Robust Retinal Blood Vessel Segmentation Based On Reinforcement Local Descriptions Using Hybrid Optimization

Navjot Kaur[1], Er. Sukhpreet Kaur[2]
[1]*SUSCET, Tangori*
(E-mail: navjotkaur7708@gmail.com*)*

Abstract— Segmentation of blood vessels in retinal images used for the early diagnosis of retinal diseases such as hypertension, diabetes and glaucoma. The high resolution, variability in vessel width, brightness and low contrast make vessel segmentation as difficult task. There exist several methods for segmenting blood vessels from retinal images. However, most of these methods fail to segment high resolution (large in size) images, very few methods provide solution for such a high resolution images but it require lengthy elapsed time and the accuracy of these methods is not completely satisfactory. In the research work, the robust retinal blood vessel segmentation method based on reinforcement local descriptions has been proposed. Vessel segmentation approach uses supervised and unsupervised method to segment the blood vessel features. The unsupervised method sub divided into techniques based on the morphological processing, matched filter, multi scale analysis and vessel tracking. The proposed a robust vessel segmentation method was based on the reinforcement local description. The reinforcement local descriptions contain line set based feature, local intensity feature, and morphology gradient feature. The line set based features can represent the local shape of the vessels, local intensity feature can reveal the gray information of the local area, and the morphology gradient feature can enhance local edge of small vessels, which made the reinforcement local description more robust. Moreover, the post process based on morphological reconstruction can connect the discontinuous vessels. For designing of more effective segmentation model, the multi-layer perceptron (MLP) has been used for classifications. The feature optimization technique has also been applied by using the Glowworm Swarm Optimization (GSO) and Particle swarm optimization (PSO). The performance of the proposed work has analyzed by using the parameters such as accuracy, sensitivity, specificity, Precision and Recall.

Keywords—*PSO;GSO;MLP; recall; vessels; segmentation*

I. INTRODUCTION

The segmentation of retinal blood vessels has been of great interest as it is used as a nonintrusive diagnosis in modern ophthalmology. The morphology of the retinal blood vessel and the optic disk is an important structural indicator for assessing the presence and severity of retinal diseases such as diabetic retinopathy, hypertension, glaucoma, hemorrhages, vein occlusion, and neovascularization. However, to assess the diameter and tortuosity of the retinal blood vessel or the shape of the optic disk, manual polarimetry has commonly been used by ophthalmologists, which is generally time consuming and prone to human error, especially when the vessel structures are complicated or a large number of images are acquired to be labelled by hand. An automated segmentation and inspection of retinal blood vessel features allows ophthalmologists to perform mass vision screening exams for early detection of retinal diseases and treatment evaluation. This could prevent and reduce vision impairments, age-related diseases, and many cardiovascular diseases, as well as reduce the cost of the screening. There are several techniques employed for the segmentation of retinal structures such as blood vessels and optic disks and diseases like lesions in fundus retinal images and diagnosis of diseases related to retina. The blood vessels consist of two types of vessels, i.e., thin vessels and wide vessels. Therefore, a segmentation method may require two different processes to treat different vessels. However, traditional segmentation algorithms hardly draw a distinction between thin and wide vessels, but deal with them together. The major problems of these methods are as follows: (1) If more emphasis is placed on the extraction of thin vessels, the wide vessels tend to be over detected; and more artificial vessels are generated, too.(12) If more attention is paid on the wide vessels, the thin and low contrast vessels are likely to be missing. The radial projection method is used to locate the vessel center lines which include the low-contrast and narrow vessels. Further, we modify the steerable complex wavelet to provide better capability of enhancing vessels under different scales, and construct the vector feature to represent the vessel pixel by line strength. Then, semi-supervised self-training is used for extraction of the major structures of vessels.

II. EASE OF USE

A. Retinal Fundus Images

Retinal fundus images play an important role to diagnose and treatment of cardiovascular and ophthalmologic diseases [1]. Its very time consuming if we go for manual analysis procedure for retinal fundus image. So, it is required to build a procedure to segment blood vessels through automatic analysis of retinal fundus images. Retinal blood vessel segmentation is the fundamental work of retinal fundus images analysis due to attributes such as width, branching pattern, tortuosity of retinal blood vessels [5]. An automated segmentation and inspection of retinal blood vessel features such as diameter, colour, and tortuosity as well as the optic disk morphology allows ophthalmologists to perform mass vision screening exams for early detection of retinal diseases and treatment evaluation. Thus it will also prevent and reduce vision impairments, age-related diseases, and many cardiovascular diseases, as well as reduce the cost of the screening [10]. Optic disc is the visible part of the optic nerve where the optic nerve fibers and blood vessels enter the eye. It does not contain any rod or cone photoreceptors, so it cannot respond to light. Thus, it is also called a blind spot. The retinal arteries and veins emerge from the optic disc. Retinal arteries are typically narrower than veins. Macula fovea, optic disc, veins and arteries are illustrated in Figure.

