International Journal of Advance Research in Science and Engineering
Volume No.06, Issue No. 12, December 2017
www.ijarse.com
IJARSE
ISSN: 2319-8354

A SURVEY ON DISEASE IDENTIFICATION AND BLOOD VESSEL SEGMENTATION IN HUMAN RETINAL IMAGES

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ABSTRACT

This paper reviews the algorithms for extracting blood vessels network from retinal images. Retina is a complex and delicate ocular structure, the computer vision is dedicated to study blood vessels network which helps to diagnosis the pathologies like diabetic retinopathy, hypertension retinopathy, retinopathy of prematurity or glaucoma. This paper presents 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.,

Key Words—Blood Vessel, image analysis, Diabetic Retinopathy, Glaucoma, Retina, Retinal Vessels Segmentation,

I.INTRODUCTION

The **retina** is a thin layer of tissue that lines the back of the eye on the inside. It is located near the optic nerve. The main function of the retina is to receive light that the lens has focused, convert the light into neural signals, and send these signals on to the brain for visual recognition. It is thus the extension of the brain. Retinal tissue is highly active tissue with a double blood supply. [1]

Data in the blood vessel in retinal images will help to diagnose the diseases. Conventional retinal disease identification techniques are based on the manual observation of Blood vessel, This technique does not produce accurate results because sometimes minor vessels are vanished. Digital Retinal Image segmentation is relatively new technology that can be used to diagnoses various cardio vascular and ophthalmologic diseases such as diabetes, hypertension, glaucoma and Retinopathy of Prematurity (ROP).

Segmentation involves dividing image into subsection such as defining areas of an image that are appropriate to be subsequently analysed or finding circles, lines or other shape of interest and segmentation can stop when such objects of interest have been isolated. Fundus photography, Optical coherence Tomography (OCT) and fluorescein angiography are widely used Retinal imaging techniques. Fundus imaging is the most established

technique among them. The automated disease identification system consists of different steps and it is referred in Figure 1.

- Fundus images are obtained from retinal image database such as STARE and DRIVE.
- Fundus images are often noisy and poorly contrasted, this noisy can be reduced by some pre processing techniques.
- The noise reduced retinal images undergo segmentation to detect blood vessels
- Automated blood vessel segmentation diagnoses many eye diseases and abnormalities based on the feature extraction.

Figure 1: Automated Disease Identification System

II.RETINAL IMAGE PROCESSING

Eye is like a camera. The external object is perceived like the camera takes the picture of any object. Light enters the eye through a small hole called the **pupil** and is absorbed on the **retina**, which is like a camera film. Eye also consists of focusing **lens**, which focuses images from different distances on the retina. The colored ring of the eye, the **iris**, controls the sum of light entering the eye. It closes when light is bright and opens when light is dim. A tough white sheet called **sclera** covers the outside of the eye. Front of this sheet (sclera) is transparent which allows the light to enter the eye, the **cornea**. Ciliary muscles in ciliary body control the focusing of lens automatically. [2]

Choroid forms the vascular layer of the eye supplying nutrition to the eye structures. Image formed on the retina is transmitted to brain by **optic nerve**. The image is finally perceived by brain. A jelly like substance called **vitreous** humor fill the space between lens and retina. The lens, iris and cornea are nourished by clear fluid, **aqueous** humor, formed by the ciliary body and fill the space between lens and cornea. This space is known as **anterior chamber**. The fluid flows from ciliary body to the pupil and is absorbed through the channels in the angle of anterior chamber. The delicate balance of aqueous production and absorption controls pressure within the eye.

