IJCSE International Journal of Computer Sciences and Engineering Open Access
Research Paper Vol.6, Special Issue.11, Dec 2018 E-ISSN: 2347-2693

An Image Mining Technique Using Support Vector Machine Based Retinal Image Classification

M. Arulkothaipriya

Department of Computer Science, National College, Trichy, India

Available online at: www.ijcseonline.org

***Abstract*—**The attention is routinely mentioned to furnish a window into the health of a person for it's only in the e Diabetic retinopathy (DR) is a significant eye disease originating from diabetes mellitus ye that one can surely see the exposed flesh of the subject without utilizing invasive tactics. There are quantities of diseases, primarily vascular disorder that depart telltale markers within the retina. Micro aneurysms (MAs) are early signs of DR, so the detection of these lesions is predominant in an efficient screening application to satisfy medical protocols. Retinal photos provide enormous knowledge on pathological alterations brought on via regional ocular disorder which exhibits diabetes, hypertension, arteriosclerosis, cardiovascular disease and stroke. Computer-aided evaluation of retinal picture performs a significant position in diagnostic procedures. Nonetheless, computerized retinal segmentation is problematic by means of the fact that retinal photographs are by and large noisy, poorly contrasted, and the vessel widths can fluctuate from very giant to very small. This paper grants photo processing systems similar to darkish object detection to analyze the situation or increase the enter photograph so as to make it suitable for further processing and beef up the visibility of vessels in color fungus portraits. Then we are able to put in force okay-way clustering algorithm to segment the vessels and automate classification procedure headquartered on support vector computing device to provide regional know-how about arteries and veins. And finally predict cardio vascular diseases and other ailments utilizing CRAE and CRVE measurements.

***Keywords*—**Image processing, Eye components, Disease diagnosis, Cardio vascular diseases, Classification, Support Vector machine

I. INTRODUCTION

Nowadays diseases related to eye are increasing and many people fell in to blindness. Image processing is the area which leads with image analysis and which involves the study of feature extraction, segmentation and classification. The process of recognizing the vessel patterns that are used to analyze the vessels in retinal image. Diabetic retinopathy one of the complicated disease which affects to the retina and outcome is the total blindness. Segmentation is the method of identifying regions of pixels in an image so as to find out the correlation with objects. The retina is internal part of the eye. In the center of retina there is the optic disk, a circular to oval shape. From the center of optical nerve radiates the major blood vessels of the retina. Detection of retinal blood vessels for disease diagnosis has provided more information about retinal blood vessels and disease. Compared with the other more traditional technology, detection of retinal blood vessels for disease diagnosis has the benefits of high anti-counterfeiting strength, small imaging devices, low cost, easy collection of images with contactless operation universality and liveness. Furthermore, since the blood vessels are located internally within the living body, the disease identification system is less affected by the outer skin surroundings (skin disease, humidity, dirtiness, etc.). Hence retinal blood vessels for disease identification are considered as one of the most promising solution for disease diagnosis in the future.

The blood vessels network is an important anatomical structure in human retina, which is use to recognize different types of disease. However, manual detection of blood vessels is not simple because the vessels in retina image are complex and have low contrast. For retinal anatomy ophthalmologist uses an ophthalmoscope. The programmed mining of blood vessels in retinal images is one of the important step in computer aided diagnosis and treatment of diabetic retinopathy, glaucoma, arteriosclerosis, obesity, retinal artery occlusion and hypertension. Retinal images are influenced by all the factors that affect the body vasculature in general. The human eye is a unique region of the human body where the vascular condition can be directly observed. In addition to fovea and optic disc, the blood vessels contribute one of the main features of an retinal fundus image and several of its properties are noticeably affected by worldwide major diseases such as diabetes, hypertension, and arteriosclerosis. Further, certain eye diseases such as choroidal neovascularization and retinal artery occlusion also make changes in the retinal vasculature. As per previous statement, the segmentation of blood vessels in retinal images can be a

valuable aid for the detection of diabetic retinopathy and glaucoma diagnosis Segmentation can be done by supervised, unsupervised or semi supervised. Here using semi supervised segmentation method because of easy to use labeled data and unlabeled data together. Semi supervised segmentation have much applications in medical image data sets.