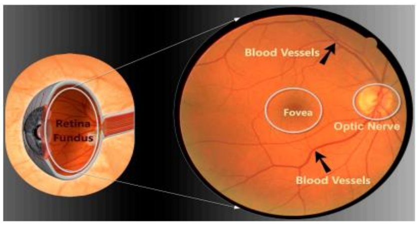

Fig. 1 Retina Fundus

B. *Retinal Blood Vessel Segmentation*

The retinal blood vessels originate from the centre of optical disc and spreads over the region of the retina. Retinal vessel segmentation is divided into seven main categories; (1) pattern recognition techniques, (2) matched filtering, (3) mathematical morphology, (4) multiscale approaches, (5) vessel tracking, (6) model based approaches, and (7) parallel/hardware based approaches. Pattern recognition deals with classification of retinal blood vessels and non-vessels together with background, based on key features. Matched filtering uses convolution of two dimensional kernels, which is designed to model a feature at some position and orientation, with the retinal image and detect vessels by maximizing the responses of kernels used [40]. Mathematical morphology deals with the mathematical theory of 8 representing shapes like features, boundaries, etc. using sets. The combination of multiscale enhancement, fuzzy filter and watershed transformation is used to extract vessels from retinal image [28]. In vessel tracking method, the tracing of the vessel, which seems like a line, is done by using local information and by following vessel edges. Model based approach uses fully and clearly expressed vessel models to extract blood vessels. Model based approach uses fully and clearly expressed vessel models to extract blood vessels. The models like snake or active contour model [35], multi-concavity modelling method [46], Hessian-based technique [49] are some of the methods used in this approach. Parallel hardware based approach is mainly for fast and real time performance, and implementation is done in hardware chips. The retinal blood vessels are damaged due to the aging of the people and other factors. The retinal blood vessel detection and segmentation are one of the pre-processing steps for the detection and diagnosis of these abnormal lesions. Ignoring these lesion symptoms leads to the loss of vision, as these symptoms are not exposed easily and require diagnosis at an earlier stage [30].

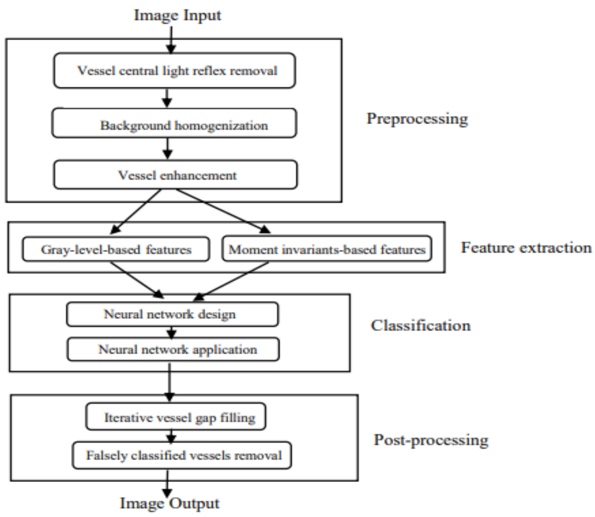

Fig. 2 Steps for blood vessel segmentation using Gray level & moment invariants features with neural network

Some methods are proposed for retinal blood segmentation. The methods can be divided into two categories: supervised methods and unsupervised methods. In supervised methods, a number of different features are extracted from fundus images, and applied to train the effective classifiers with the purpose of extracting retinal blood vessels. Unsupervised methods mainly contain four categories: matched filtering, vessel tracking, morphology processing, and model based algorithms [5].

III. METHODS

Several features have been introduced for blood vessel segmentation in retinal images in the past years. In general, all of them are extracted from the green channel of the original color image, since it exhibits the best vessel/background contrast while the red and blue ones tend to be very noisy. In the basic process, green channel is firstly extracted from the original RGB image due to its higher contrast. And then the line sets based feature, local intensity, and multi-scale morphology feature are extracted and combined into the reinforcement local descriptions for each pixel. After feature extraction, SVM is trained based on the reinforcement local descriptions and used for vessel segmentation.

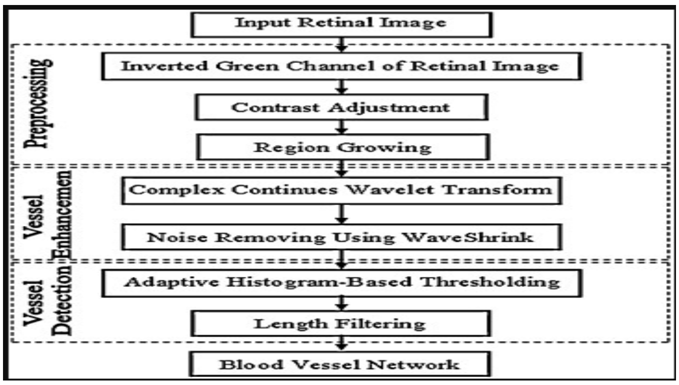

Fig. 3 Flowchart of the proposed method

A. Pre- processing

Color fundus retinal images show some lighting variations, poor contrast and noise. To reduce these imperfections and generate images more suitable for extracting blood vessels, need to understand the properties of fundus image then apply pre-processing steps. By applying morphological opening to the green channel of image, the bright central lines can be removed from the blood vessels. During the process, the input image is preprocessed in order to reduce image imperfection like noise, poor contrast and lightning variation [18]. The pre-processing step includes removal of brighter strips by applying morphological opening, followed by generating shade-corrected image to produce background homogenized image. This result is further processed by using Top-Hat transformation to remove bright retinal structures (i.e., reflection artifacts, optic disc). The processed image is then subjected to the module which generates five gray-level and two moment invariants features.

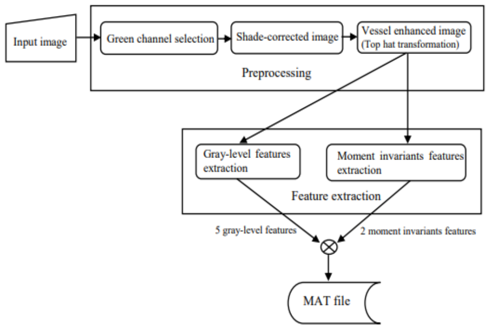

Fig. 4 Pre -processing steps for retinal images

Following are the steps of pre-processing so that blood vessels easily get detected and segmented for further major post-processing steps.

1) Vessel Central Light Reflex Removal: Blood vessels have lower reflectance than other retinal surfaces, so they appear darker relative to the background. The green plane of the fundus image is used to remove this brighter strip. Then it is filtered by applying a morphological opening using a three-pixel diameter disc as structuring element.