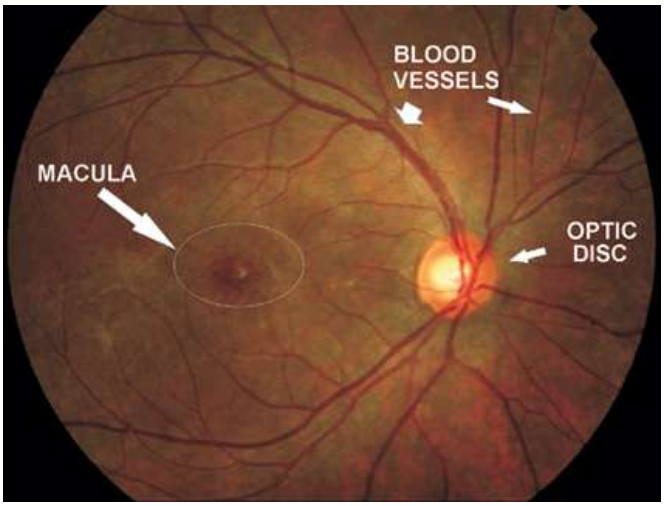

Figure 2: Fundus Image [4]

Retinal Photography: Fundus camera is a low power microscope with an attached camera. Its optical design is built on the indirect ophthalmoscope. Fundus cameras are defined by the angle of view - the optical angle of acceptance of the lens. Fundus photograph can be achieved with colored filters, or with specialized dyes including fluorescein and indocyanine green and it is shown in the Figure 2.

Blood Vessel

The retinal blood vessels are usually referred to; arteries and veins. Then artery and central vein normally appear near each other in the nasal side of the optical disc center. Information about the structure of the blood vessels can help to classify the severity of the disease and may also serve as a reference during operation. Two strategies have been used for the detection of blood vessels in image. One is the detection of edges; and the other is monitoring that requires a priori knowledge of the position from the image [32]. Information about blood vessels can be used in grading disease severity or as part of process of automated diagnosis of diseases with ocular manifestations. Blood vessels can act as landmarks for localizing the optic nerve, the fovea (central vision area), and lesions. As a result of systematic or local ocular disease; the blood vessels can have measurable abnormalities in diameter and color. For example, central retinal artery occlusion usually causes generalized constriction of retinal arteries; hypertension may result in focal constriction of retinal arteries, central retinal vein occlusion typically produces dilated tortuous veins, arteriosclerosis can cause the arteries to acquire a copper or silver color, and diabetes can generate new blood vessels (neovascularization). Thus, a reliable method of vessel detection is needed, which preserves various vessel measurements.

OPTIC DISC: The location of optic disc (OD) is of critical importance in retinal image analysis. In normal images, the OD is brighter than any part of the retina and is normally circular in shape. This is also the entry and exit point for nerves entering and leaving the retina to and from the brain. A typical retina image, the bright OD. OD detection helps the ophthalmologists to find whether the patient is affected by diabetic retinopathy or not [31].

RETINAL IMAGE DATABASE

DRIVE Database

The photographs for the DRIVE database were obtained from a diabetic retinopathy screening program in The Netherlands. The screening population consisted of 400 diabetic subjects between 25-90 years of age. Forty photographs have been randomly selected, 33 do not show any sign of diabetic retinopathy and 7 show signs of mild early diabetic retinopathy.

Each image has been JPEG compressed. The images were acquired using a Canon CR5 non-mydriatic 3CCD camera with a 45 degree field of view (FOV). Each image was captured using 8 bits per color plane at 768 by 584 pixels. The FOV of each image is circular with a diameter of approximately 540 pixels. For this database, the images have been cropped around the FOV. For each image, a mask image is provided that delineates the FOV.

The set of 40 images has been divided into a training and a test set, both containing 20 images. For the training images, a single manual segmentation of the vasculature is available. For the test cases, two manual segmentations are available; one is used as gold standard, the other one can be used to compare computer generated segmentations with those of an independent human observer. All human observers that manually segmented the vasculature were instructed and trained by an experienced ophthalmologist. The expert were asked to mark all pixels for which they were for at least 70% certain that they were vessel. All of the images contained in the database were actually used for making clinical diagnoses [3] and it is shown in the Figure 3.