An automatic segmentation and inspection of retinal blood vessel points such as diameter, colour and tortuosity as well as the optic disc morphology makes it possible for ophthalmologist and eye care experts to perform mass imaginative and prescient screening exams for early detection of retinal ailments and cure evaluation. This could prevent and minimize vision impairments; age associated ailments and lots of cardiovascular illnesses as well as lowering the price of the screening. The basic retinal image processing is shown in fig 1.

Figure1. Retinal Image Processing

II. RELATED WORK

Michael, et.al[1] can be compared only with the human reads, because access to the true state of disease in the dataset is not available. Only access to the human reads is available, which is erroneous to some degree as explained, but which has to be the reference dataset. In the real world, there is no manner in which one can know better what the true state of disease is than this reference dataset. To exclude any potential influence on performance from the training data, the same training data for both algorithms were used. DR detection algorithms achieve comparable performance to a single retinal expert reader and are close to mature, and further measurable improvements in detection performance are unlikely. There is a concern about quality of care, because a visit to an eye care provider involves more than the evaluation of the retina for the presence of DR and may result in detection of other pathologic features, such as glaucoma or cataract. Some may be comfortable with digital photography and reading of the images by eye care providers but not by a computer algorithm.

Meindert Niemeijer, et.al,[2] Fascinated with micro aneurysm detection because micro aneurysm detection is a critical task for automatic diabetic retinopathy screening. In this procedure candidate detection is carried out on the fairway aircraft of the colour image. The image is first resized so that the area of view has a specified width and the photo is normalized through subtracting an estimate of the photo historical past. The estimate relies on median filtering the snapshot utilising a colossal kernel. On the normalized photo intensities, the candidate detection step is performed using an unmonitored blend model established clustering process. To examine the idea from the earlier paragraph, we've got performed an extra experiment to evaluate the potential of the quite a lot of systems to notice DR on the picture degree by assuming the presence of DR is indicated completely by the presence of micro aneurysms and combining the found lesions utilizing the highest rule. In our scan the maximum probability lesion in the image (that's not inappropriate) suggests possibility of the whole image to contain indicators of DR.

Istvan Lazar, et.al,…[3] developed a computer aided diagnostic (CAD) system for the detection of DR and other eye related diseases is rather extensive, and the analysis of retinal images is a very vivid field for the digital image processing community. MAs have a clinically established maximal diameter, usually considered to be less than the diameter of the major optic veins. Crossings of thin blood vessels may result in small circular spots that are locally similar to MAs, both in size and shape. Vessel segments may be disconnected from the vascular tree, and appearas small, dark objects of various shapes. Almost every state-of-the-art method considers some sort of image preprocessing step, which usually consists of noise reduction, filtering or shade correction. Retinal images have the largest contrast in the green channel; accordingly it is a common practice to use the green channel for segmentation purposes. For noise reduction, convolution with Gaussian masks and median filtering are widely applied methods. The proposed method does not require a specific preprocessing step, however, we found that it is beneficial to consider a certain amount of image smoothing before the actual steps of detection.

Carla Pereira, et.al,…[4] Allowed performance that each and every agent are not able to furnish in my opinion. A new, small, pink-lesion segmentation algorithm, headquartered on a MAS procedure, was once proposed on this learn. By way of agent nearby interplay, the advance of traditional algorithm results was possible, specially with the aid of the detection of MAs close to vessels. The addition of a validation step through a nearby characteristic evaluation allowed the discount of the common quantity of FP and encourages the inclusion of some agent learning capability for future growth of the algorithm. A new, small, red-lesion segmentation algorithm, founded on a MAS process, was

once proposed in this gain knowledge of. By way of agent local interplay, the development of natural algorithm results used to be possible, notably by the detection of MAs virtually vessels. The addition of a validation step by means of a nearby function analysis allowed the discount of the usual quantity of FP and encourages the inclusion of some agent learning ability for future improvement of the algorithm. The comparison with the ROC approaches was essential for displaying the scientific have an impact on of the proposed approach. Certainly, despite now not being highest quality, our results are encouraging and can be when put next with people who have previously been suggested.

