

BLOODVESSEL SEGMENTATION AND DETECTION FROM SLO IMAGE FOR DETECTING RETINAL DISEASES

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Abstract: Scanning laser ophthalmoscopes (SLOs) are used for early detection of retinal disorder. The advantage of using SLO is its wide field of view, which can image a large part of the retina for better diagnosis of the retinal diseases. On the other hand, during the imaging process, artifacts such as eyelashes and eyelids are also imaged along with the retinal area. This brings a big challenge on how to exclude these artifacts. The most important part of the retina for human vision is fovea. The person becomes blind due to the damage of delicate cones of fovea. The size of fovea zone in the images is related to various disorders that lead to blindness. The radius of the fovea region is also an indication of the stages of retinopathy. This paper, propose an approach to automatically extract out retinal area from an SLO image by using External Limited Member(ELM) method for composition of imagesand it also carry out the blood vessel segmentation and detection in images by using Modified Design Based Unsymmetric Trimmed Median (MDBUTM) Filter.

Keywords: SLO, MDBUTM, ELM, fovea.

1. Introduction

For vision scientists, the human retina promises to be a window into the health of a patient. A clear view of the retina in-vivo with high resolution detail of photoreceptors and vascular flow could give the vital detail that would enable clinicians to make early and accurate diagnosis of diseases. This window is blurred, because of imperfections in the eye itself: the cornea and crystalline lens, as well as the viscous and non-uniform nature of the vitreous humor, prevents clinicians from viewing the important cellular structures. Optically, this image distortion of the retina stems from tissue-induced wave front aberrations and results in a low resolution image. By accurately correcting for wave front aberration in the optical path between the imaging camera and the retina, adaptive optics has emerged as an enabling technology for retinal imaging with cellular-level resolution. This technology holds promise for non-invasivedetection and diagnoses of leading eye

pathologies such as glaucoma, diabetic retinopathy, and age related macular degeneration. Optosbeing the leading provider of devices for diagnosing and treating diseases present in the retina of the eye. Our wide field retinal imaging technology, combined with the specific data that can be derived from OCT images offers ophthalmologists and optometrists the most powerful tools for disease diagnosis and management. The retina is found in the back of the eye where it functions in the same way as film in a camera. As light enters the eye, it is focused on the retina and this visual information is then sent directly from the retina to the brain so you can see images. The retina has blood vessels that supply it with oxygen and these blood vessels can be seen by your optometrist when looking into your eye. This window into your circulatory system allows the doctor to diagnose and detect conditions such as diabetes, high blood pressure, retinal detachments, glaucoma and macular degeneration. Optometrists have always been able to look at the retina and its blood vessels, but now technology has made it possible to capture the image with a digital camera. This allows the image to be stored or printed so that accurate comparisons can be made to identify changes over time.

The use of Telemedicine is integration of telecommunication and information technologies which will provide clinical health care at a distance and thus it eliminates distance barriers and can improve access to medical resources that would often not be consistently available in distant rural communities. It also saves lives in critical care and situations. These technologies permit communications between patient and medical staff with both convenience and fidelity, as well as the transmission of medical, imaging and health informatics data from one site to another. The telemedicine achieved with telephone and radio which was an early form and have been supplemented with video telephony, advanced diagnostic methods supported by distributed client/server applications, and additionally with telemedical devices to support in-home care.

A recent study identified three major barriers for adoption of telemedicine in emergency and critical care units.

They include:

- Regulatory challenges related to the difficulty and cost of obtaining licensure across multiple states, malpractice protection and privileges at multiple facilities.
- Lack of acceptance and reimbursement by government payers and some commercial insurance carriers creating a major financial barrier, which places the investment burden squarely upon the hospital or healthcare system.
- Cultural barriers occurring from the lack of desire, or unwillingness, of some physicians to adapt clinical paradigms for telemedicine applications.