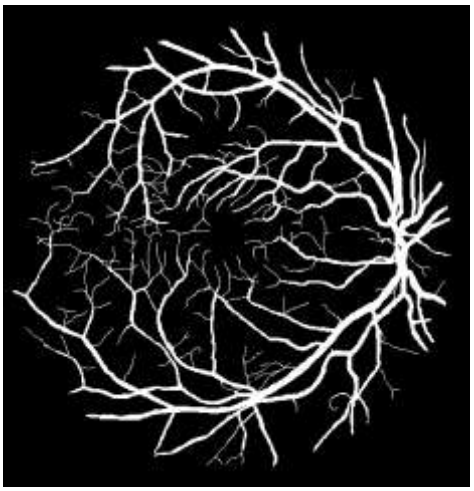

Figure 3: Blood Vessel Image[3]

STARE Database

The STARE database [21] contains 20 images for blood vessel segmentation; ten of these contain pathology. The digitized slides are captured by a TopCon TRV-50 fundus camera at 35◦ field of view. The slides were digitized to 605 × 700 pixels, 8 bits per color channel. The approximate diameter of the FOV is 650 × 500 pixels. Two observers manually segmented all the images. The first observer segmented 10.4% of pixels as vessel, against 14.9% vessels for the second observer. [5]. The difference in segmentation between the two observers is due to the fact that the second observer segmented many more of the thinner vessels than the first one. Performance is computed with the segmentation of the first observer as the ground truth.

Other Database

STARE and DRIVE are the commonly used Retinal Database for disease identification. Apart from these database some online retinal databases are available, they are ARIA, ImageRet, Messidor, VAMPHIRE, CHASE-DBI, Review, ROC micro aneurysm set, and VICAVR .

Performance Measures

In the retinal vessel segmentation process, the outcome is a pixel-based classification result. The true positive rate (TPR) represents the fraction of pixels correctly detected as vessel pixels. The false positive rate (FPR) is the fraction of pixels

erroneously detected as vessel pixels. The ratio of the total number of correctly classified pixels to the number of pixels in the image field of view is referred as Accuracy(ACC). Sum of true positives and true negative pixels are stated as the correctly classified pixels. Sensitivity (SN) reflects the ability of the algorithm to detect the vessel pixels. Specificity (SP) is the ability to detect non-vessel pixels.

III. LITERATURE SURVEY

Several existing vessel segmentation systems are elaborately discussed.

In [6] Quiangfeng Peter Lak et al, proposed semi automated retinal image analyzing tool Graph Tracer. SOLO tracer and Graph tracer are analyzed by clean and noisy images. Graph tracer performs better than the SOLO tracer.

In [7] M.Ramya et al, Proposed Pattern recognition for personal identification on blood vessel segmentation. This method discussed various fundus databases.

In [8] Roya Aramesh et al, proposed Automated combined approach of histogram maximum and minimum points and mathematical morphology for retinal image analysis.

In [9] K.S. Sreejini et al, proposed a noise suppression feature of multiscale filters which works better than single scale matched filter.

In [10] S.Saranya Rubini et al, proposed Semi Automated and Automated Hessian based candidate selection Algorithm. This system is suitable for Diabetic Retinopathy disease identification.

In [11] Nameirpam Dhanchandra et al, proposed Subtractive clustering algorithm, this system obtained better performance than the K means clustering.

In [12] Jose Tomas et al, developed optic disc vasculature localization for Diabetic Retinopathy disease identification.

In [13] Gehad Hasan et al, proposed K means clustering with mathematical morphology. This system produces high accuracy details.

In [14] Yitian Jaho et al, proposed Infinite active contour model, This model uses combination of intensity information and local phase based enhancement map (Hybrid), which is used for analyzing vascular related disease.

In [15] Sohini Roychowdhury et al, proposed Unsupervised Iterative vessel segmentation of fundus images. Pixels are identified iteratively by adaptive thresholding.

In [16] Jingdan Zhang et al proposed Unsupervised Blood vessel segmentation with clustering technique. Accuracy is high.

In[17] Parath Panchal et al, proposed hybrid method with morphology and Scanning Window Analysis. DR images accuracy is very less than other images due to spurs in the picture.

In [18] Sharathkumar et al proposed Multilevel histogram analysis for automatic detection and classification of retina .This system could not classify 28% of the retinal images due to less image quality.