Adam Hoover, et.al,…[5] Describes an automatic process to locate and description blood vessels in photos of the ocular fundus. This sort of instrument must show priceless to eye care professionals for purposes of patient screening, treatment evaluation, and clinical learn. Our procedure differs from previously recognized methods in that it makes use of nearby and international vessel points cooperatively to section the vessel network. The force of the matched filter response (MFR) is coded in gray scale: the darker a pixel, the stronger the response. Realize that the strong responses in the center of the MFR photograph, which are undoubtedly no longer vessel, are sadly so much more suitable than the responses on the left part of the MFR photo, which might be vessel. The MFR photograph, computed as described, is threshold utilizing a novel probing system. The probe examines the picture in portions, trying out a number of vicinity-situated properties. If the probe decides a section is vessel, then the constituent pixels are simultaneously segmented and categorized. Contrasted against classifier-based ways, our probing procedure allows a pixel to be established in more than one area configurations before ultimate classification. The described method segments roughly two thirds of the vessels in a retinal funds photograph. Compared to a beforehand pronounced approach, which makes use of best a world threshold, the proposed system produces roughly half of the false constructive responses, and a slightly diminished genuine constructive response.

III. EXISTING METHODOLOGY

Considering both data has been validated to boom the retinal imaging accuracy extensively. There are two essential classes such as vessel or non-vessel utilizing functions: to extract some sort of features (e.g., texture, color, and shape features), and to at once use pixels in a small neighborhood for joint type assuming that these pixels normally percentage the same magnificence membership. Existing algorithms are derived as follows:

MRF Model:

The MRF model, which combines retinal parts with vessles, is widely used in classification. It can provide an exact feature representation of pixels and their neighborhoods. The basic principle of MRF is to integrate spatial correlation information into the posterior probability of the spectral structures. Based on the maximum posterior probability principle, the classic MRF model can be expressed as follows:

$$\rho(x_i) = -\frac{1}{2}\ln|\Sigma k| - \frac{1}{2}(x_i - m_k)^T \Sigma_k^{-1}(x_i - m_k) - \beta \sum_{\partial i}[1 - \delta(\omega_{ki}, \omega_{\partial i})]$$

------ Eqn(1)

where and Σ_k are the mean vector and covariance matrix, respectively, of class k and the neighborhood and class of pixel i are represented by and ω_k , respectively. The constant parameter β, called the weight coefficient, is used to control the influence of the spatial term. According to Equation (1), the MRF model can be separated into two components: the vessel term and non-vessel term. Thus, Equation (1) can be represented in the form

$$\rho(x_i) = a_i($$ --------- Eqn(2)

Where the vessel is term and is the non-vessel term. Then

$$b_i(k) = \sum_{\partial i}[1 - \delta(\omega_{ki}, \omega_{\partial i})]$$

where is the kronecker delta function, defined as

$$\delta(\omega_{ki}, \omega_{\partial i}) = \begin{cases} 1 & \omega_{ki} = \omega_{\partial i} \\ 0 & \omega_{ki} \neq \omega_{\partial i} \end{cases}$$

When a center pixel has the similar elegance label as the rest of its community, this pixel has an excessive probability of being in a homogeneous area and has a strong consistency. Thus, those spatial framework relationships can be used to revise the magnificence labels. However, one-of-a-kind floor items showcase huge differences in distribution. For example, the overcorrection phenomenon can be recommended if pixels with complex boundary situations are given the equal weight coefficients as the ones in homogeneous areas. By assessment, full gain of the spatial context features of comparable regions cannot be taken if the spatial term is given a decrease weight. To address this trouble, within the area-constraint-based eMRF approach and the RHI-based totally aMRF technique, nearby spatial weights are described to be used in location of the global spatial weight to evaluation the variety of spatial continuity.