2) Background homogenization: A background intensity variation due to non-uniform illumination is associated with retinal fundus images. Consequently, background pixels may have different intensity for the same image and, although their gray-levels are usually higher than those of vessel pixels as given in green channel images, so the intensity values of some background pixels is comparable to that of brighter vessel pixels. For the purpose of removing these background lightening variations a shade- corrected image estimated from a background. Shade corrected image is the result of a filtering operation with a large arithmetic mean kernel.

3) Vessel enhancement: The final pre-processing step consists on generating a new vessel-enhanced image, which proves more suitable for further post-processing steps required for segmentation and detection of blood vessels. Vessel enhancement is performed by estimating the complementary image of the homogenized image, and subsequently applying the morphological Top-Hat transformation where is a morphological opening operation using a disc of eight pixels in radius. Thus, while bright retinal structures are removed (i.e., optic disc, possible presence of exudates or reflection artifacts), the darker structures remaining after the opening operation become enhanced (i.e., blood vessels, fovea, possible presence of microaneurysms or hemorrhages).

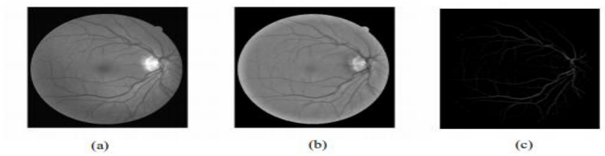

Fig. 5 Example of Pre-processing stage: (a) Green channel of original retinal image (DRIVE database image) (b) Homogenized image (c) Vessel-enhanced image.

B. Reinforcement local descriptions:

A technique of retinal vessel segmentation method based on reinforcement local descriptions is proposed to overcome segmentation performance degradation and to avoid discontinuous vessels after segmentation that may appeared due to the influence of noise or illumination. The technique that involved the novel line sets based feature by employing the length prior of vessels, which capture the local shape information of vessels has been presented. Then the method to develop the ensemble features by fusing the line sets based feature and local intensity feature with morphology gradient feature is implemented as line set based features only reflect local shape of vessels. Ensemble features not only captures local shape but also local intensity and local edge information of vessels which can reinforce description of local characteristics. Ensemble method is based on the creation of super-pixels using a simple linear iterative clustering (SLIC) approach where one pixel from each of the super-pixels is randomly selected for feature extraction. A trainable hierarchical feature extraction approach using a convolutional neural network (CNN) is then used on the selected pixel with an ensemble based Random Forest (RF) being used as the main classifier. Morphological reconstruction is employed to connect some discontinuous vessels to further improve segmentation result. The reinforcement local descriptions are generated by combining the line set based feature, local intensity feature, and morphological gradient feature into a vector [26].

1) Line Set Based Feature: The line set based feature has been proposed to represent the shape characteristics of a local area which contains the pixel. The line sets are used for searching the blood vessels pixels on local rectangle. Line segments are firstly extracted in many directions in order to represent the shape of local area; then features are extracted based on all the line segments. The line set based feature can represent the characteristics of the local rectangle, which can distinguish between vessel and background or noise [31]. The average grey level is measured along lines of a particular length passing through the pixel under consideration at different orientations. The line with the highest average gray value is marked. The line strength of a pixel is calculated by computing the difference in the average gray values of a square sub-window centred at the target pixel with the average gray value of the marked line. The calculated line strength for each pixel is taken as pixel feature vector.

2) Local Intensity Feature: Blood vessels are darker than background, so it is required extract local intensity feature from the green channel image. Intensity-based features are based on the application of different filters to enhance blood vessels. Those filters can be typical from the image processing domain, such as mean or standard deviation filters, or can be designed according to local properties of the vessels, as in the case of matched filter responses. In addition, considering different size of the vessel, we calculate the local intensity feature based on different size of square area [42].

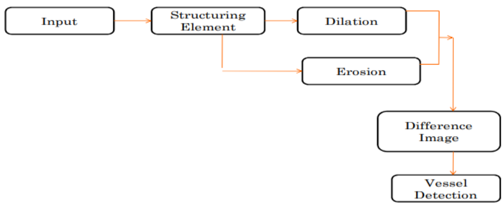

Fig. 6 Flow diagram of Vessel Detection

C. Post-processing:

The post processing stage is another import operation to obtain better and accurate segmentation. Post-processing method has been used for eliminating background noise, undesired segments and erroneously detected vessel pixels. The effective segmentation outcome is gained by the insertion of a two-step post-processing steps using morphological operations: the foremost step is the hole filling among pixels in the identified blood vessels and subsequent step is elimination of falsely detected isolated pixels. The vessels might have gaps which are vessel pixels but have been classified as non-vessels. By applying iterative filling procedure these gaps can be filled .

The probability image is the output of support vector classifier. The probability represents the likelihood of the pixel belong to the blood vessels. Based on the probability image, a threshold (T) zero is given to separate blood vessels and background. Some noise can still exists in these segmented images. In addition, another binary image is obtained by giving a higher threshold T, and the obtained image can remove some noise. However, higher threshold can make some thin vessels discontinuous. We are using the morphological reconstruction on the segmented image obtained via threshold T, and the template is the binary image obtained via threshold zero to connect the discontinuous thin vessels as shown in figure. The morphological reconstruction can connect the discontinuous vessels which are connected on the binary image obtained via threshold zero without introducing the noise.

