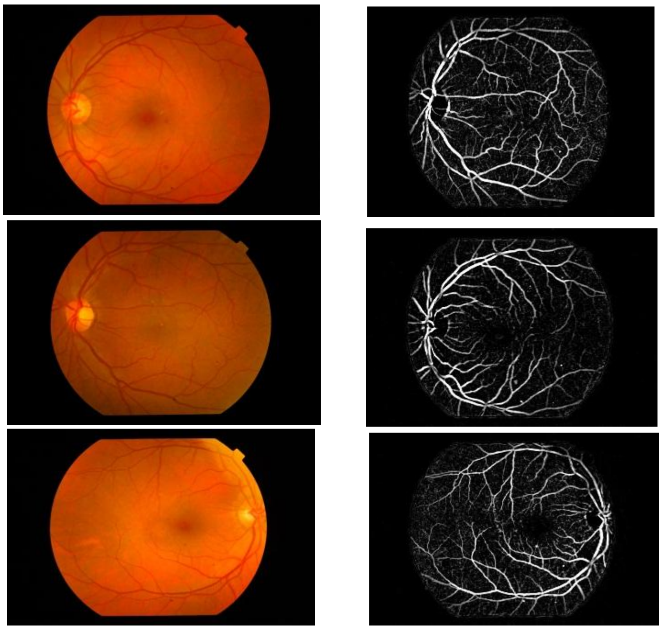


Figure 3: Fundus image and Blood vessels Enhanced images

Here A ∘ B is morphological opening, ⊖ is Erosion and ⊕ is Dilation.

Use the 2D median filter for highlighting and removing noise from the Morphological open function.

$$y[m,n] = \text{median}\{x[i,j], (i,j) \in \omega\} (8)$$

Here ω Represents a neighborhood centered around

Color Fundus Images **Blood Vessels Extracted Images**

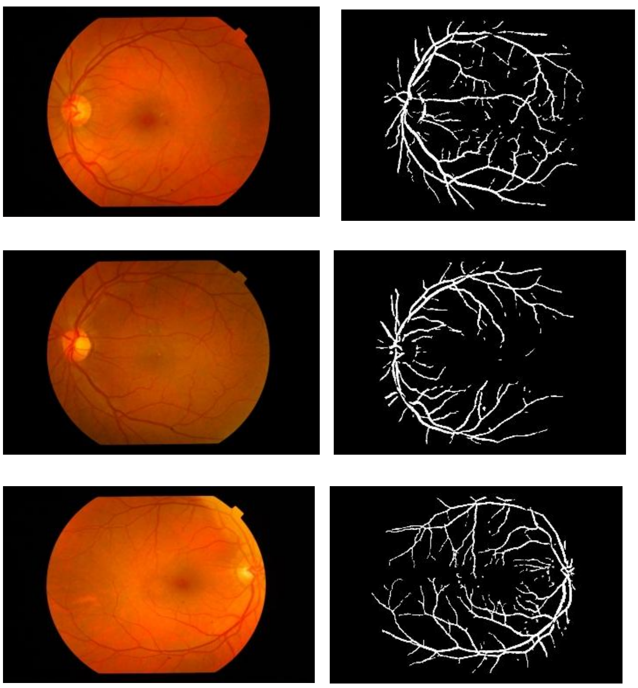


Figure 4: Fundus images and Images obtained using Threshold to Extract Blood Vessels

location(m,n) in the image

Then use enhancement techniques like histogram equalization, intensity transformation function and some image processing techniques on 2D Median filter image and Threshold function for extracting the retinal blood vessels, result images are shown in the figure 4.

2.3 Blood Vessels Thinning

After blood vessels extraction use morphological thinning for extracting the centerline of the vessels the mathematical formula shows the morphological thinning.

$$S(X) = \bigcup_{P>0} \bigcap_{\mu>0} [(X \ominus \rho B) - (X \ominus \rho B)\, o\, \mu \bar{B}] \quad (9)$$

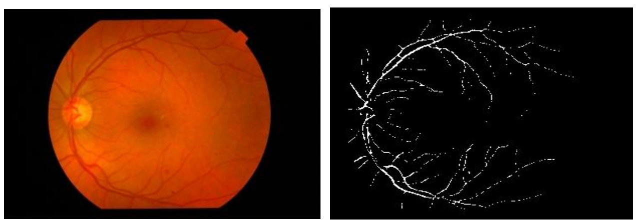
Where ⊖ and o arethe morphological erosion and opening, respectively, ρB is an open ball of radius ρ, and $\bar{B}$ is the closure of B.