But above methodologies can handle difficult-to-separate classes with irregular class boundaries and these approach can't work on integration of sparse-MKL-based feature learning and sparse-representation-based classifier for vessel classification.

Deformable Models:

The recent one of the methods of contour detection is deformable models or snake. A snake is an active contour model that is manually initiated near to the contour of interest. This contour model deforms according to some

criteria and image features to finally stay to the actual contour(s) in the image. An energy function is formulated to obtain an estimate of the quality of the mode in terms of its internal shape, and external forces e.g. underlying image forces and user-constraint forces. The energy function integrates a weighted-linear combination of the internal and external forces of the contour:

$$1 \le i \le L - N + 1, 1 \le j \le M - N + 1$$

The internal energy of the contour with respect to elastic deformations and the bending of the snake:

$$\epsilon_{internal}(v(s)) = \alpha_{elasticity}(s)\epsilon_{elasticity}(v(s)) + \alpha_{bending}(s)\epsilon_{bending}(v(s))$$
$$= \alpha_{elas} + \alpha_{be} \text{--- Eqn(3)}$$

The first order derivative term make the snake behave like a membrane and represent the elastic energy of the contour. The second order derivative term makes the snake act like a thin plate and represents the contour bending energy. Decreasing αelasticity allows the contour to develop gaps, while increasing increases the tension of the model by reducing its length. Decreasing αbending allows the active contour model to develop corners, and increasing increases the bending rigidity, making the contour smoother and less flixible. Setting either of the weighting coefficients to zero permits first and second order discontinuities respectively. The external energy term represents the energy due to image forces like lines, edges and terminations of line segments and corners.

$$\epsilon^{*}_{image}(v(s)) = \alpha_{line}(s)\epsilon_{line}(v(s)) + \alpha_{edge}(s)\epsilon_{edge}(v(s)) + \alpha_{term}(s)\epsilon_{term}(v(s))$$

-----Eqn(4)

Existing approaches only consider vessel segmentation and can't analyze vessel classification.

IV. PROPOSED FRAMEWORK

Examination of blood vessels within the eye allows for detection of eye illnesses such as glaucoma and diabetic retinopathy. Often, the vascular community is mapped by way of hand in a time-ingesting method that requires each coaching and ability. Automating the method permits consistency, and most significantly, frees up the time that a expert technician or health care professional would often use for manual screening. Implement computerized procedure to evaluate the blood vessels to establish the cardio vascular illnesses in retinal pix. It makes use of the notion of energetic contours to get rid of noise, enhance the snapshot, monitor the sides of the vessels, calculate the perimeter of vessels and identify the cardio diseases. Put in force okay-way clustering to phase blood vessels and calculate perimeter of the blood vessels. An efficient and amazing segmentation model with hybrid area terms for vessel segmentation with just right efficiency. This will be a powerful instrument for inspecting vasculature for higher management of a vast spectrum of vascular-related illnesses. Retinal vascular caliber CRAE and CRVE was analyzed as continuous variables. Analysis of covariance to estimate mean retinal vascular caliber associated with the presence versus absence of categorical variables or growing quartiles of continuous variables to foretell the cardio vascular illnesses. The proposed framework contains following modules:

4.1 Retinal image analysis

In this module is used to accumulate a digital photo. Retinal pics of people play an most important role in the detection and prognosis of cardiovascular ailments that together with stroke, diabetes, arterio sclerosis, cardiovascular diseases and hypertension. Vascular illnesses are usually life vital for members, and reward a difficult public sickness for society. The detection for retinal photos is critical and amongst them the detection of blood vessels is most important. The transformations about blood vessels such as length, width and branching sample, are not able to most effective provide information on pathological alterations however may additionally help to grade illnesses severity or robotically diagnose the illnesses. Upload the retinal pix. The fundus of the attention is the internal surface of the attention, reverse the lens, and entails the retina, optic disc, macula and fovea, and posterior pole. The fundus may also be examined by ophthalmoscope or fundus photography. The retina is a layered constitution with a number of layers of neurons interconnected by synapses. In retina we are able to identify the vessels. Blood vessels exhibit abnormalities at early stages additionally blood vessel changes. Generalized arteriolar and venular narrowing which is concerning the bigger blood strain levels, which is almost always expressed by way of the Arteriolar to Venular diameter ratio. It built a dataset of pictures for the educational and analysis of our proposed method. This picture dataset was received from publically to be had datasets equivalent to power and superstar. Every image was once captured using 24 bit per pixel (average RGB) at 760 x 570 pixels. First, demonstrated in opposition to traditional pictures which are easier to differentiate. Second, some level of success with irregular vessel appearances need to be situated to recommend clinical utilization. As can also be obvious, a traditional photo includes blood vessels, optic disc, fovea and the historical past, but the abnormal snapshot additionally has multiple artifacts of unique shapes and colors brought on by means of different diseases.