In [19] Sambandan et al, proposed Self adaptive dragon fly optimization algorithm form blood vessel segmentation. This method is suitable for both real life and medical images.

In [20] Lorenza Banaldi et al, proposed synthetic vascular network for retinal fundus. This system guarantee the control flow of the blood and oxygenation of retinal surfaces.

In [21] Harry Pratt et al, proposed Convolutional Neural Network and data augmentation for Diabetic Retinopathy detection.

In [22] Jiong Zhang et al proposed Filter based approach for retinal vessel segmentation based on wavelet score and locally adaptive frame. This system is used in large screening program.

In [23] Qiaoliang Li et al proposed Supervised segmentation technique with cross modality data transformation. This system produces accurate results.

In [24] Pawel Liskowski et al proposed Supervised segmentation technique with Deep Neural Network. This model gives superior performance in vessel segmentation.

In [25] Anand Deshpande et al, proposed Long range captured IRIS image segmentation technique. This method accurately detects the eyelid.

In [26] R.Rexoni Bindhya et al proposed principal component analysis for Blood vessel segmentation. This system recognize the disease from extracted image.

In [27] Ishmeet Kaur et al, proposed Nuetrosopic approach and Fuzzy C means clustering for early detection of Diabetes.

In [28] Kaustav Jyoti Borah et al. proposed wavelet based segmentation. Used for determine the presence of cardiovascular diseases.

In [29] Sonal Wilson Pillai et al. proposed Morphological Operation for ISODATA Clustering for retina vessel segmentation.

In [30] Meng Li et al proposed Supervised Blood vessel segmentation with reinforcement local descriptions, Feature extraction. SVM is trained for vessel segmentation.

Vessel segmentation algorithms are the critical components of circulatory blood vessel analysis systems. The survey of vessel extraction techniques and algorithms are tabulated in Table 1.

TABLE1: SURVEY OF VESSEL SEGMENTATION TECHNIQUES

SL.NO	EXISTING SYSTEM	CONCEPT	TECHNIQUE	HIGHLIGHTING FEATURES
1	Quiangfeng Peter Lak et al. 2013[6]	Graph Tracer	Semi automated retinal image analysis tool	SOLO tracer and GRAPH Tracer are analyzed by clean and noisy images and computes Pearson correlation coefficient (PCC)
2	M.Ramya et al, 2014.[7]	Pattern Recognition	Neuro Fuzzy Classification	STARE D/B, DRIVE D/B, MESSIDOR D/B, REVIEW D/B, VARIA D/B
3	Roya Aramesh et al. 2014[8]	Automated Retinal image analysis	Combined approach of Histogram maximum and minimum points and Mathematical morphology	This model tested based on Specificity, Sensitivity , Accuracy and FPR. FPR is low in this model.
4	K.S.Sreejini, et al. 2015[9]	Multiscale Matched Filter	Improved noise suppression features of multiscale filters(Particle Swarm Optimization)	This approach tested with DRIVE & STARE Database. (Multiscale filter works better than the single scale filters)
5	S. Saranya Rubini, et al ELSEVIER 2015[10]	Semi Automated and Automated Hessian based Candidate Selection Algorithm	Eigen Values of the Hessian Matrix	Based on TPRMA, TPRHMA, FPI, TPR Red Lesian values, DR detection are obtained. SHCS has the better result than AHCS
6	ELSEVIER 2015 Nameirapam Dhanchandra et al, 2015[11]	Image Segmentation using K-means clustering Algorithm.	Subtractive clustering method	Consists of partial contrast, stretching, subtractive clustering, K-means clustering and median filter. The Quality of the images are analyzed based on RMSE(Root Mean Square Error) and PSNR (Peak to Signal Noise Ratio)
7	ELSEVIER 2015	Optic Disc	Vasculature	Results are tested based on