After extraction of retinal blood vessels perform Morphological thinning operation, Morphological thinning is very important because using this operation blood vessels centerline is get extracted. After extracting the centerline of blood vessels calculate its diameter to see whether the extracted blood vessels is normal or not. 25 mm is normal range of healthy blood vessels. If diameter is equal to length or length * 5 then it is called as a venous beading. And then calculate tortuosity using the length upon distance. If the image does not have venous beading nor tortuosity then the image is normal otherwise abnormal because both venous beading and tortuosity is very dangerous as far as vision are concern. Using this algorithm ophthalmologist comes to know whether the patient is normal or not.

3. RESULT

For this algorithm we have designed one GUI in MATLAB, shown in the figure 6 and figure 7, for result analysis we have used Receiver Operating Characteristic Curve (ROC).ROC curve for Saswade database is shown in figure 7, this algorithm achieves a true positive rate of 98%, false positive rate of 0% and accuracy score 0.9202. Roc for Diaretdb0 this algorithm achieves a true positive rate of 95%, false positive rate of 0%, and accuracy score of 0.9514 as shownin figure 8, on diaretdb1 this algorithm achieves a true positive rate of 96%, false positive rate of 0%, and accuracy score of 0.9665 as shown in figure 9 and on DRIVE this algorithm achieves a true positive rate of 98%, false positive rate of 0%, and accuracy score of 0.9802 as shown in figure 10. Table 1

Color Fundus Images **Centerline of Extracted Blood Vessels**



shows Performance Evaluation and table 2 shows accuracy.

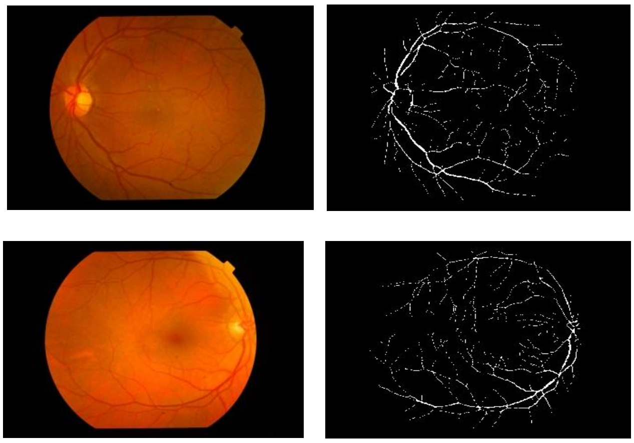


Figure 5: Fundus images and Images showing Boundaries

Table 1: Performance Evaluation

Test Result	**Present**	**Absent**
Positive	True Positive (TP)	False Positive (FP)
Negative	True Negative (TN)	False Negative (FN)

$$\text{Sensitivity} = \frac{\text{TP}}{\text{TP} + \text{FN}} \qquad (10)$$

$$Specificity = \frac{\text{TN}}{\text{TN} + \text{FP}} \qquad (11)$$

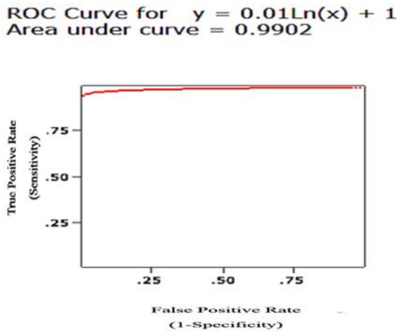


Figure 7: Receiver Operating Characteristics CurveCurve for Calculation of Retinal Blood vessels Tortuosity on online on Dr. Saswade's Image Database

Table 2: Shows Sensitivity, Specificity and Accuracy

Sr. No.	**Database**	**Sensi-tivity**	**Speci-ficity**	**ROC**	**Accuracy**
1	Saswade	0.92	0	0.9202	98%
2	Diaretdb0	0.95	0	0.9514	95%
3	Diaretdb1	0.96	0	0.9665	96%
4	DRIVE	0.98	0	0.9802	98%