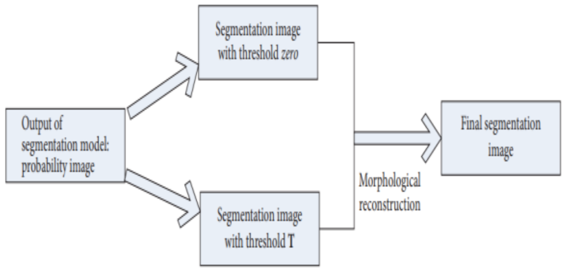

Fig. 7 Flow Diagram for Post processing

D. Literature review

Meng Li et al. (2017) proposed robust retinal blood vessel segmentation method based on reinforcement local descriptions. A novel line set based feature is firstly developed to capture local shape information of vessels by employing the length prior of vessels, which is robust to intensity variety. After that, local intensity feature is calculated for each pixel, and then morphological gradient feature is extracted for enhancing the local edge of smaller vessel. At last, line set based feature, local intensity feature, and morphological gradient feature are combined to obtain the reinforcement local descriptions. Compared with existing local descriptions, proposed reinforcement local description contains more local information of local shape, intensity, and edge of vessels, which is more robust. After feature extraction, SVM is trained for blood vessel segmentation. In addition, they also developed a postprocessing method based on morphological reconstruction to connect some discontinuous vessels and further obtain more accurate segmentation result. Experimental results on two public databases (DRIVE and STARE) demonstrate that proposed reinforcement local descriptions outperform the state-of-the-art method.

P Hosanna Princye et al. (2017) proposed a technique that involves the extraction of the geometric properties of blood vessel features are carried out making use of Grey Level Co-occurrence Matrix (GLCM) and the feature selection is conducted employing Mutual Information and Naive Bayesian Classifier. They also proposed that the noise elimination is performed by applying Modified Kalman filter with image enhancement making use of the Hybrid PCA technique. The OD segmentation process is improved by using the Discrete Anisotropic Filter and Bee colony algorithm. At last, the classification of the true blood vessels is done by making use of SVM classifier. Therefore the retinal blood vessels are accurately classified considering the morphological changes that can be noticed from the experimental results. Therefore this technique yields an effective platform for suitable medicinal preparation and a precise diagnosis of retinal diseases.

Lua Ngo et al. (2017) presented state-of-the-art of deep learning applications in medical imaging interfered with achievements of blood vessel segmentation methods in neurosensory retinal fundus images. Successful segmentation based on deep learning offers advantage in diagnosing ophthalmological disease or pathology.

Fauziah Kasmin et al. (2017) described a method on segmentation of blood vessel in retinal images using supervised approach. Blood vessel segmentation in retinal images can be used for analyses in diabetic retinopathy automated screening. It is a very exhausting job and took a very long time to segment retinal blood vessels manually. Moreover these tasks also require training and skills. The strategy involves the applications of Support Vector Machine to classify each pixel whether it belongs to a vessel or not. Single mask filters which consist of intensity values of normalized green channel have been generated according to the direction of angles. These single oriented mask filters contain the vectors of the neighborhood of each pixel. Five images randomly selected from DRIVE database are used to train the classifier. Every single oriented mask filters are ranked according to the average accuracy of training images and their weights are assigned based on this rank. Ensemble approaches that are Addition with Weight and Product with weight have been used to combine all these single mask filters. In order to test the proposed approach, two standard databases, DRIVE and STARE have been used. The results of the proposed method clearly show improvement compared to other single oriented mask filters.

K.Geethalakshmi et al. (2017) presented the review on different segmentation algorithm to identify the blood vessels in the retinal images. Many preprocessing procedures are followed to apply these algorithms. Most of these algorithms have been tested on public retinal databases like DRIVE and STARE. These methods include combinations of algorithms like Pattern recognition, supervised method, clustering, neural networks etc.

J. Kowski Rajan et al. (2017) presented a color image segmentation using support vector machine (SVM) pixel classification. Firstly, the pixel level color and texture features of the image are extracted and they are used as input to the SVM classifier. These features are extracted using the homogeneity model and Gabor Filter. With the extracted pixel level features, the SVM Classifier is trained by using FCM (Fuzzy C-Means).The image segmentation takes the advantage of both the pixel level information of the image and also the ability of the SVM Classifier.

Sindhu Saranya et al. (2017) analyzed various existing approaches, methodologies, and algorithms for separating the vessels from the retinal image. Segmenting blood vessel from the retinal image is important for detecting many retinal vascular disorders. Diseases which are all affecting the blood vessels of the eye are known as Retinal vascular disorders. Vessel separation of retinal image is a fundamental step in finding the affected area of vascular. Some of the disorders of retinal vascular are Diabetic Retinopathy (DR), Hypertensive Retinopathy, Retinal Vein Occlusion (RVO), Central Retinal Artery Occlusion (CRAO), and Glaucoma. For identifying diseases and changes in the retina Retinal Blood Vessel Separation (RBVS) is important.

Rezty Amalia Aras et al. (2016) reviewed public retinal image dataset and several methods from various conducted researches. Diabetic retinopathy (DR) is effect of diabetes mellitus to the human vision that is the major cause of blindness. Early diagnosis of DR is an important requirement in diabetes treatment. Retinal fundus image is commonly used to observe the diabetic retinopathy symptoms. It can present retinal features such as blood vessel and also capture the pathologies which may lead to DR. Blood vessel is one of retinal features which can show the retina pathologies. It can be extracted from retinal image by image processing with following stages: preprocessing, segmentation, and post-processing.

Surya G et al. (2016) proposed a novel method for retinal blood vessel segmentation. Simple morphological parameters are used for retinal blood vessel segmentation. Retinal image segmentation helps to analysis retinal blood vessel damages due to various causes. Hence the segmentation of retinal blood vessel is an important task. Segmentation can be effectively implemented using morphological operators. Many morphological approaches had been implemented. They emphasized segmentation using morphological approaches which can be done more accurately. This approach is implemented using MATLAB.

Jingdan Zhang et al. (2015) proposed an automatic un-supervised blood vessel segmentation method for retinal images. Firstly, a multidimensional feature vector is constructed with the green channel intensity and the vessel enhanced intensity feature by the morphological operation. Secondly, self-organizing map (SOM) is exploited for pixel clustering, which is an unsupervised neural network. They classified each neuron in the output layer of SOM as retinal neuron or non-vessel neuron with Otsu's method, and get the final segmentation result. Our proposed method is validated on the publicly available DRIVE database, and compared with the state-of-the-art algorithms.