4.2 Preprocessing

To beef up the photograph in ways that raises the chances for success of the opposite processes. The gray scale conversion operation is to determine black and white illumination. Noise in coloured retinal snapshot is in general as a result of noise pixels and pixels whose colour is distorted so implement median filter can be used to increase and sharpen the vascular pattern for preprocessing and blood vessel segmentation of retinal pictures performing well in preprocessing, improving and segmenting the retinal picture and vascular sample. Human notion is enormously touchy to

edges and exceptional small print of an photo, and because they are composed notably through excessive frequency add-ons, the visual first-rate of an photo may also be vastly degraded if the excessive frequencies are attenuated or accomplished removed. In distinction, enhancing the high frequency add-ons of an snapshot leads to an growth within the visible fine. Image sharpening refers to any enhancement process that highlights edges and quality small print in an picture. Photo sharpening is generally used in printing and photographic industries for growing the nearby contrast and sharpening the images. In principle, snapshot sharpening contains adding to the long-established photo a sign that's proportional to a excessive-pass filtered variation of the fashioned picture. On this filter, the usual picture is first filtered by means of a high-pass filter that extracts the excessive-frequency add-ons, after which a scaled variation of the high-move filter output is introduced to the common image, hence producing a sharpened snapshot of the normal. Be aware that the homogeneous regions of the signal, i.E., the place the sign is consistent, stay unchanged.

4.3 Vessels segmentation

In this module perform partitions an enter retinal picture in to its constituent parts or objects. Function extraction and vessel segmentation steps utilizing deep neural network model. It could actually create vascular network utilizing active contour with vessel measure with regional operate. It might extract the map is a representation of the vascular community, the place each node denotes an intersection point within the vascular tree, and each link corresponds to a vessel segment between two intersection features. Okay-means is one of the simplest unsupervised learning algorithms that clear up the well-known clustering challenge. The system follows a easy and easy manner to classify a given information set via a distinct number of clusters assume k clusters fixed a priori. The major notion is to outline ok centroids, one for every cluster. These centroids should be placed in a cunning means due to the fact that of extraordinary vicinity explanations one-of-a-kind effect. So, the better choice is to place them as a lot as viable far away from each different. The next step is to take each and every point belonging to a given knowledge set and accomplice it to the nearest centroid. At this factor we must re-calculate ok new centroids as bary facilities of the clusters as a consequence of the prior step. After now we have these k new centroids, a new binding needs to be finished between the same knowledge set features and the nearest new centroid. A loop has been generated. Thus of this loop we may just observe that the k centroids exchange their area step-by-step until no extra alterations are performed. The nodes are extracted from the centerline photograph with the aid of discovering the bifurcation points which are detected by way of given those pixels with more than two neighbors and the endpoints or terminal facets by pixels having just one neighbor. As a way to find the links between nodes vessel segments, all of the bifurcation features and their neighbors are removed from the centerline photo and as effect we get a snapshot with separate accessories that are the vessel segments. Alternatively, any given link can best connect two. Vessels segmentation binary masks are created by using detecting vessels edges from sharpened photo. The blood vessels are marked by way of the protecting method which assigns one to all those pixels which belong to blood vessels and 0 to non-vessels pixels. Final sophisticated vessel segmentation masks are created through lively contour mannequin. On this strategy, a snake is an vigor minimizing, deformable spline influenced by way of constraint and photograph forces that pull it toward object contours and interior forces that face up to deformation. Snakes may be understood as a distinctive case of the final process of matching a deformable model to a snapshot by way of vigor minimization. In two dimensions, the lively form model represents a discrete variation of this procedure, taking advantage of the factor distribution mannequin to preclude the shape range to an express domain realized from a coaching set. Subsequently provide the segmentation mask for preprocessed retinal images.