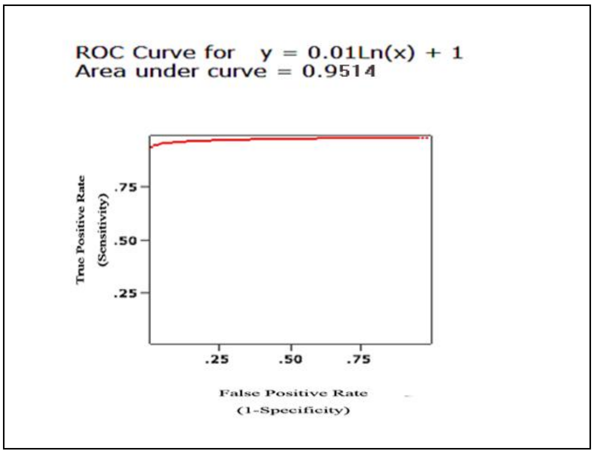


Figure 8: Receiver Operating Characteristics Curve for Calculation of Retinal Blood vessels Tortuosity on online on online available Database diaretdb0

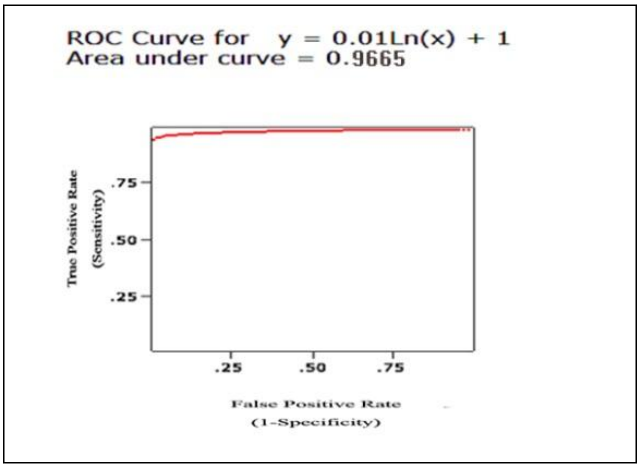


Figure 9: Receiver Operating Characteristics Curve for Classification and Calculation of Retinal Blood vessels Parameterson online available Database diaretdb1

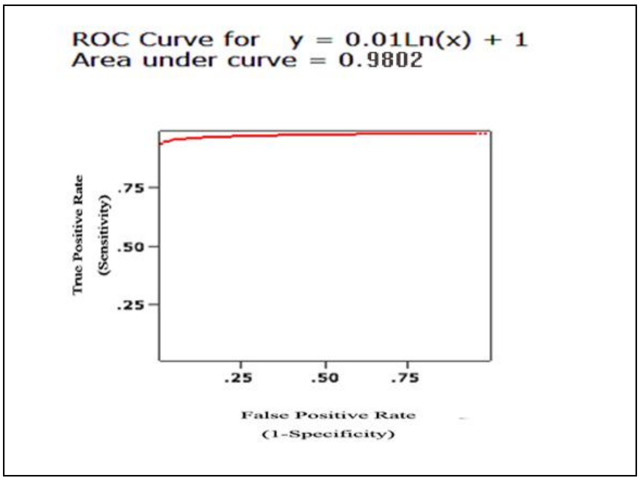


Figure 10: Receiver Operating Characteristics Curve for Calculation of Retinal Blood vessels Tortuosityon online available Database DRIVE

4. DISCUSSION

For this algorithm we have used 300 high resolution fundus images and perform Image processing techniques for extraction and calculation of retinal venous beading and Tortuosity,for manipulating the image processing techniques use MATLAB 2013a and with the help of this tool we have design one GUI for retinal blood vessels extraction and calculate its centerline by using morphological Skeletanization. For result analysis we have used Receiver operating characteristic curve.

5. CONCLUSION

In this algorithm perform Image processing techniques for extraction of retinal blood vessels and calculates the tortuosity and venous beading values on extracted blood vessels. Database is taken from Dr. ManojSaswade, Dr. Neha Deshpande (300 high resolution fundus images) and online available databases diaretdb0, diaretdb1 and DRIVE. This algorithm for Saswade database achieves accuracy of 98% with 0.92 sensitivity and 0 specificity,for diaretdb0 accuracy 95% sensitivity and specificity 0, accuracy 96% with 0.96 sensitivity and specificity 0 for diaretdb1, and for DRIVE 98% with 0.98 sensitivity and specificity 0 respectively.