R Geetharamani et al. (2015) proposed that blood vessel segmentation is attempted through image processing and data mining techniques. The retinal blood vessels were segmented through color space conversion and color channel extraction, image pre-processing, Gabor filtering, image post processing, feature construction through application of principal component analysis, k-means clustering and first level classification using Naïve–Bayes classification algorithm and second level classification using C4.5 enhanced with bagging techniques. Association of every pixel against the feature vector necessitates Big Data analysis. They evaluated the proposed methodology on a publicly available database, STARE. The results reported 95.05% accuracy on entire dataset; however the accuracy was 95.20% on normal images and 94.89% on pathological images. They also reported a comparison of these results with the existing methodologies.

Nalan Karunanayake et al. (2015) proposed framework in which a novel method based on Gabo Filter and adaptive thresholding has been used. The results have been tested using sensitivity and specificity and the values are 92.36% and 87.52% respectively. Ophthalmologists detect NDPR by observing disorders in the vessel system. Therefore segmentation of the vessel system will be an aid for ophthalmologist in order to detect an early retinopathy.

V. Jefrins et al. (2014) examined the blood vessel segmentation methodology in two dimensional retinal images acquired from a fundus camera. Many deduction methods are available but the results are not satisfactory. The measurement of the various morphology parameters of these retinal blood vessels plays a vital role for detecting the diseases and obviously clear that the wrong identification of these measurements leads to a wrong clinical diagnosis. Hence there comes the need for identifying the true vessels of the segmented retinal images. They presented a new method for identifying the true vessels with apparent preprocessing phase: as a first step the acquired images are pre-processed with three steps as i. Gray scale conversion, ii. Detection of edges and corners, iii. Median filtering for the removal of any salt and pepper noise if present, and then a Gaussian model for segmentation. True vessels are identified based on the connectivity of the eight neighborhoods and also on the black to nonblack transition in the morphological opening. In the second step the preprocessed and then segmented image is used for the identification of true vessels by modeling the segmented graph though finding the morphological parameters. Locating the cross over's and the bifurcations are slightly the hard-hitting effort and done in various ways. The work was carried out with the images from the publicly available DRIVE and STARE databases which are widely used for this purpose, since they contain retinal images where the vascular structure has been precisely marked.

IV. RESEARCH PROBLEM FORMULATIONS

Retinal fundus images play an important role for diagnose and treatment of cardiovascular and ophthalmologic diseases. However, the manual analysis of the retinal fundus image is time-consuming and needs the empirical knowledge. Therefore, it is necessary for developing automatic analysis of retinal fundus images. Retinal blood vessel segmentation is the fundamental work of retinal fundus images analysis because some attributes of retinal blood vessels [4], such as width, tortuosity, and branching pattern, are important symptoms of diseases. Besides, retinal blood vessels segmentation is also useful for other applications such as optic disk detection.

The proposed a robust vessel segmentation method will be based on the reinforcement local description. The reinforcement local descriptions contain line set based feature, local intensity feature, and morphology gradient feature. The line set based features can represent the local shape of the vessels, local intensity feature can reveal the gray information of the local area, and the morphology gradient feature can enhance local edge of small vessels, which made the reinforcement local description more robust. Moreover, the post process based on morphological reconstruction can connect the discontinuous vessels. For designing of more effective segmentation model, the multi-layer perceptron (MLP) will classify the vessels. The feature optimization technique will also be applied by using the Glowworm Swarm Optimization (GSO). The performance of the purposed work will also analyzed on the basis of accuracy, sensitivity, specificity, Precision and Recall.

A. *objectives*

The research work presents a technique for automatically segmenting retinal blood vessels from the fundus image for retinal analysis and disease diagnosis.

The objective of the research includes:

1. To study and understand the existing blood vessels segmentation techniques.

2. To propose and implement the hybrid optimization (Particle swarm optimization and Glowworm Swarm Optimization (GSO) techniques) for the optimization of the proposed work.

3. To apply the Multi-layer perceptron (MLP) for classification of the vessels for the improvement of the results

4. To analyze the performance of the proposed work on the basis of parameters such as sensitivity, specificity, Precision, Recall and Accuracy.

V. RESULTS AND DISCUSSION

A. *Algorithms Used In The Proposed Work*

1) Particle swarm optimization: Particle Swarm Optimization (PSO) is a simplified algorithm and optimizes the problem in an iterative manner which will provide global best solutions from the number of solutions. It deals with free space search operations over the particle's position and velocity and can seek vast spaces to get best optimize solution. So, PSO is generally considered for the sake of optimization which is popularly known as routing optimization.

For every particle j = 1, ..., swarm do

Set the particle's location with a consistently dispersed random vector Xi

Set the particle's best recognized location to its initial location Pi

If f (Pi) <f (gb) then

1. Update the swarm's finest known position: gb

2. Set the particle's speed: vi

3. While a finishing is not encountered do

For each particle ij= 1, ..., Swarm do

For each measurement d = 1, ..., n do

4. Evaluate fitness function

5. Update the particle's speed: vi, Update the particle's location: xi, Update the best known location: gb

Where gb is the resultant global best optimize solution which is done in the iterative manner

2) GlowWorm Swarm Optimization algorithm: It is also one of the efficient algorithm which is used to achieve optimizations and having less error rate probabilities while reducing the randomness of the worms and achieving high link stability. The steps of the algorithm are discussed below

1) Objective function: f (x) , x = (x 1 , x 2 , . . . , x d)

2) Generate an initial population of worms x i (i = 1 , 2 , n

3) Formulate light intensity I so that it is associated with f(x)

4) Define absorption coefficient γ

While (t < MaxGeneration)

for i = 1 : n (all n fireflies)

for j = 1 : n (n worms)

if (I j > I i)

Vary attractiveness with distance r via exp(− γ r)

move worm i towards j;

Evaluate new solutions and update light intensity;

end if

end for j

end for i

Rank worms and find the current best;

end while

end

The results of the proposed approach are discussed below which are the solutions of the proposed implemented techniques.