	Jose Tomas Arenas-cavalli et al, 2015[12]	Localization	Localization	Sensitivity on Specificity
8	ELSEVIER Gehad Hasan et al. 2015[13]	K-mean clustering	Mathematical Morphology	This Approach tested on DRIVE Database. Results are obtained based on TPR FPR, Specificity, Sensitivity and Accuracy indices.
9	IEEE Transaction 2015 Yitian Jhao et al,[14]	Infinitive active contour model	This model uses combination of intensity information and local phase based enhancement map (Hybrid)	Drive, STARE and VAMPHIRE dataset used. This model tested based on Specificity, Sensitivity and Accuracy.
10	IEEE Transaction 2015 Sohini Roychowdhury et al.[15]	Unsupervised iterative blood vessel segmentation.	Pixels are identified iteratively by adaptive thresholding.	DRIVE, STARE and CHASE_DBI Databases used.
11	Springer 2015 Jingdan Zhang et al[16]	Unsupervised Blood vessel segmentation	Clustering Method	Accuracy is high.
12	ELSEVIER 2016 *Parath Panchal et.al[17]*	Hybrid method	Line tracking Morphology and scanning Window Analysis(SWA)	Tested with Retinal Identification Database(RIDB)
13	ELSEVIER 2016 Sharath Kumar et.al [18]	Automatic detection and classification of retina	Multilevel Histogram Analysis	1344 image data set is used. Each image is graded as DR and Non DR. Accuracy is measures based on sensitivity and specificity.
14	ELSEVIER 2016 Sambandan R.K et.al[19]	DFO Algorithm (Dragon Fly Optimization) Multilevel Segmentation	SADFO(Self Adaptive Dragon Fly Optimization)	Bench mark images and medical images, histogram images are used. Results are evaluated with 3 indices PSNR, SSI and SDI
15	ELSEVIER Lorenza Banaldi et al, 2016[20]	Synthetic vascular network.	Active shape model, Kalman Filter and multiresolution	Combined approach of Kalman Filter as vascular cross section model.

			Hermite vascular cross section model	Result tested based on specificity and accuracy. VAMPIRE Software is used for segmentation
16	ELSEVIER Harry Pratt et al, 2016[21]	Convolutional neural network	Network with CNN and data augmentation	Kaggle dataset is used. Results are tested based on Sensitivity, Specificity and Accuracy
17	IEEE Transactions 2016 Jiong Zhang et al, [22]	Filter based approach for retinal vessel segmentation	2D image is lifted to 3D orientation score by wavelet type transform approach based on 2^{nd} order locally adaptive derivative frame.	Avoids computation of full Laplacian segmentation. (RGB Dataset) DRIVE STARE CHASE-DBI, (Scanning Laser Ophthalmoscopy Dataset) HRF, IOSTAR, RC-SLO
18	IEEE Transaction 2016 Qiaoliang Li et al. [23]	Supervised method for vessel segmentation	Cross modality data transformation	This model tested based on Specificity, Sensitivity and Accuracy. DRIVE, STARE and CHASE_DBI Databases used.
19	IEEE Transaction 2016 Pawel Liskowski et al, [24]	Supervised segmentation technique	Deep Neural Network, Global contrast normalization, zero phase whitening, Geometric transformation and gamma correction.	This model tested based on Augmentation, Specificity, Sensitivity and Accuracy. DRIVE, STARE and CHASE_DBI Databases used.
20	ICTACT 2016 Anand Deshpande et al,[25]	Long range captured IRIS image segmentation	Eye lid detection and Eyelash removal technique	CASIA long range Iris database is used for analysis. The proposal method compared with Hough transform method with low contrast noise, occlusion unbalanced illumination values
21	IJARECE R.Rexoni Bindhya et al, 2016. [26]	Blood Vessel Segmentation	Principal Component Analysis	This method found the feature points Eigen values and Eigen vector. This model tested based on Specificity, Sensitivity and

				Accuracy.
22	IJIR Ishmeet Kaur et al, 2016[27]	Fuzzy C-means	Neutrosophic approach	This method tested on DRIVE and DIARETDB1 Specificity, Sensitivity and Accuracy values are more in proposed system.
23	IJERT 2016 Kaustav Jyoti Borah et al.[28]	Wavelet based segmentation	Discrete Wavelet Transform	This model tested based on Specificity, Sensitivity , & Accuracy. Used for determine the presence of cardiovascular diseases.
24	IJERT 2016 Sonal Wilson Pillai et al.[29]	Morphological Operation	ISODATA Clustering	contrast limited adaptive histogram equalization (CLAHE)
25	BioMed Research International 2016 Meng Li et al [30]	Supervised Blood vessel segmentation	reinforcement local descriptions	Feature extraction, SVM is trained for vessel segmentation.

