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A Bayesian Set Approach (BSM) for Segmentation of Retinal Fundus Images for Retinal Disorder Detection

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Abstract: **Research in medical image processing has been aggregating significant contributions and findings aided by the advent of state of the art image acquisition systems and processing algorithms. One such field of interest is the processing of retinal fundus image for detection of a series of disorders related to eye as well as diabetes prone patients. Segmentation forms the backbone behind retinal image processing as the segmentation of blood vessels in the retinal image brings out key findings about the condition of the eye. A novel Bayesian set approach/model is proposed in this research article for segmentation of blood vessels and compared with learning based model for the accuracy as well as computation time. Experimental results justify the simplicity of the proposed model with a high degree of observed precision.**

Keywords —Bayesian Set Theory, Blood Vessels, Precision, Region of Convergence, Retinal Images, Segmentation

I. INTRODUCTION

In recent times, medical image processing has been found to be an integral part of almost all hospital management systems for patient disorder diagnosis and treatment [1] [15]. It could be rightly justified that the processing of such medical images greatly depends on the image acquisition methods employed. Further, in most cases, in spite of utilization of state of the art image acquisition methods, effective processing methods and algorithms employed bring about the required objective. On the other hand, these techniques are quite challenging due presence of significant amount of constraints [4]. One such field of medical image processing is the processing of retinal fundus images [6] for detection of eye related disorders. One such serious disorder observed from the literature is the diabetic retinopathy [11] [13] which is found to be prevalent among individuals with age groups ranging from teens aged around early 20's to 60's. This needs to be carefully and systematically handled supported by early detection schemes which if undetected may result in partial or even in complete blindness in individuals. This forms the motivation behind this research work and a strong detection method which could provide occurrence of the syndrome quite early could greatly aid in treatment and subsequent eradication of the disorder. Retinal fundus images play a key role in which appropriate segmentation methods may help in achieving the target objective. Blood vessels in the retina play a vital role as they convey useful information regarding the onset of the disorder. Other related disorders may include diabetic retinopathy (DR) and a typical difference between normal and abnormal eye image is illustrated in figure 1 shown below.

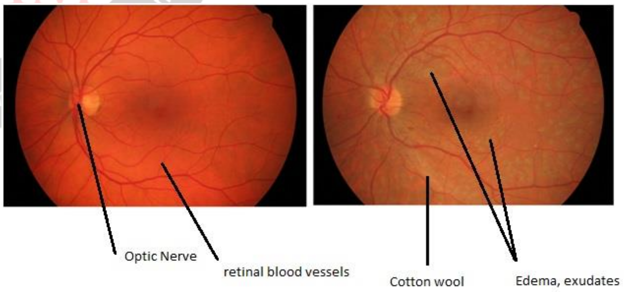

Figure 1 a. Normal retinal image b. Retinal image with Diabetic Retinopathy

As clearly illustrated in figure 1, it could be seen that images with DR are well characterized by features such as aneurysms, edema, cotton wool appearances etc. In order to detect these features a clear cut and precise segmentation algorithm is required which has been taken as the primary objective of this research article. The rest of this article is categorized into a systematic literature survey highlighting various research contributions related to segmentation, followed by the proposed Bayesian set model in section 3. Section 4 presents the experimental results followed by a brief conclusion.

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II. Literature Survey

Any image segmentation and classification methods involve key steps like preprocessing, image enhancement and image segmentation which may be done in spatial or frequency domains. Many relevant literature related to preprocessing highlight superior performances with utilization of filters like median filters [5], matched filters [10] [16], hybrid combinations of median and mean filters, Gaussian filters and Wiener filters [11] which help in reduction of speckle noise [12] which is characteristic of medical images. With respect to segmentation, a wide range of techniques are available in the literature [5]. A conventional line detection method has been proposed in the literature [1] addressing the segmentation of slightly color disoriented images like pale blood vessels. Further, the segmentation has been carried out in an automated manner. The input images have been taken from DRIVE database [4] and an accuracy of 94.47% has been recorded in the literature. Comparison has been done against supervised learning methods and reduced computation time has also been observed. Images from the same data set have been taken up for investigation in the literature using Ada Boost classifier algorithms [3] with a data set of 20 images with 94.73% accuracy. But the demerit observed in this method is the variable precision of accuracy due to limited amount of retinal images taken up for study. A conventional method available in the frequency domain is the use of wavelet transforms [6] which involve the decomposition of input image into its constituent 2^k sub bands with k depicting the number of decomposition levels. An added feature in wavelet transforms is that it supports denoising as well as processing in the high frequency sub bands where noise is more prevalent. Wavelet based research advances include a number of transforms like Contourlet transform and Ridgelet transforms [11] for retinal blood vessel segmentation. Fusion based methods [8] have also been investigated in the literature which could be ideal for application over retinal images for detection of eye related disorders. Spatial domain methods involve morphological operations such as the well-known region growing method found in the literature [7] more suitable for optic disc segmentation approaches. Preprocessing and post processing filters are applied over the proposed method for smoothening the segmented output obtained through adaptive histogram equalization and blood vessel subtraction. However, the model complexity increases with increasing number of samples.