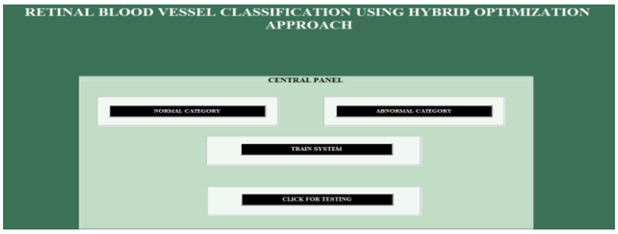

Fig. 8 Main Panel

The figure 8 shows the main panel in which the GUI interface which is made using user interface controls such as pushbuttons, edit texts and static texts. These are used for user interface and are made in the MATLAB environment. The above fig shows the panel which covers the training and testing process.

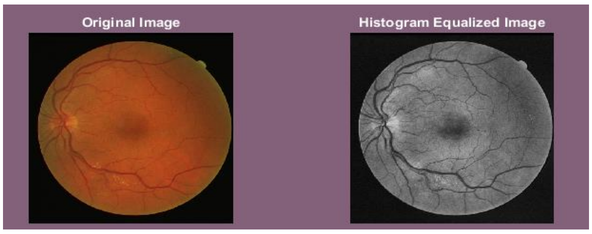

Fig. 9 Normal category Samples

In figure 9 shows the uploading of the original samples in which the original image is shown and the contrast enhancement of the original image is done

In this firstly the pre-processing is done based on the histogram equalization process which in the form of contrast limiting. This can also be applicable on global histogram equalization, which give rise to the contrast limited histogram equalization and is very less used in real time.

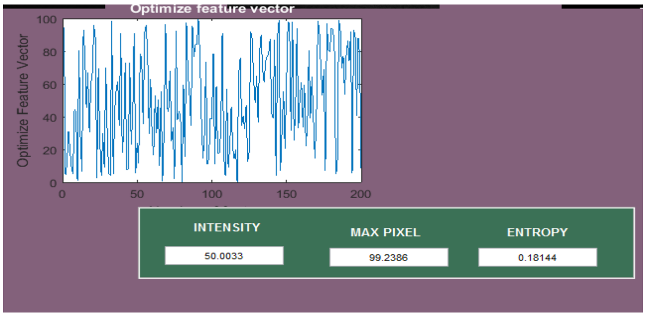

Fig. 10 Feature Extraction

The above figure shows the optimize feature values which is done using hybrid glow worm optimization and particle swarm optimization approach which shows with respect to the vector length in which the feature vector is saved. These features are also considered as the characteristic values.

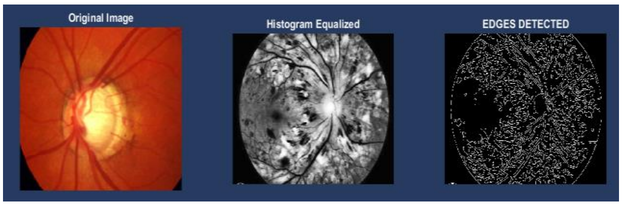

Fig 11 Abnormal category processing

The figure 11 shows the abnormal category panel which shows the abnormal blood vessel sample, equalized sample of the uploaded category and the edge detection using canny edge detector. It follows the same process as in the training of the normal category.

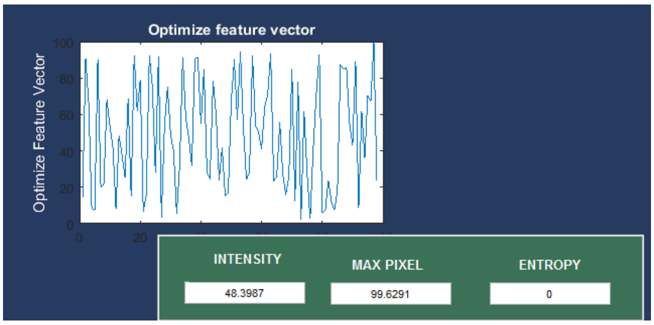

Fig. 12 Abnormal feature vector

The above figure shows the feature extraction in an optimized manner for the abnormal category and shows the intensity, pixel and entropy value extracted and shows the graphical representation of the feature vector with respect to the length of the feature vector.

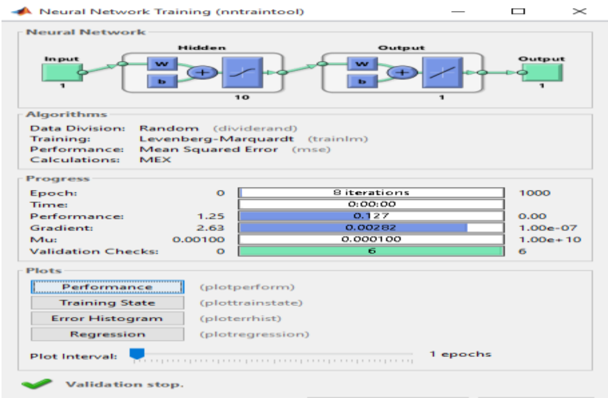

Fig. 13 Training using deep neural network

The above figure shows the training process which deals with the training set based on the optimized feature vector for both the lung cancer and non-lung cancer and shows that the neural is achieving less mean square error rate with training of the whole system in 8 iterations. It also shows the that the system is achieve less loss function and low gradient which shows that there is less randomness and updates of the weights to achieve high classification rates