2. Literature survey

D. Marin, A. Aquino, M. E. Gegundez-Arias and J. M. Bravo (2011) have proposed a method for blood vessel detection in digital retinal images that uses neural network (NN) scheme for pixel classification and computes a 7-D vector that is composed of gray-level and moment invariants-based features used for pixel representation. This method was derived on the DRIVE and STARE databases, which is publicly available and widely used for this purpose, since they contain retinal images where the vascular structure has been precisely marked by experts. Performance of various methods on both sets of test images is better than other existing solutions in literature. The method proves especially accurate for vessel detection in STARE images. Its application to this database (even when the NN was trained on the DRIVE database) outperforms all analyzed segmentation approaches. Its effectiveness and robustness with different image conditions, together with its simplicity and fast implementation, make this blood vessel segmentation proposal suitable for retinal image computer analyses such as automated screening for early diabetic retinopathy detection. The system has a limitation that it provides only average accuracy rate.

S. Esakkirajan, T. Veerakumar, A. N. Subramanyam and C. H. Premchand (2011) have proposed a system about a modified decision based unsymmetrical trimmed median filter algorithm for the restoration of gray scale, and colour images that are highly corrupted by salt and pepper noise is proposed in this paper. The proposed method uses trimmed median value that replaces the noisy pixel by when other pixel values, 0's and 255's are present in the selected window and when the entire pixel values are 0's and 255's then the noise pixel is replaced by mean value of all the elements present in the selected window. This proposed method shows good results when compared to the Decision Based Algorithm (DBA) and Standard Median Filter (MF). The proposed

algorithm is tested against different gray scale and colour images. This system gives better Peak Signal-to- Noise Ratio (PSNR) and Image Enhancement Factor (IEF).

H. Yu, C. Agurto, S. Barigga, S. C. Nemeth, P. Soliz and G. Zamora (2012) have proposed a system that can automatically determine whether the quality of a retinal image is sufficient for computer-based diabetic retinopathy (DR) screening. The system integrates global histogram features, textural features, and vessel density, as well as a local non-reference perceptual sharpness metric. A classifier called partial least square (PLS) is trained to distinguish low quality images from normal quality images.

The system was evaluated on a large, representative set of 1884 non-mydiatic retinal images from 412 subjects. The retinal image quality evaluation system consists of two main processing phases: Feature extraction and PLS classification. Histogram features, textural features, vessel density and local sharpness metrics are the four categories of features that are used to evaluate the image quality. The seven histogram features describe the overall image information such as brightness, contrast, and lightness homogeneity. Texture is one of the important characteristics used in identifying objects in an image. The texture information can be obtained by computing the co-occurrence matrix of an image. The vessel density is calculated as the ratio of the area of segmented vessels over the area of field of view (FOV) in an image. Partial least squares (PLS) classifier was used to develop a predictor of image quality. This SVM-RBF kernel method uses Separate required data and provides accuracy. This method has a limitation that it is complex to execute.

Veena Raj, Dr. Vidya Devi (2013) have proposed a method to detect fovea. The destruction of delicate cones of fovea uses the person to become blind. The area in size off ovesa zone in fund us eye image is related to various diseases that lead to blindness. The zone of fovea is a circle of radius 200 micron approximately. The indication of any infection of the eye that may lead to disease is indicated to be the small radius of fovea region. The indication of the stages of retinopathy is because of the radius of the fovea region. The images are exposed to two types of noises like salt and pepper and Gaussian noise, Denoising using two different filters is compared as a case in this paper. The two methods are compared on the basis of PSNR values. The algorithm that is used to carry out general-purpose method involves the procedure called Unsymmetrical Trimmed Median Filter, Blood Vessel Segmentation, Localization of Fovea Region and Fovea Detection for detecting the Fovea region of noisy images.