On the other hand, cluster based approaches [17] have also been implemented over retinal images using radius based clustering algorithm (RACAL) [9] using a distance based mapping method. A significant number of false positives have been observed in the experimentation and is basically a unsupervised learning based clustering. Supervised methods have also been used for retinal blood vessel segmentation using multiple kernel learning methods [13] which reduces the challenges encountered in manual segmentation approaches and is based on computation of Hessian matrix have been discussed elaborately in the literature. A drastic reduction in computation time is reduced due to the automated feature in this work. Decision based methods [14] invoking fuzzy c means method have been experimented on STARE database images and accuracy of up to 92% have been reported in the literature. From the survey of literature, it could be clearly seen that most of methods have focused towards automatic segmentation methods using cluster based approaches, line detection outlier based methods, supervised and unsupervised methods. Satisfactory levels of accuracy have been reported. On the contrary the complexity of the methods still remains to be a critical design challenge.

III. Proposed Work

In this research work, the proposed work is based a simple structure of Bayesian set theory which drastically reduces the overall complexity of the segmentation method. The proposed algorithm is spatial domain based and involves concepts of regularization of distance parameter. The proposed model is progresses into three modules as pre-processing, vessel segmentation and post processing. In the pre-processing step closing operation and filtering operations are performed to remove the disc inference so that it retains the blood vessel images in the disc. It is easy to enhance the vessel information based on the variations in retinal images through the preprocessing module. The segmentation process used level set based model which includes Gaussian mixture and distance regularization terms to segment the vessels. This segmentation module reduces the energy function of the data set and in last post processing the length of the filter is defined to remove the unwanted data in the vessel due to noise and other factors.

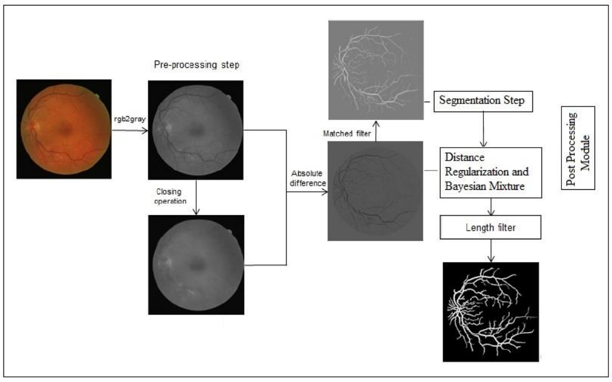

Figure 2 Illustration of proposed Bayesian set segmentation method

The mathematical model of the proposed work used Bayesian model along with level set segmentation as a hybrid process to improve the segmentation accuracy. Figure 2 gives an illustration of proposed model.

The mathematical model of preprocessing for improving the efficiency includes vessel information for the grey level

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image and closed image. Based on the variation in intensity the Gaussian curve is defined as

$$f(x,y) = GI\left(1 - re^{\frac{-pd^2}{2\alpha^2}}\right) \quad (1)$$

Where pd is the perpendicular distance, GI is the grey level intensity, r is the reflectance ratio value for blood vessel neighborhood, α is the vessel intensity. The matched filter representation for the actual image is given as

$$MF(x,y) = \left(-e^{\frac{-x^2}{2\alpha^2}}\right) \text{for} |y| \ll \frac{l}{2} \quad (2)$$

where l is the length of the vessel in a fixed direction. The filter response is suppressed due to the noise and a set of kernel filter in addition to the level set method provides better vessel information as input to the segmentation section. The hybrid segmentation process used intensity of the vessel distribution and the region information is extracted using difference images. Also distance regularization terms avoids noises due to intensity and the components used to define the parameters uses pixel intensity values. The iteration for conditional expectation is simplified into

$$Q = E_{GI}(\ln P(X,Y|\Theta|Y,\Theta^t) \quad (3)$$

The above equation represents all the possible labels for maximizing the parameters. While comparing the proposed model with supervised learning models the proposed model converges quickly for the given parameter training process. The Gaussian mixture term and its energy level is given as

$$E_F(\theta) = \int_0^\infty \log(P(Y|X,\Theta)\, dxdy \quad (4)$$

where Θ is the constant coefficient which is used to calculate the negative likelihood segmentation probability. The final term is obtained as

$$E_F(\theta) = v\int_0^\infty \log(P(Y|X,\Theta)\, dxdy \quad (5)$$

where v is the coefficient for level based segmentation process. The Dirac delta function is given as

$$\delta(\theta) = \frac{d}{d\theta}H(\theta) = \begin{cases} \frac{1}{2e}\left(1 + cos\frac{\pi\theta}{\xi}\right) & for \le \xi \\ 0 & \end{cases} \quad (6)$$

The post processing module uses background values as misclassified vessel values and by investigating the results the level set method found the contours have more intensity as noise in homogeneity values. Using length filter the noises are eliminated and discards the connected graph pixels which are lesser than threshold values.