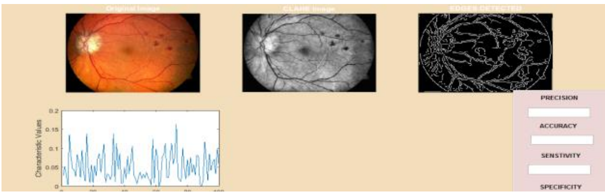

Fig. 14 Testing panel

The figure 14 shows the testing process which deals with the random upload of the normal and abnormal lung cancer images and shows that the feature extraction of the test image sample on the basis of which the classification will be done using deep neural networks

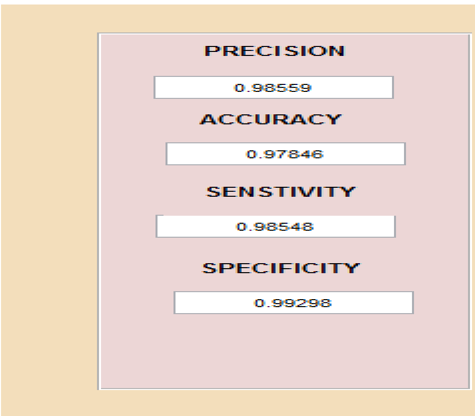

Fig. 15 Performance evaluation and Classification

The figure 15 shows the classification and the performance evaluation of the system and shows that the proposed approach is able to achieve high precision rate which shows the classification closest to the true values, high accuracy rate, high sensitivity and high specificity.

TABLE 1 Performance analysis using PSO and Glow worm Optimization with multilayer perceptron model

Category	Sensitivity	Specificity	Accuracy	Precision
Normal Image 1	0.98548	0.9928	0.97846	0.98559
Normal Image 2	0.989	0.9988	0.9843	0.9831
Normal Image 3	0.989	0.9832	0.9815	0.9894
Abnormal Image 1	0.9965	0.98699	0.98682	0.988
Abnormal Image 2	0.9964	0.9932	0.98652	0.9843
Abnormal Image 3	0.9941	0.997	0.9909	0.9854

CONCLUSION

Retinal fundus images play an important role for diagnose and treatment of cardiovascular and ophthalmologic diseases. However, the manual analysis of the retinal fundus image is time-consuming and needs the empirical knowledge. Therefore, it is necessary for developing automatic analysis of retinal fundus images. Retinal blood vessel segmentation is the fundamental work of retinal fundus images analysis because some attributes of retinal blood vessels, such as width, tortuosity, and branching pattern, are important symptoms of diseases. Besides, retinal blood vessels segmentation is also useful for other applications such as optic disk detection. Based on the position of vessels, optic disk and fovea in the funds image can be detected through their relative location to blood vessels. Accurate segmentation of retinal blood vessels is an important task in computer aided diagnosis and surgery planning of retinopathy. Despite the high resolution of photographs in fundus photography, the contrast between the blood vessels and retinal background tends to be poor. Furthermore, pathological changes of the retinal vessel tree can be observed in a variety of diseases such as diabetes and glaucoma. Vessels with small diameters are much liable to effects of diseases and imaging problems. Vessel segmentation approach uses supervised and unsupervised method to segment the blood vessel features. The unsupervised method sub divided into techniques based on the morphological processing, matched filter, multi scale analysis and vessel tracking. The proposed a robust vessel segmentation method was based on the reinforcement local description. The reinforcement local descriptions contain line set based feature, local intensity feature, and morphology gradient feature. The line set based features can represent the local shape of the vessels, local intensity feature can reveal the gray information of the local area, and the morphology gradient feature can enhance local edge of small vessels, which made the reinforcement local description more robust. Moreover, the post process based on morphological reconstruction can connect the discontinuous vessels. For designing of more effective segmentation model, the multi-layer perceptron (MLP) has been used for classifications. The feature optimization technique has also been applied by using the Glowworm Swarm Optimization (GSO) and Particle swarm optimization (PSO). The performance of the proposed work has analyzed by using the parameters such as accuracy, sensitivity, specificity, Precision and Recall.

REFERENCES

[1] Ahmed Hamza Asad, Ahmad Taher Azar, Mohamed Mostafa M. Fouad, Aboul Ella Hassanien "An Improved Ant Colony System for Retinal Blood Vessel Segmentation" in Proceedings of the Federated Conference on Computer Science and Information Systems, Sepember 2013, pp. 199–205

[2] Alfred R. Fuller, Robert J. Zawadzki, Stacey Choi, David F. Wiley, John S. Werner, Bernd Hamann "Segmentation of Three-dimensional Retinal Image Data" in IEEE Trans Vis Comput Graph, Vol 13, Issue 6, 2007, pp 1- 26

[3] A. Osareh, B. Shadgar "Automatic Blood Vessel Segmentation In Color Images Of Retina" in Iranian Journal of Science & Technology, Transaction B, Engineering, Vol. 33, No. B2, pp 191-206

[4] D. J. Cornforth, H. J. Jelinek, J. J. G. Leandro, J. V. B. Soares , R. M .Cesar, Jr., M. J. Cree, P. Mitchell, T. Bossomaier "Development of retinal blood vessel segmentation methodology using wavelet transforms for assessment of diabetic retinopathy" in Complexity international, Vol 11, 2005, pp 50–61.

[5] Florence Rossant, Maddalena Badellino, Alexandre Chavillon, Isabelle Bloch, and Michel Paques "A Morphological Approach for Vessel Segmentation in Eye Fundus Images, with Quantitative Evaluation" in Journal of Medical Imaging and Health Informatics Vol. 1, 42–49, 2011, pp 42- 49.

[6] Fauziah Kasmin, Azizi Abdullah, Anton Satria Prabuwono "Retinal blood vessel segmentation using ensemble of single oriented mask filters in International Journal of Electrical and Computer Engineering (IJECE) Vol. 7, No. 3, June 2017, pp 1414-1422.