S. Xu and Y. Liu in (2012) have proposed a system that Higher Order Neural Networks (HONNs) are Artificial Neural Networks (ANNs) in which the net input to a computational neuron is a weighted sum of products of its inputs (rather than just a weighted sum of its inputs as in traditional ANNs). It was known that HONNs can implement invariant pattern recognition as well as handling high frequency and high order nonlinear business data. Extreme Learning Machine (ELM) randomly chooses hidden neurons and analytically determines the output weights. With ELM algorithm, only the connection weights between hidden layer and output layer are adjusted. This paper enhances an ELM algorithm for HONN models and applies it in several significant medical cases. The experimental results demonstrate significant advantages of HONN models with ELM algorithm such as faster training and improved generalization abilities (in comparison with standard HONN models).

This system has high accuracy by randomly generating the input weights of single layer feed forward neural networks. It also provides high learning speed and good generalization performance for almost all datasets. Thus, the network weights can be easily solved.

3. Working of the system

By using the elm algorithm we are enhancing the blood vessels vascular pattern and detecting the affected area in a SLO image, and also the origin and detection of fovea diseases with that we are detecting the parameters of GLCM using the elm algorithm and calculating the number of lesions detected and maximum size of lesions detected, in that we are achieving the accuracy upto 97%. The most important part of the retina for human vision is fovea. The damage of delicate cones of fovea causes the person to become blind. The cause that leads to blindness depends on the size of fovea zone in fundus eye image that is related to various diseases. If the radius is smaller it may be an indication of an infection of the eye that may lead to disease. There may be indication of the stages of retinopathy with respect to radius of the fovea region. These cases that is compared in this paper is where the images are exposed to two types of noises like salt and pepper and Gaussian noise. Denoising using two filters namely adaptive wavelet filter and Modified Decision Based Unsymmetrical Trimmed Median Filter (MDBUTMF). The proposed method is used to carry out the blood vessel segmentation and detection in images.

4. System Architecture

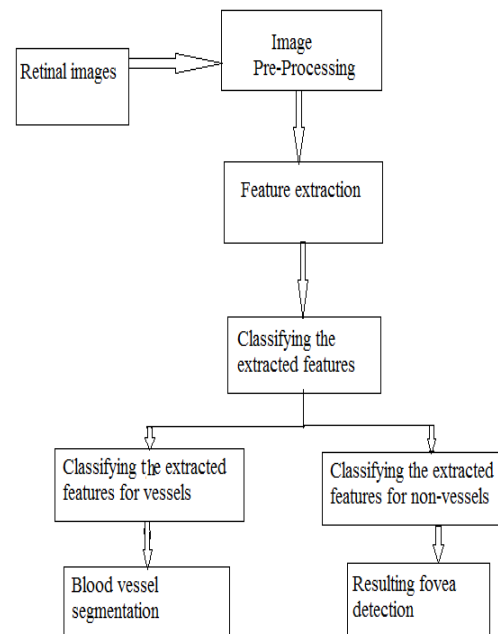


Figure 1. Block diagram of the system

Image pre-processing

Images were normalized by applying a Gamma (γ) adjustment to bring the mean image intensity to a target value. γ was calculated using $\Gamma = \log_{10}(\mu_{\text{target}}) - \log_{10}(255) / \log_{10}(\mu_{\text{orig}}) - \log_{10}(255)$ (1)

Where μ_{orig} is the mean intensity of the original image and μ_{target} is the mean intensity of the target image. For image visualization, μ_{target} is set to 80. Finally, the Gamma adjustment of the image is given as

$$I_{\text{norm}} = I_{255}^{\gamma} \quad (2)$$

Image normalization

In image processing, the range of pixel intensity values can be moderated using normalization. The photographs with poor contrast due to glare are some of the considering application. Many other type of images can be brought to range using dynamic range expansion. Normalization is done to set data, signals, or images in consistent manner and to avoid mental distraction or fatigue.