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7. REFERENCES

[1] M. Rema& R. Pradeepa "Diabetic retinopathy: An Indian perspective", Indian J Med Res 125, March 2007, pp 297-310

[2] P. H. Gregson, Z.Shen, et al., Automated Grading of Venous Beading, Computer And Biomedical Research., 28, 291-304(1995).

[3] Manjiri B. Patwari, Dr. Ramesh R. Manza, Dr. ManojSaswade and Dr. Neha Deshpande, "A Critical Review of Expert Systems for Detection and Diagnosis of Diabetic Retinopathy", Ciit International Journal of Fuzzy Systems, February 2012, DOI: FS022012001 ISSN 0974-9721, 0974-9608. (IF 1.3).

[4] Yogesh M. Rajput, Ramesh R. Manza, Manjiri B. Patwari, Neha Deshpande, "Retinal Blood Vessels Extraction Using 2D Median Filter", Third National Conference on Advances in Computing(NCAC-2013), 5th to 6th March 2013, School of Computer Sciences, North Maharashtra University, Jalgaon-425001 (MS) India.

[5] Yogesh M. Rajput, Ramesh R. Manza, Manjiri B. Patwari, Neha Deshpande, "Retinal Optic Disc Detection Using Speed Up Robust Features", National Conference on Computer & Management Science [CMS-13], April 25-26, 2013, RadhaiMahavidyalaya, Auarngabad-431003(MS India).

[6] Manjiri B. Patwari, Ramesh R. Manza, Yogesh M. Rajput, Neha K. Deshpande, ManojSaswade, "Extraction of the Retinal Blood Vessels and Detection of the Bifurcation Points", International Journal in Computer Application(IJCA), September 18, 2013. ISBN : 973-93-80877-61-7,

[7] Manjiri B. Patwari, Ramesh R. Manza, Yogesh M. Rajput, ManojSaswade, Neha K. Deshpande, "Review on Detection and Classification of Diabetic Retinopathy Lesions Using Image Processing Techniques", International Journal of Engineering Research & Technology (IJERT), ISSN: 2278-0181, Vol. 2 Issue 10, October - 2013,

[8] Manjiri B. Patwari, Ramesh R. Manza, Yogesh M. Rajput, ManojSaswade, Neha K. Deshpande, "Detection and Counting the Microaneurysms using Image Processing Techniques International Journal of Applied Information Systems (IJAIS) – 6(5):11-17, November 2013. Published by Foundation of Computer Science, New York, USA., ISSN : 2249-0868, Vol. 6 Number 5, October - 2013, Impact Factor 1.187

[9] Manjiri B. Patwari, Dr. Ramesh R. Manza,Yogesh M. Rajput, Dr. ManojSaswade, Dr. Neha K. Deshpande, Sangramsing N. Kayte," Calculation of Retinal Blood vessels Tortuosity by using Image processing Techniques and Statistical Techniques", 2nd International Conference on System Modeling & Advancement in Research Trends (SMART) Department of Computer Applications, TMIMT ,TeerthankerMahaveer University, published in Academic Journal online (AJO), International Journal of Trends in Computer Science, ISSN: 7462 – 8452, Volume 2, Issue 11, 2013.

