ISSN:2347-7385

Screening of Diabetic Retinopathy Images in LabView

Purushottama T L
Department of Electronics and Communication
Siddaganga Institute of Technology
Tumkur-572103
purushothama.t.l@gmail.com

Kishore C
Department of Electronics and Instrumentation
Siddaganga Institute of Technology
Tumkur-572103
kishore66655@gmail.com

***Abstract*— Diabetic Retinopathy (DR) is gradual obstruction in the functioning of the blood vessels in retina of the eye caused by chronic hyperglycemia which may be due to diabetes type 1 or diabetes type 2. Initially, DR may not be easily recognizable, but it can cause vision loss if it reaches a severe level. Diabetic retinopathy is main cause of vision loss for more than 5 percent of the diabetic patients around the world. So the early detection of Diabetic retinopathy through proper screening is essential.**

The paper presents a Diabetic Retinopathy Screening System which can be used as a primary diagnosis tool by doctors in the diagnosis for identifying the features of Diabetic Retinopathy. The system processes the retinal images and scans the basic parts like blood vessels, exudates and microaneurysms. The retinal images are segmented and classified as normal or DR affected images by extracting features from segmented images and the Gray Level Co-occurrence Matrix (GLCM). The classifier used is Support Vector Machine (SVM) which gives a better accuracy.

The system is implemented and tested LabView for the standard database and need to be optimized for real time screening of images. LabView creates distributable .EXE files and .DLL files which can be downloaded into the FPGA/DSP processor. Hardware implementation on LabView FPGA presents a small learning curve which drastically reduces development time and eliminates the need for custom hardware design.

Keywords:- Diabetes Type-2, exudates, micro aneurysms (MA), LabView, morphological operators, Grey level co-occurrence matrix (GLCM), Support vector machine classifier(SVM).

I. INTRODUCTION

Diabetic retinopathy (DR) is an eye affecting disease for the patients suffering from diabetes. The diabetes mellitus is the main reason for vision loss which happens due to damage in the retina. The DR has to be treated in the earlier stages to avoid vision loss for patients. Thus, large scale diagnosis of eyes of the patients having diabetes is very much essential, but manual screening is time consuming and requires more resources [2]. The images of retina of the DR affected patient captured by the camera are utilized for diagnosis of eye of diabetic patient. The advanced techniques of DR diagnosis assist to fasten the processing reduce expenditure and avoid vision loss of patients compared to the regular techniques of screening.

The important objective of this work is to write a smart and efficient segmentation, classification and identification technique for retinal image analysis to assist the doctor in screening and to be utilized as a modern tool for the diagnosis of diabetic retinopathy. The DR Screening system should accept a poor quality color retinal image, and separate the features such as the optic disk, fovea and the retinal blood vessels. Then the system must identify hard exudates, cotton wool spots, hemorrhages and microaneurysms [3]. The system should process, segment, compute the parameters and classify the retinal images even if there are changes in color, illumination and presence of different noises. Finally to develop an algorithm that has the ability to identify and classify the patients with normal, moderate and severe from the obtained retinal fundus image of the patients.

A. Abnormalities associated with the retina

Diabetic retinopathy occurs because of the damages of blood vessels, formation of dark spots on retinal surface, etc. The clinical symptoms of diabetic retinopathy are discussed below. Fig.1 shows the difference between a normal person and a diabetic retinopathy patient vision.

Fig.1: Distinction in the vision of normal person and a person with diabetic retinopathy

ISSN:2347-7385

Microaneurysms: The presence of microaneurysms marks the beginning stage of diabetic retinopathy in the eye [8]. If the blood contains high sugar level which damages the walls of tiny blood vessels then microaneurysms will appear. They can be present in single or in group as very small, dark red dots. They are very small in dimension ranging from ten to hundred and are round in shape. The presence of microaneurysms does not affect the vision much [1].

Hemorrhages: They are in circular shape and occur in the last regions of the retina and are frequently termed as 'blot' hemorrhages. The number of hemorrhages is directly proportional to the amount of damage of the blood vessels in the retina of the eye. The hemorrhages appear as tiny red dots or blots similar to microaneurysms or as bigger oval hemorrhages.