[7] J. Kowski Rajan , D. Ferlin Deva Shahil , M.Tamil Elakkiya , Rajesh Prasad "Image Segmentation Using SVM Pixel Classification" in International Journal of Advanced Research in Basic Engineering Sciences and Technology (IJARBEST) Vol.3, Issue.3, March 2017, pp 45-51.

[8] Jingdan Zhang, Yingjie Cui , Wuhan Jiang , and Le Wang "Blood Vessel Segmentation of Retinal Images Based on Neural Network" in International Conference on Image and Graphics, 2015, pp 11 – 17.

[9] Jegatha R, Lakshmi K "Retinal Blood Vessel Segmentation using Gray-Level and Moment Invariants-Based Features" in Journal of Computer Applications Volume-5, Issue EICA2012-3, February 10, 2012, pp 271-280.

[10] Joes Staal, Michael D. Abràmoff, Meindert Niemeijer, Max A. Viergever, Bram van Ginneken "Ridge-Based Vessel Segmentation in Color Images of the Retina" in IEEE transactions on medical imaging, Vol. 23, Issue. 4, April 2004, pp 501- 509.

[11] Joao V. B. Soares, Jorge J. G. Leandro, Roberto M. Cesar-Jr, Herbert F. Jelinek, Michael J. Cree "Retinal Vessel Segmentation Using the 2-D Morlet Wavelet and Supervised Classification" in International Conference on Intelligent and Advanced Systems, May 2006, pp 1-9.

[12] K.Geethalakshmi, Dr.V.S.Meenakshi "A survey on disease identification and blood vessel segmentation in human retinal images" in International Journal of Advance Research in Science and Engineering (IJARSE), Volume 06, Issue 12, December 2017, pp 574- 585.

[13] Kinjan Chauhan, Dr. Ravi Gulati "Pre-processing of Retinal Image and Image Segmentation using OTSU Histogram" in International Journal of Advanced Information Science and Technology (IJAIST), Vol.29, No.29, September 2014, pp 26-29.

[14] Lili Xu, Shuqian Luo "A novel method for blood vessel detection from retinal images" in BioMedical Engineering OnLine, Vol 9, Issue 14, February 2010, pp 1-7.

[15] Lua Ngo and Jae-Ho Han "Advanced deep learning for blood vessel segmentation in retinal fundus images" in 5th International Winter Conference on Brain-Computer Interface (BCI), February 2017 pp 91 – 92.

[16] M.M. Fraz, P. Remagnino, A. Hoppe, B. Uyyanonvara, A.R. Rudnicka , C.G. Owen , S.A. Barman "Blood vessel segmentation methodologies in retinal images – A survey" in computer methods and programs in biomedicine, Vol 108, Issue 1, October 2012, pp 407 – 433.

[17] Meng Li, Zhenshen Ma, Chao Liu, Guang Zhang, and Zhe Han "Robust Retinal Blood Vessel Segmentation Based on Reinforcement Local Descriptions" in Hindawi BioMed Research International, Vol 2017, January 2017, pp 1- 10.

[18] Marwan D. Saleh, C. Eswaran, Ahmed Mueen "An Automated Blood Vessel Segmentation Algorithm Using Histogram Equalization and Automatic Threshold Selection" in Journal of Digital Imaging, Vol 24, Issue 4, August 2011: pp 564 – 572.

[19] Nalan Karunanayake , Manaram Gnanasekera , N.D. Kodikara "A Robust Algorithm for Retinal Blood Vessel Extraction" in International Journal of Innovative Research in Computer and Communication Engineering, Vol. 3, Issue 9, September 2015, pp 7921-7929 .

[20] Nancy M. Salem, Sameh A. Salem, and Asoke K. Nandi "Segmentation Of Retinal Blood Vessels Based On Analysis Of The Hessian Matrix And Clustering Algorithm" in 15th European Signal Processing Conference, September 2007, pp 428 – 432.

[21] P Hosanna Princye, V Vijayakumari "Retinal disease diagnosis by morphological feature extraction and SVM classification of retinal blood vessels" in Biomedical Research, Volume 0, Issue 0, February 2017, pp S22-S30.

[22] Rezty Amalia Aras, Tri Lestari, Hanung Adi Nugroho, Igi Ardiyanto "Segmentation of retinal blood vessels for detection of diabetic retinopathy: A review" in Communications in Science and Technology Vol 1, Issue 1, 2016, pp 33-41.

[23] R Geetharamani, Lakshmi Balasubamanian "Automatic segmentation of blood vessels from retinal fundus images through image processing and data mining techniques" in Indian Academy of Sciences, Vol 40, Issue 6, September 2015, pp 1715–1736.

[24] Shilpa Joshi, Dr P.T. Karule "Retinal Blood Vessel Segmentation " in International Journal of Engineering and Innovative Technology (IJEIT) Volume 1, Issue 3, March 2012, pp 175 – 178.

[25] Surya G, Pratheesh M Vincent, Shanida K "Automatic method for retinal blood vessel segmentation" in International Journal of Recent Advances in Engineering & Technology (IJRAET), Volume-4, Issue -7, 2016, pp 23-27.

[26] Sindhu Saranya and V. Ellappan "Retinal Blood Vessels Separation – A Survey" in Indian journal of Scientific Research (IJSR) Vol 17, Issue 1, 2017, pp 142-151.

[27] Temitope Mapayi, Serestina Viriri, Jules-Raymond Tapamo "Comparative Study of Retinal Vessel Segmentation Based on Global Thresholding Techniques" in Computational and mathematical methods in medicine, February 2015, pp 1-15.

[28] Uyen T. V. Nguyen, Alauddin Bhuiyan, Laurence A. F. Park, Liang Wang, Kotagiri Ramamohanarao "A Quantitative Measure for Retinal Blood Vessel Segmentation Evaluation" in International Journal of Computer Vision & Signal Processing, Vol. 1, Issue 1, January 2012, pp 1-8.