4.4 Vessel classification

The segmented vessels are categorised into arteries and veins. Correct classification of vessels is relevant, on account that heart ailments impact arteries and veins another way. The adjustments in veins and arteries can not be analyzed without distinguishing them. Segmented vessels are categorized through the supervised process help Vector machine. After extraction of blood vessels, function vector is fashioned centered on houses of artery and veins. The facets get extracted on the basis of centerline extracted picture and a label is assigned to every centerline, indicating the artery and vein pixel. Based on these labeling segment, the final goal is now to assign probably the most labels with the artery classification (A), and the other with vein category (V). To be able to permit the ultimate classification between A/V courses together with vessel intensity information the structural knowledge and are additionally used. This can be finished utilising SVM classification. The informed classifier is used for assigning the A/V lessons to each one of the sub graph labels. First, every centerline pixel is classified right into a or V lessons, then for each and every label (Ci j , j = 1, 2) in sub graph i, he likelihood of its being an artery is calculated situated on the number of associated centerline pixels labeled with the aid of LDA to be an artery or a vein. The chance of label Ci j to be an artery is

$$Pa(Ci\ j) = naCi\ j / (naCi\ j + nvCi)$$

the place naCi j is the number of centerline pixels of a label categorised as an artery and nvCi j is the number of centerline pixels labeled as a vein. For each pair of labels in every sub graph, the label with bigger artery chance will be assigned as an artery classification, and the other as a vein class. Sooner or later, to hinder a mistaken classification for

that reason of a wrong graph evaluation, we calculate the chance of being an artery or a vein for each and every hyperlink personally.

4.5 Disease prediction

Analysis the ailments using AVR ratio established on CRAE and CRVE measurements. The vessel measurements CRAE, CRVE were observed to be correlated with dangers motives of cardiovascular diseases and are positive real numbers. The major systemic determinant for smaller CRAE is greater blood pressure whereas wider CRVE is quite often because of present cigarette smoking, greater blood pressure, systemic irritation and obesity. A more latest learn located a strong bad correlation between renal perform and retinal parameters (CRAE and CRVE) in a cohort of eighty healthy individuals which suggests a usual determinant in pre-clinical goal organ harm. This is in support of earlier experiences examining the organization between retinal vascular signs and incident hypertension delivering proof that a diminish in CRAE is indeed an antecedent to medical onset of hypertension and occurs prior to different indicators of goal organ harm. Apart from the worth of CRAE in predicting hypertension, it additionally suggests high-quality capabilities in different pathologies including stroke and diabetes. Generalized arteriolar narrowing as reflected by way of a minimize in CRAE is associated with an elevated threat of stroke with measurements. The overall proposed framework is shown in fig 2.