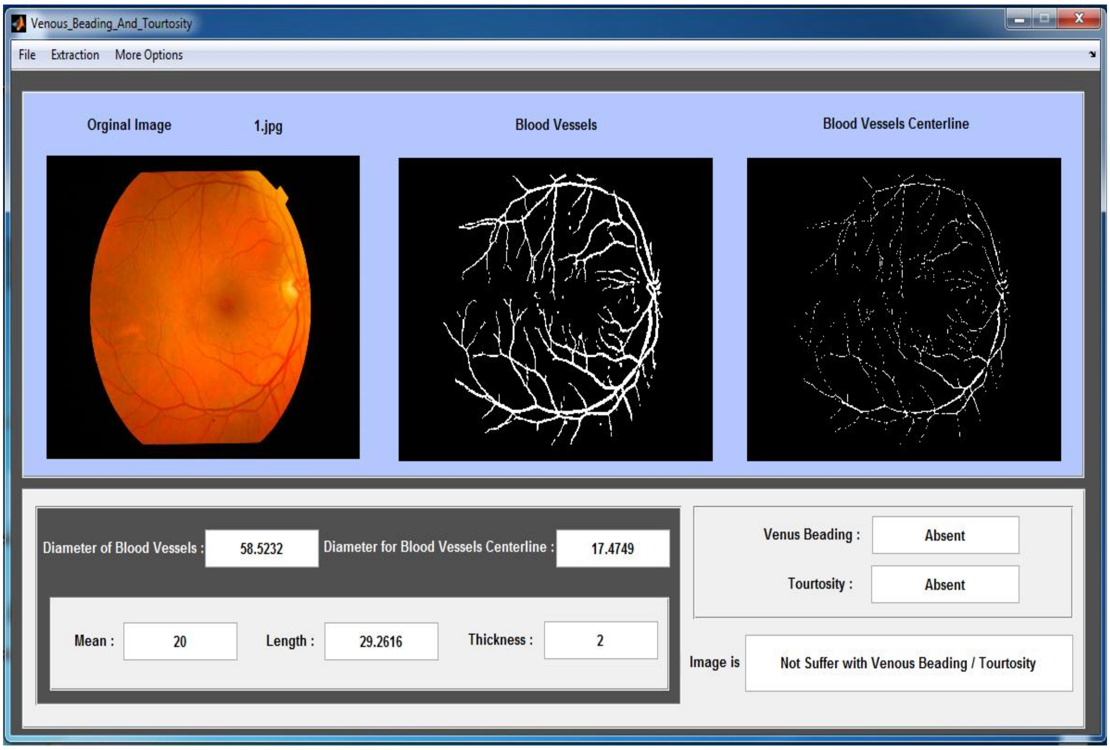

Figure 7: GUI for Automatic Detection Venous Beading and Tortuosity

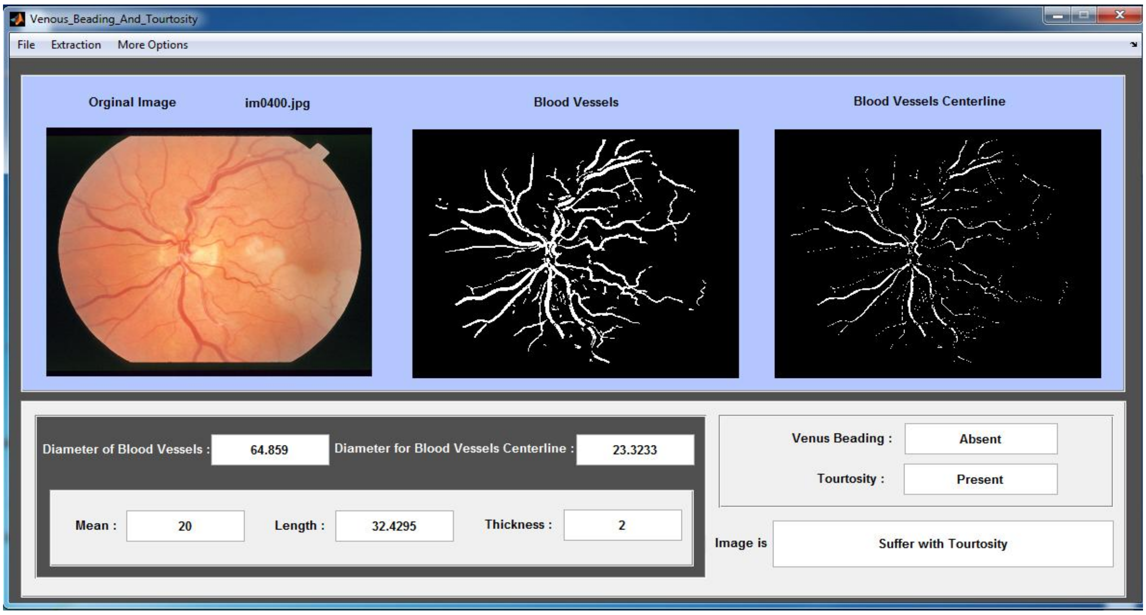

Figure 6: GUI for Extraction of Retinal Blood Vessels and Calculating Venous Beading and Tortuosity