Normalization transforms an n-dimensional grayscale image

$$I: \{X \subseteq \mathbb{R}^n\} \rightarrow \{\text{Min}, \dots, \text{Max}\}$$

With intensity values in the range (Min, Max), into a new image

$$I_N: \{X \subseteq R^n\} \rightarrow \{\text{newMin}, \dots, \text{newMax}\}$$

With intensity values in the range (new Min, new Max).

The linear normalization of a grayscale digital image is performed according to the formula

$$I_N = (I - \text{Min}) \frac{\text{newMax} - \text{newMin}}{\text{Max} - \text{Min}} + \text{newMin}$$

Normalization sometimes be nonlinear, when there isn't a linear relationship between I and I_N . The normalized image is computed according to the formula

$$I_N = (\text{newMax} - \text{newMin}) \frac{1}{1 + e^{-\frac{I - \beta}{\alpha}}} + \text{newMin}$$

Where α defines the width of the input intensity range, and β defines the intensity around which the range is centered. The one that normalizes the images to full dynamic range of the number system specified in the image file format is called auto-normalization.

5. Classification

Extreme learning machines are feed forward neural network for classification or regression with a single layer of hidden nodes, where the weights connecting inputs to hidden nodes are randomly assigned and never updated. These weights between hidden nodes and outputs are learned in a single step, which essentially amounts to learning a linear model. The name "extreme learning machine" (ELM) was given to such models by Guang-Bin Huang.

A. ELM Method

This training algorithm learns a model of the form which is

$$\hat{Y} = W_2 \sigma(W_1 x)$$

Where W_1 is the matrix of input-to-hidden-layer weights, σ is some activation function, and W_2 is the matrix of hidden-to-output-layer weights. The algorithm proceeds as follows:

- Fill W_1 with Gaussian random noise;
- Estimate W_2 by least-squares fit to a matrix of response variables Y , computed using the pseudo inverse, given a design matrix X .

$$W_2 = (W_1 X)^+ Y$$

The main purposes for feature selection are reducing execution time, determination of features most relevant to the classification, and dimensionality reduction. For feature selection, we have selected sequential forward selection (SFS) approach. In the "SFS approach," the interaction among features is taken into account. From the available set of features, the feature with the highest area under the curve (AUC) is selected.

The next feature is chosen in such a way that when it is used, along with the first selected feature, it will

give the highest, AUC compared to other non-selected features. The process is repeated until ten features were selected, since a higher number of features resulted in a very small improvement in AUC. The efficiency of the SFS has been compared with other feature selection approaches such as "Filter approach" and "Filter and SFS" approach. In the filter approach, the features are ranked with respect to their effectiveness in classification and higher ranked features are threshold out. In order to determine most relevant features, an independent evaluation criterion for binary classification is used and AUC is selected as its evaluation measure. The features with higher AUC are ranked higher, and the features with AUC greater than 0.9 are selected.

In this way, 33 features are selected for classifier construction. The "Filter and SFS" approach is similar to SFS approach except that it is applied on the filtered feature set rather than complete feature set. The individual and collective performance of the features selected in the feature sets from the above mentioned approaches. The axis of "Feature Index" is ordered according to descending independent evaluation criterion. The axis of "Number of Selected Features" in represents the order with which the features are selected using the SFS approach. We have not applied SFS on the "Filter approach;" therefore, axis of "Number of Selected Features" for "Filter Approach" would be same as that of "Feature Index". The features represented by "Feature Index" and "Number of Selected Features". SFS is computationally intensive as it required 5 min/feature on filtered feature set and 30 min/feature on complete feature set. But the results show that the SFS approach performed better compared to other two approaches despite of the fact that the feature set also consists of those features which ranked low in independent evaluation criterion.