IV.CONCLUSION

Retinal image of human plays a vital role in detection and diagnosis of various eye diseases for ophthalmologist. This paper elaborates the various approaches for identifying and segmenting the blood vessels. Automated blood vessel segmentation diagnoses many eye diseases and abnormalities based on the feature extraction. This survey also covers the way for new innovative approaches such as hybrid techniques, mathematical morphology, clustering method, vasculature localization, Neural Network etc., for segmenting the blood vessels. The performance of these approaches are measured by TPR, FPR, Accuracy, Sensitivity and Specificity. The image segmentation is the foundation for the retinal fundus images. Hence the new methodologies to detect blood vessels for identifying eye disease and the efficient use of already existing methods are the interest of future work.

REFERENCES

[1.] Shobha Rani Baben, Paul P Mathai, "Retinal Area Detector for Classifying Retinal Disorders from SLO Images" IJIRST – Volume 3 Issue 04 September 2016

[2.] http://www.midwestglaucoma.com

[3.]http://www.isi.uu.nl/Research/Databases/DRIVE/

[4.] 4.https://www.rpfightingblindness.org.uk

[5.] Sneha Purusharthi, Bhakti Kurhade, "Identification of Diabetic Retinopathy in Retinal Images using Support Vector Machine" IJCAT Volume 1, Issue 2, March 2014

[6.] Qiangfeng Peter Lau, Mong Li Lee, Wynne Hsu, and Tien Yin Wong, "Simultaneously Identifying All True Vessels From Segmented Retinal Images" IEEE Transactions On Biomedical Engineering, Vol. 60, No. 7, July 2013.

[7.] M.Ramya, M.Sornalatha, "Personal identification based on retinal blood vessel segmentation" IJETCSE, Vol 7, March 2014.

[8.] Roya Aramesh, Karim Faez, "A new method for segmentation of retinal blood vessels using morphological image processing technique" , IJASCSE, Vol 3, Issue 1, 2014.

[9.] K.S.Sreejini, V.K. Govidan "Improved multiscale matched filter for retina vessel segmentation usin PSO Algorithm " Egyptian Informatics Journal(2015) 16, 253-260.

[10.] S.Saranya Rubini, Dr.A.Kunthavai, "Diabetic Retinopathy Detection based on Eigenvalues of the Hessian Matrix", Elsevier , Graph algorithm, High performance Implmentations and Applications, 2015, 311-318.

[11.] Nameirakpam Dhanachandra*, Khumanthem Manglem and Yambem Jina Chanu, "Image Segmentation using *K*-means Clustering Algorithm and Subtractive Clustering Algorithm" Elsevier, Eleventh International Multi-Conference on Information Processing-2015, 764 – 771.

[12.] Jose Tomas Arenas-Cavalli, Sebastian A. Rıos, Mariano Pola, Rodrigo Donoso, Elsevier "A Web-Based Platform for Automated Diabetic Retinopathy Screening", International Conference on Knowledge Based and Intelligent Information and Engineering Systems", (2015) 557 – 563.

[13.] Retinal blood vessel segmentation approach based on mathematical morphology, Elsevier Gehad Hassan, Nashwa El-Bendary, et.al , (ICCMIT 2015), 612 – 622.

[14.] Yitian Zhao, Lavdie, Lavdie Rada, et.al, "Automated Vessel Segmentaion Using Infinite Perimeter Active Contour Model With Hybrid Region Information With Application To Retinal Images", IEEE Transaction On Medical Imaging, Vol 34,No.9, Sep 2015.