IV. Results and Discussion

The proposed method was evaluated on database which includes dataset of 50 color images with 768×564 pixels in RGB channel, which were captured by a Canon CR5 camera and saved in JEPG-format. The test and training data set includes segmented images and performance of the set is compared with conventional model. In this the first set of 25 images is abnormal and second 25 images are normal. The performance is evaluated by the parameters such as true positive and false positive rate, efficiency and accuracy. The number of true negatives is obtained by measuring the values based on the image and the segmented area. Table 1 gives the performance comparison of the proposed model for normal images.

Table 1 Performance comparison of proposed model [Normal Images]

S.No	Method	True Positive	False Positive
1	ANN	0.8245	0.0242
2	Fuzzy C means	0.8606	0.0194
3	Proposed BSM	0.8962	0.0157

Table 2 gives comparison for abnormal images.

Table 2 Performance comparison of proposed model [Abnormal Images]

S.No	Method	True Positive	False Positive
1	ANN	0.6542	0.0523
2	Fuzzy C means	0.6844	0.03455
3	Proposed BSM	0.7642	0.0220

In order to provide hybrid level based terms in the proposed model the performance is compared with efficiency for the data set results obtained after the training process. In the ANN and fuzzy C based models, the learning process needs more data for training process and the experimentation takes more computation time when compared to the proposed model. Based on the training set results and data the performance particularly the efficiency of the proposed model and ANN model is defined. Figure 4 gives the detailed description of the proposed model results in terms of retinal image and segmented results and ground image for the normal sample. Figure 5 gives the same for the abnormal sample.

(a) (b) (c)

Figure 4 Normal Sample (a) Retinal Image (b) Proposed model Segmentation (c) Ground Image

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(a) (b) (c)

Figure 5 Abnormal Sample (a) Retinal Image (b) Proposed model Segmentation (c) Ground Image

The next analysis involves utilizing standard deviation for quantifying the amount of difference between vessel and non vessel segmentation. It could be seen from figure 6 that the proposed BSM provides a close degree of separation indicating the efficiency of the proposed methodology to segregate a vessel from non-vessel based on minute feature details.

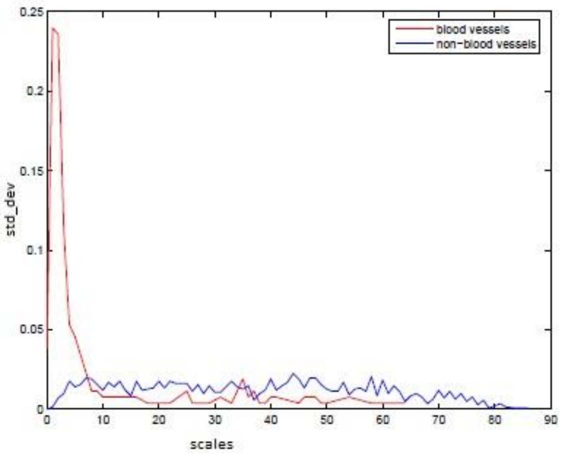

Figure 6 Analysis of variation between vessel and non-vessel segregation

From the segmented results the accuracy of the proposed model is using segmented results and also it defines the overall efficiency of the system. Table 3 gives the comparison of proposed model and ANN, Fuzzy C means model accuracy for normal and abnormal samples.

Table 3 Accuracy comparison

S.No	Model	Normal Sample	Abnormal Sample
1	ANN	0.9133	0.9024
2	Fuzzy C Means	0.9455	0.9199
3	Proposed BSM	0.9642	0.9542

The final analysis is based on computation time required for the proposed BSM compared over the supervised and decision based segmentation models. The efficiency and reduction in computation time has been tested against increasing number of images in the dataset varying from 10 to 100 and in each case the proposed BSM model outperforms the conventional learning based models justifying the simplicity of the proposed approach which at the same time exhibiting improvement in accuracy.