B. Blood vessel segmentation

The trimmed filter is used to reject the noisy pixel from the selected 3x3 window. The noisy pixel symmetrically trimmed in either end and also the uncorrupted pixels are trimmed using Alpha Trimmed Mean Filtering (ATMF). This may lead to loss of image details and may end up blurring the image. The Unsymmetrical Trimmed Median Filter (UTMF) removes the drawback, where the selected 3x3 window elements are arranged in either increasing or decreasing order. The pixel values from 0's to 255's responsible for the salt and pepper noise are removed from the image. Then the median value of the remaining pixels is used. This median value is used to replace the noisy pixel. The pixel values 0's and 255's are removed from the selected window and is called trimmed median filter. UTMF is advanced to ATMF in removing noise.

$$\text{psnr in dB} = 10\log_{10}(255^2/\text{MSE})$$

$$\text{MSE} = (\sum_i \sum_j (y(i,j) - \hat{y}(i,j))^2) / m \times n$$

The early diagnosis of disease is detected with the blood in vessels segmentation and retinal images; automation of this process provides various benefits including minimizing subjectivity and eliminating a painstaking, tedious task. Many other previous approaches require some changes that can take the case of abnormal retinal images. The proposed model utilizes a median filtering scheme to carry out denoising of the image and thereby to find the fovea of the retina. Observation of blood vessels in the eye allows detection of eye diseases such as glaucoma and diabetic retinopathy. Traditionally, the vascular network is mapped by hand in a time-consuming process that requires both training and skill. Automating the process allows consistency, and most importantly, frees up the time that a skilled technician or doctor would normally use for manual screening. The variable retinal background and low contrast between vessels and surrounding pixels occurs in popular convolution approaches. Some tracking algorithms fail in special cases that have abnormal images; they are often sidetracked by light objects and sometimes experience difficulty locating starting points. Current levels of success are still frequently inadequate for wide scale implementation. The proposed method uses Modified Decision Based Unsymmetrical Trimmed Median Filter (MDBUTMF) to remove salt and pepper noise, enhance the image. To find its performance over noise, we can add some salt and pepper noise. After this, we calculated the peak signal to noise ratio. Performing basic morphological operation to find the blood vessels of the eyes.

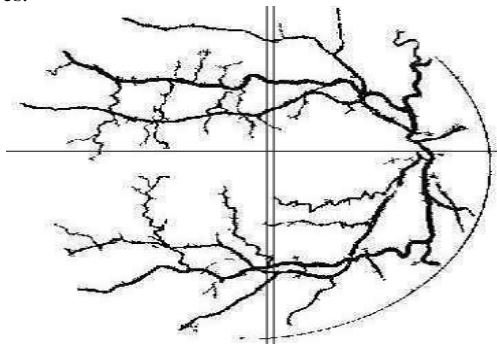


Figure 2. Blood vessel segmentation

C. Localization of Fovea Region

The localization of fovea is detected by blood vessels. In this method the scheme relies on information regarding optical disk (OD). Thus it becomes necessary to detect OD. In this method, the accuracy in detection is not very important as it deals with certain average

global information of the disk. The previously used schemes followed Gaussian matched filter to point out the direction of the main blood vessels and then thinning and filtering of the segmented main blood vessels is carried out to represent the OD center. The method to determine the center and contour of the optic disk is adopted in this paper that uses the mathematical morphology. An iterative algorithm is carried out when the major blood vessels are identified. The algorithm is used to find out the position of OD which is in the either side of the image and also the centroid of the blood vessels is calculated. A reference line will be the vertical line through the centroid. Removal of the vessels located in the temporal side (opposite side) of OD and beyond the reference line is carried. Skeletonize the retained vessels and are pruned to obtain the parabola shaped vessel. The point where the centroid and parabola is cut by a horizontal line denotes the vessel intersecting each other and is taken as the center of OD. Watershed transformations with internal and external markers are used to determine the OD contour. Calculation with the center and contour of the optic disk, the diameter of the disk can be easily calculated. Thus to localize the fovea region, we start with the image, containing only the blood vessels. Let the roughly assigned center of the OD be P, Q be the point on the horizontal line passing through the center at a distance in the direction of centroid. P lies in the vicinity (may be above/below/within) of the macula region. In order to extract the fovea region a strip of width k pixels through the point Q (take Q as middle of the strip) in a direction perpendicular to the line GP is considered. We consider on the fact that the fovea region is free from any vessel. A sliding window of size k x k is applied along the strip starting from point Q in upward and downward direction. An array of number is obtained where the number denotes the occurrence of black pixels lying in the window. Finally, the maximum run length of zeros in the array enables us to localize the fovea region. In our experiment k is taken as nine.