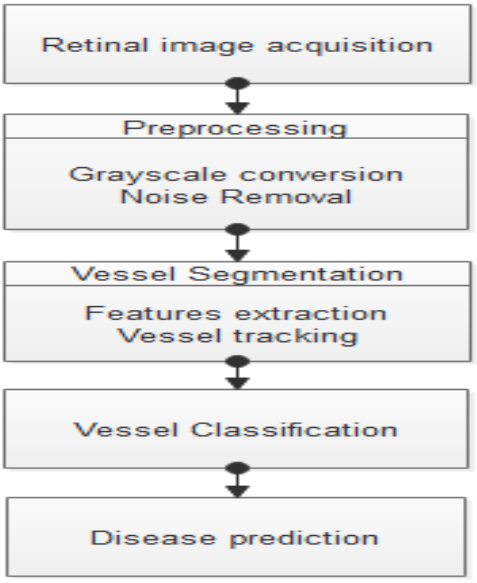
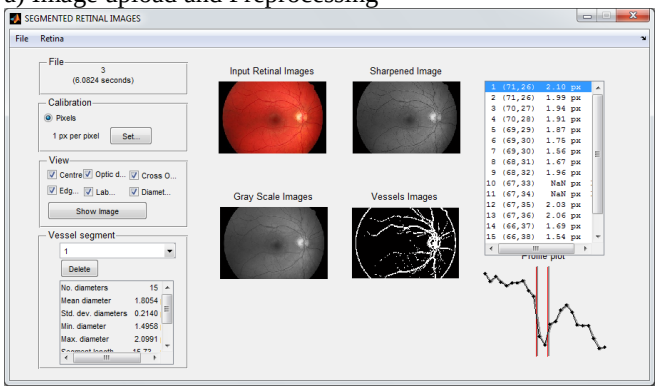


Fig 2 Proposed Framework

V. EXPERIMENTAL RESULTS

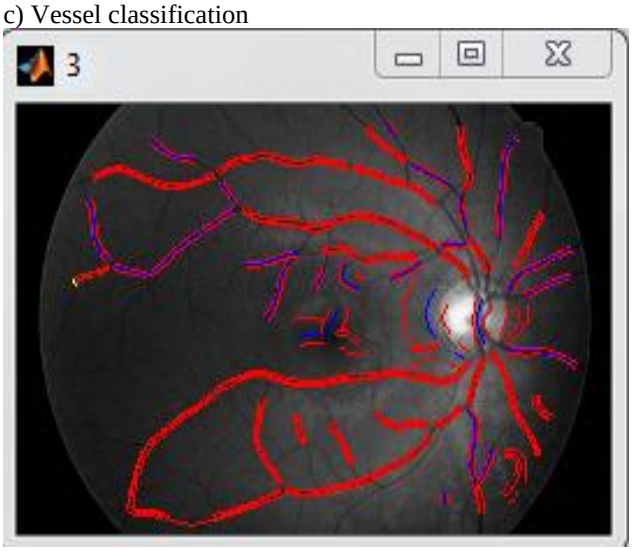
In experimental outcome we got retinal pics from drive datasets, are employed to evaluate the effectiveness of the proposed system. For the entire records, we randomly pick out categorized pixels in line with class for vessels or non-vessels from retinal pictures. The implementation results are shown in fig 3.

a) Image upload and Preprocessing



b) Vessel segmentation

c) Vessel classification



d) Disease prediction

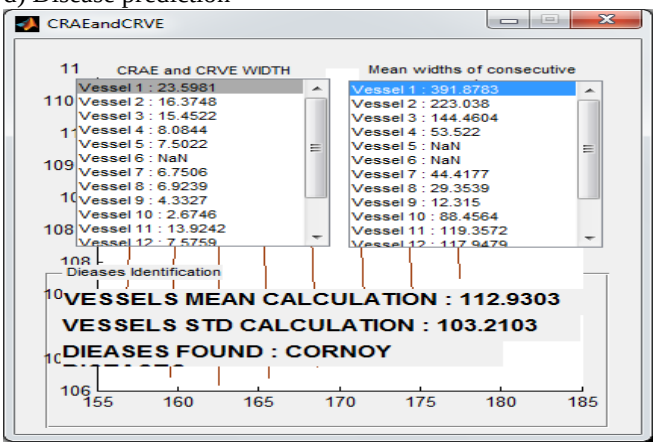


Figure 3: Implementation results

The following measures are used so that it will evaluate the overall performance of different type techniques. 1) Average Accuracy (AA): This metric suggests the common cost of the magnificence classification accuracy. 2) Overall Accuracy (OA): This metric refers back to the wide variety of samples which might be classified correctly divided by the range of take a look at samples. The performance of proposed work is illustrated in following graph as fig 4. From performance measures, our proposed system provides better accuracy results than state-art- algorithms.