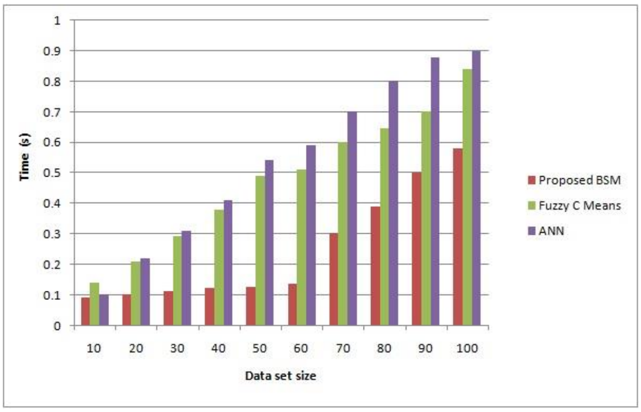

Figure 7 Analysis of computation time

V. CONCLUSION

The proposed hybrid retinal blood vessel segmentation model attains better accuracy in segmentation process as 96.4% for normal sample and 95.45% for abnormal sample. Compared to conventional supervised learning model, the proposed model achieves 5% average improved accuracy by using Bayesian level set based segmentation process. Overall process has improved true positive and false positive values than supervised learning model. Proposed model provides better detection and the overall efficiency also higher than conventional model. The further scope of the research to improve the segmentation accuracy has attained using nature inspired or Meta heuristic optimization algorithm.

REFERENCES

[1] Yue K, B. Zou, Z. Chen and Q. Liu (2018), "Improved multi-scale line detection method for retinal blood vessel segmentation", in *IET Image Processing*, 12(8): 1450-1457.

[2] Kirbas C, F. Quek (2004), "A review of vessel extraction techniques and algorithms", ACM Computer Survey, 36(2): 81-121.

[3] Lupascu C A, D. Tegolo and E. Trucco (2010), "FABC: Retinal Vessel Segmentation Using AdaBoost", in IEEE Transactions on Information Technology in Biomedicine, 14(5): 1267-1274.

[4] Biswal, Birendra & Pooja, Thotakura & Balasubramanyam, N. (2017) "Robust retinal blood vessel segmentation using line detectors with multiple masks", IET Image Processing, 12(3).

[5] Sangmesh Biradar, Jadhav A S (2015), "A survey on blood vessel segmentation and optic disc segmentation of retinal images", International journal of advanced research in computer and communication engineering, 4(5): 21 – 26.

[6] Arnodo A, Decoster N and Roux S G (2000), "A wavelet based method for multi fractal image analysis: Methodology and test applications on isotropic and

 DOI : 10.18231/2454-9150.2019.0350

anisotropic random rough surfaces", European journal of physics, 15: 567 – 600.

[7] Lydia Glory Priyadharshini M and J. Anitha (2014), "A Region Growing method of Optic Disc segmentation in retinal images", in proceedings of the International Conference on Electronics and Communication Systems, 1-5.

[8] Kathiresan N and Samuel Manoharan J (2015), "A comparative analysis of fusion techniques on multi resolution transforms", National academy science letters, 38(1): 61 – 65.

[9] Salem S A and Nandi A K (2006), "Novel clustering algorithm and a partial supervision strategy for classification", IEEE international workshop on machine learning for signal processing, 313 – 318.

[10] Hoover A et al. (2000), "Locating blood vessels in retinal images by piece wise threshold probing of a matched filter response", IEEE transactions on medical imaging, 19:203 – 210.

[11] Staal J, Abramoff D, Niemeijer M, Viergever M A (2004), "Ridge based vessel segmentation in color images of the retina", IEEE transactions on medical imaging, 23: 501 – 509.

[12] Wu D, Zhang M, Liu J and Bauman W (2006), "On the adaptive detection of blood vessels in retinal images", IEEE transactions on biomedical engineering, 53(2):341 – 343.

[13] Liu X, Zeng Z and Wng X (2014), "Vessel segmentation in retinal images with a multiple kernel learning based method", proceedings of the joint conference on neural networks, 507 – 511.

[14] Memari N, Ramli A R, Saripan M I B (2018), "Retinal blood vessel segmentation by using matched filtering and fuzzy C-means clustering with integrated level set method for diabetic retinopathy assessment", Journal of medical and biological engineering, 1 – 19.

[15] Narain Ponraj D, Evangelin Jenifer, Poongodi P and Samuel Manoharan J (2011), "A survey on the preprocessing techniques of mammogram for the detection of breast cancer", Journal of emerging trends in computing and information science, 2(12):656 – 664.

[16] AI-Rawi M, Qutaishat M, Arrar M (2007), "An improved matched filter for blood vessel detection of digital retinal images, Journal of Computers in Biology and Medicine, 37(2): 262-267.

[17] Chinki Chandhok, Soni Chaturvedi and A.A Khurshid (2012), "An approach to Image Segmentation using K-means Clustering algorithm", International Journal of Information Technology, 1:552 - 557.

 DOI : 10.18231/2454-9150.2019.0350