D. Fovea detection

The most essential part of the retina for human vision is fovea. The region of fovea has some delicate cones, once destroyed the person may become blind. The fovea zone has a fundus eye image that determines whether it may lead to various diseases, which may turn out to blindness. Fovea is characterized by the center of the macula. The macula is the darkest part in fundus retinal image approximated by a circle.

Geometrically fovea is at a distance 2.5 times the diameter of the Optic Disk (OD) from its center.

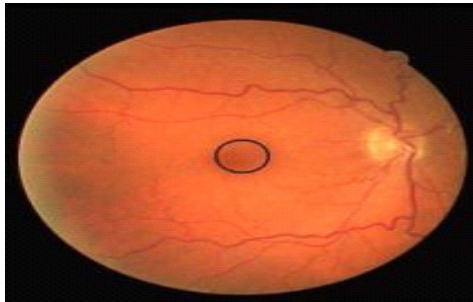


Figure 3. Detection of Fovea

Various attempts were made for the successful detection of fovea region. In one of such attempts Sinthanayothin et al. have used a template of size 40×40 with Gaussian distribution with $\sigma = 2.2$. They evaluate the maximum correlation coefficient between template and intensity image to find the fovea region subject to the condition that it will be an acceptable distance from the OD and in a region of darkest intensity. The method based on Parabola fitting on the main blood vessels was proposed by Chutatape. In fact many techniques first detect blood vessels to locate fovea region.

6. Simulation Results

A. Input design

A process of converting the Input image to computer-based format as a binary image. Input design is in an important part of development process since inaccurate input image are the most common errors in image processing, enormous image entry could be controlled by input algorithm. It consists of as input data, function, variable, matrix, loops, arguments, command, file, vector, must be in a simple format. The goal of input design is to make an image to process image easily from errors as possible. In input design, we make the source file as an image that has many data for pre-processing the image and then select the required image to post-processing them to the computer.

B. Output design

Computer output becomes most important and reliable source of information to the user. Efficient output design should improve the system relationship with the user and help in decision making.

- The standard for the required output suggest the following.
- Give each output a specific name or title.
- Provide a sample of the output location of each field.
- Each has a required space and area.

The retinal image is given as the input image to the system as shown in Figure 4

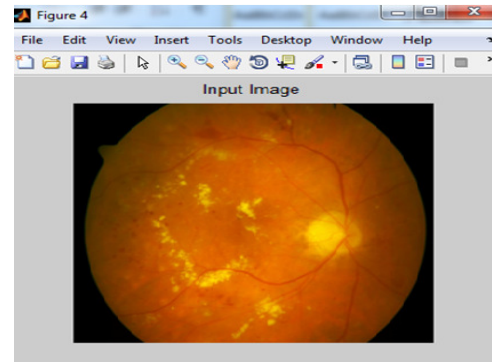


Figure 4. Input image

The input image is normalized to change the range of pixel intensity value as shown in Figure 5