Hard exudates: They are the key features of the disease whose size ranges from small blots to large patches with distinct edges. The hard exudates are the route cause for vision loss which avoids the light falling on the retina.

Soft exudates: The soft exudates appear as large number of small patches of the retina and become ischemic deprived of blood the advanced stage of the disease. These regions are identifiable on the retina as fluffy whitish blobs called cotton wool spots.

II. LITERATURE SURVEY

Retinal image feature extraction and classification has been carried out using different techniques. Iqbal.M.I et al has used k-means clustering of two classes for segmentation, but there is an over enhancement of noise [1]. Jestin V.K et al have extracted eleven statistical features and three disease based feature for better classification [2]. Is tvan Lazar et al have suggested a method to facilitate MA identification using the screening of directional cross-section profiles centered on the local maximum pixels of the pre-processed image [3]. Mahendran.G et al has done the severity level assessment by means of recognizing the retinal exudates using fuzzy c means clustering and cascade neural network classifier [4]. Priya R et al has considered matched filter response and fuzzy c means clustering for better segmentation and extraction of blood vessels, and used SVM for classification of diabetic images, which has given better accuracy [5]. To detect the vascular abnormalities in diabetic retinopathy Dr.Chandrashekaraiah et al have used morphological operations to extract the features like blood vessels , microaneurysms and exudates to classify the image as normal, mild or severe [6]. In pre-processing step the green channel of colour retinal images is extracted, which is good choice for contrast enhancement [1,2,6,7], where The green channel extraction produces high contrast image. The distinction with respect to contrast between vessels and the background retina in the eye is clearly indicated by green color plane which is used in the above analysis.

III. SYSTEM METHODOLOGY

The suggested method for analyzing retinal images for the diagnosis of DR shown in Fig. 2. The input to the system is retinal fundus image taken by the digital fundus camera. The input retinal images undergo pre-processing to enhance the contrast of an image. The pre-processed image is segmented to separate and detect the blood vessels, exudates and microaneurysms. Textural feature analysis is carried out by using the Co-occurrence Matrix. Then the key parameters which highlight the features such as area of blood vessels, area of exudates, and area of microaneurysm, energy, entropy, contrast and homogeneity are computed. The computed values of the above features are given to the classifier which classifies the retinal image as normal or abnormal depending on the presence of DR.

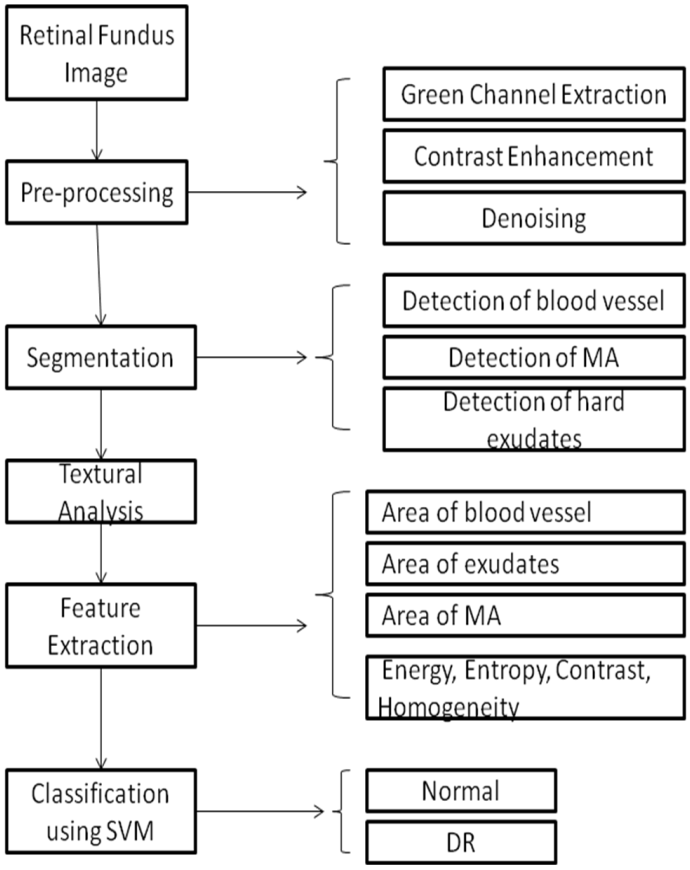

Fig. 2: Steps of Diabetic retinopathy image screening

A. Database

The retinal fundus images of the diabetic patients are collected from the Government hospital,

ISSN:2347-7385

which are taken by the dedicated camera. The data set includes 60 images of the retina, and was saved in JPEG format. These 60 images were grouped into a training group and a testing group. The database used here is diagnosed by the doctors for each image such as Diabetic Retinopathy and normal image.