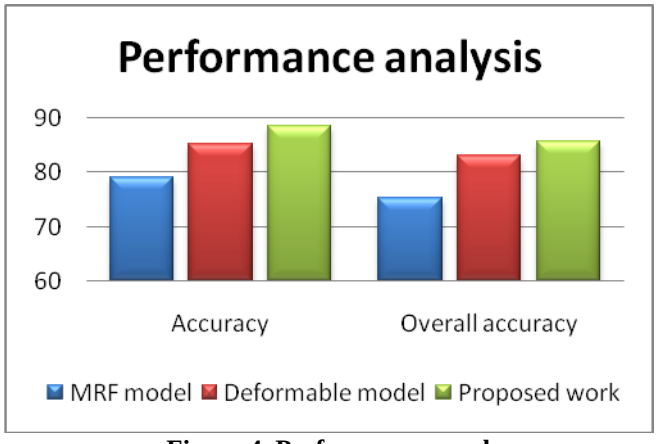


Figure 4. Performance graph

VI. CONCLUSION

We developed a new novel framework for disease classification to extract blood vessel information. Vessel Features are extracted as multi attributes profiles and we reduced the dimensionality by using supervised features extraction method such as median filter. And implementing CNN segmentation for improves the accuracy in results. The Proposed framework is considerably examined on extensively used blood vessel statistics to provide better accuracies. In addition, the new approach achieves better classification accuracies than other extensively used classification strategies, with acceptable CPU processing time. We emphasize that the proposed system is fully computerized, that's a exceedingly acceptable characteristic. In future, we can extend the framework to improve the accuracy in various kinds of datasets and try to analyze parallel processing approach and include other performance metrics.

REFERENCES

[1] Abdallah, Mariem Ben, et al. "Automatic extraction of blood vessels in the retinal vascular tree using multiscalemedialness." Journal of Biomedical Imaging 2015 (2015): 1.

[2] Kaur, Manvir, and Rajneesh Talwar. "Automatic Extraction of Blood Vessel and Eye Retinopathy Detection." European Journal of Advances in Engineering and Technology 2.4 (2015): 57-61.

[3] Wang, Shuangling, et al. "Hierarchical retinal blood vessel segmentation based on feature and ensemble learning." Neurocomputing 149 (2015): 708-717.

[4]Vidyashree, M. R., M. V. Usha, and vtuewit."Locating the optic nerve and blood vessel in a retinal images using graph partition method." (2015).

[5] Annunziata, Roberto, et al. "Leveraging multiscale hessian-based enhancement with a novel exudate inpainting technique for retinal vessel segmentation." IEEE journal of biomedical and health informatics 20.4 (2016): 1129-1138.

[6] N. Srivastava, G. Hinton, A. Krizhevsky, I. Sutskever, and R. Salakhutdinov, "Dropout: A simple way to prevent neural networks from overfitting," The Journal of Machine Learning Research, vol. 15, no. 1, pp. 1929–1958, 2014.

[7] Y. Bengio, P. Lamblin, D. Popovici, H. Larochelle et al., "Greedy layer-wise training of deep networks," Advances in neural information processing systems, vol. 19, p. 153, 2007.

[8] M. Fraz, P. Remagnino, A. Hoppe, B. Uyyanonvara, A. Rudnicka, C. Owen, and S. Barman, "Blood vessel segmentation methodologies in retinal images - a survey," Comput. Methods Prog.Biomed. vol. 108, no. 1, pp. 407–433, Oct. 2012. [Online]. Available: http://dx.doi.org/10.1016/j.cmpb.2012.03.009

[9] J. Staal, M. D. Abràmoff, M. Niemeijer, M. A. Viergever, and B. van Ginneken, "Ridge-based vessel segmentation in color images of the retina," Medical Imaging, IEEE Transactions on, vol. 23, no. 4, pp. 501–509, 2004.

[10] A. Hoover, V. Kouznetsova, and M. Goldbaum, "Locating blood vessels in retinal images by piecewise threshold probing of a matched filter response," Medical Imaging, IEEE Transactions on, vol. 19, no. 3, pp. 203–210, 2000.