[15.] Sohini Roychowdhury, *e*t.Al. "Iterative Vessel Segmentation Of Fundus Images", IEEE Transactions On Biomedical Engineering, VOL. 62, NO. 7, JULY 2015.

[16.] Jingdan Zhang et al, Blood Vessel Segmentation of Retinal Images Based on Neural Network" Springer International Publishing Switzerland 2015, Part II,LNCS 9218, pp. 11–17, 2015.

[17.] Parth Panchal, Ronak Bhojani, Tejendra Panchal, "An Algorithm for Retinal Feature Extraction using Hybrid Approach", Elsevier, 7th International Conference on Communication, Computing and Virtualization 2016, 61 – 68.

[18.] Sharath Kumar P N, Deepak R U, et al." Automated Detection System for Diabetic Retinopathy Using Two Field Fundus Photography", Elsevier, ICACC 2016, 6-8 September 2016, 486 – 494.

[19.] Rokoth Kandan Sambandam, Sasikala Jayaraman, "Self adaptive dragonfly based optimal thresholding for multilevel segmentation of digital images", Journal of King saud University Computer and Information Sciences, Computer and Information Sciences(2016).

[20.] 20. Lorenza Bonaldi, Elisa Menti, et al., "Automatic

[21.] Generation of Synthetic Retinal Fundus Images: Vascular Network" Elsevier, International Conference On Medical Imaging Understanding and Analysis 2016, MIUA 2016, 6-8 July 2016, 54 – 60.

[22.] 21. Harry Pratt, Frans Coenen, et al. "Convolutional Neural Networks for Diabetic Retinopathy", Elsevier International Conference On Medical Imaging Understanding and Analysis 2016, MIUA 2016, 6-8 July 2016, 200 – 205.

[23.] 22. Jiong Zhang, et al., "Robust retinal vessel segmentation via locally adaptive derivative frames in orientation scores", IEEE Transaction on Medical Imaging, Vol 35, No. 12, December 2016.

[24.] 23. Qiaoliang Li, et al., "A Cross Modality learning approach for vessel segmentation in retinal Images" IEEE Transaction on Medical Imaging, Vol 35, No. 1, December 2016

[25.] 24. Paweł Liskowski* and Krzysztof Krawiec, "Segmenting Retinal Blood Vessels With Deep Neural Networks", IEEE Transactions On Medical Imaging, Vol. 35, NO. 11, Nov 2016.

[26.] 25.Anand Deshpande, Prashant P.Patavardhan, " Segmentation and Quality Analysis on Long Range Captured Iris Image", IJIVP 2016,

[27.] 26. R.Rexoni Bindhya, C.S.Sree Thayanandeswari, " Identification of Diseases in Retinal Blood Vessel using Principal Component Analysis", IJARECE, Vol 5, Issue 3, March 2016.

[28.] 27. Ishmeet Kaur, Lalit Mann Singh, "A Method of Disease Detection and Segmentation of Retinal Blood Vessels using Fuzzy C-Means and Neutrosopic Approach", Imperial Journal of Interdisciplinary Research, Vol 2, Issue 6, 2016.

[29.] 28. Kaustav Jyoti Borah et al, "Wavelet Based blood Vessel Segmentation in Retinal Image Analysis", IJERT Vol. 5 Issue 11, November-2016.

[30.] 29. Sonal Wilson Pillai Et Al, "Retinal Blood Vessel Extraction Using Isodata Clustering And Morphological Operations", IJERT Vol. 6 Issue 04, April-2017.

[31.] 30.Meng Li et. al, "Robust Retinal Blood Vessel Segmentation Based on Reinforcement Local Descriptions", BioMed Research International, Volume 2017.

[32.] 31. R. Murugan, Reeba Korah, "Detection of Optic disk by line filter operator approach in Retinal Images", Advances in Computing & Inform. Technology, AISC 177, pp. 719–728. springerlink.com

[33.] 32. Manvir Kaur,Dr Rajnessh Talwar, "Review on: Blood Vessel Extraction and Eye Retinopathy Detection", (IJCSIT)

[34.] Vol. 5 (6) , 2014, 7513-7516