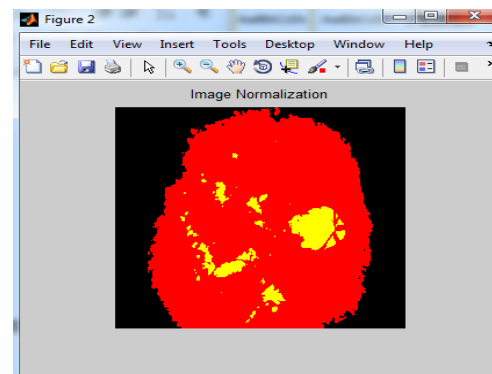


Figure 5. Normalized image

The original image is converted to grey scale image for binarization process as shown in Figure



Figure 6. Gray scale imaging

The normalized image undergoes Adaptive Histogram Equalization to enhance the definitions of edges in each region of an image as shown in Figure 7

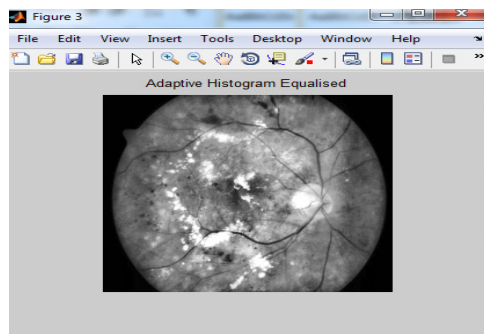


Figure 7. daptive histogram equalized image

To utilize a median filtering scheme to carry out denoising of the image, blood vessel segmentation is processed and segmented blood vascular pattern is obtained as shown in Figure 8

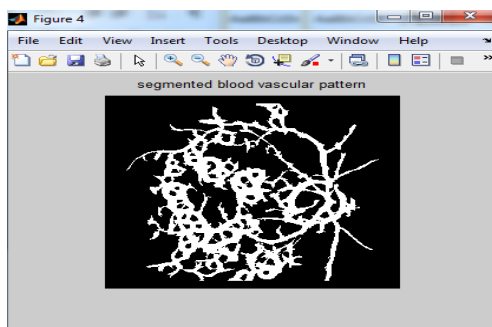


Figure 8. Image of segmented blood vascular pattern

The candidate lesion image is used to measure of the spatial density of the pixels selected as shown in Figure 9

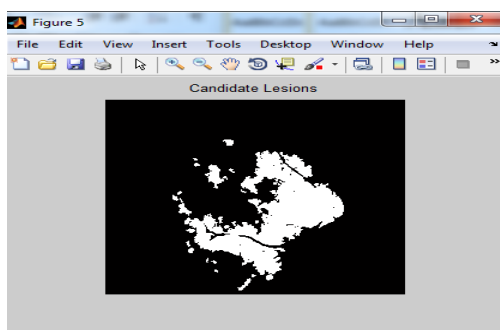


Figure 9. Image of candidate lesions

The optical disk image is used to find out the origin of fovea in the retinal area as shown in Figure 10

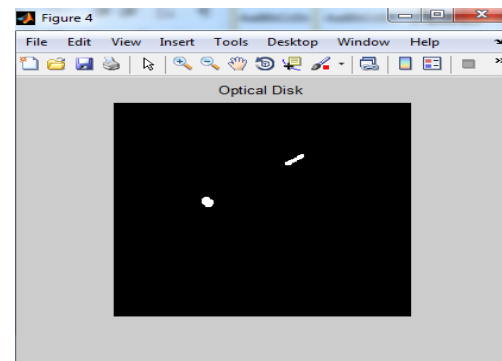


Figure 10. Image of optical disk

7. Conclusion

This paper proposes an approach to automatically extract out retinal area from an Scanning laser ophthalmoscopes (SLO) image by using ELM method for composition of images and it also carry out the blood vessel segmentation and detection in images by using MDBUTM Filter. This paper differentiates the cases where the images are exposed to two types of noises like salt and pepper and Gaussian noise. Denoising using two different filters namely adaptive wavelet filter and Modified Decision Based Unsymmetrical Trimmed Median Filter (MDBUTMF). The proposed method is used to carry out the blood vessel segmentation and detection in images. Thus, the software has been executed and the results were verified.

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