B. Pre-Processing

Green channel extraction: Green Channel Extraction is the method of converting the color image into green channel image. Normally a RGB color consists of red, green and blue color. The green channel extraction produces high contrast image.

Contrast Enhancement: The good contrast image is obtained by using Adaptive histogram equalization which increases the local contrast and highlights the smaller details in an image [4,5].

Denoising: The different noises which affect the retinal image are removed in this stage. The median filtering is used to filter off high noises by preserving the edges. The Denoising using median filtering is carried out before segmentation. The median filter alters the average value of the intensity if there is non uniform distribution of noise in the image and also it decreases the variance of the intensities in the image [8,10].

C. Segmentation of Retinal Structures

Detection of Blood Vessels: The blood vessels are segmented by incorporating the Kirsch's edge detection and morphological method which is succeeded by applying Kirsch's edges [11]. The edges of the exudates can be taken by Kirsch's edges. The Kirsch's edge detection kernel is given by,

$$k = \begin{bmatrix} 5/15 & -3/15 & -3/15 \\ 5/15 & 0 & -3/15 \\ 5/15 & -3/15 & -3/15 \end{bmatrix}$$

(1)

The outputs of the kernel are combined together by taking the maximum value found on each pixel output. After the edge detection erosion and binary conversion operations are carried out.

Detection of Exudates and Microaneurysms: The Morphological operators are utilized for the detection of exudates and MA. The necessary structures of the retina are extracted by the morphological operators by probing the image with a set of known shape called structuring element (SE) [7]. The SE is chosen depending on the prior knowledge of the geometry the shape.

The morphological operations are erosion, dilation, opening, closing. Erosion computes the minimum of each pixel's neighborhood and is given by,

$$A \Theta B = \{\langle z \in E \mid B_z \subseteq A \rangle\}$$

(2)

Where A is a binary image, B is a structuring element and E is the Euclidean space.

Dilation is the maximum of each pixel's neighborhood and can be carried out by,

$$A \oplus B = \{\langle z \in E \mid (B^s)_{\approx} \rangle \cap A \neq \phi\}$$

(3)

Opening is done by single erosion succeeded by a single dilation and is found out as,

$$A \circ B = (A \Theta B) \oplus B$$

(4)

Closing is obtained as a single dilation succeeded by a single erosion and found by,

$$A \bullet B = (A \oplus B) \Theta B$$

(5)

The exudates are detected through the following operations. First, from the retinal image the green channel is extracted. Next the image is filtered using median filtering to remove high noises. The background image is obtained using morphological operators and then it is subtracted from the original image. Then the binary image corresponding to optic disc is obtained by removing all the connected components to form the binary image that has fewer than P pixels, where P was chosen such that it is smaller than the maximum size of optic disc. The size of the optic disc is approximately 80 x 80 pixels. The binary optic disc image is subtracted from the threshold image to obtain a resultant image containing only exudates.

Microaneurysms are obtained using morphological operators. The first step is to get a good contrast image using adaptive histogram equalization. The details are removed by utilizing Closing operator. Then filling operation is carried out to fill the holes in the vessels. Then the difference between the closed image and the filled image is found.

$$f_{diff} = close\ (f) - fill\ (f)$$

(6)

Appropriate threshold is set to get binary image from the eqn.6. The extended-minima transform is taken for the image obtained. The extended-minima transform is used to make most of the valleys to zero.

The h-minima transform masks all the minima in the intensity image whose depth is less than or equal to a predefined threshold. In the output binary image (*fE*), the white pixels represent the regional minima in the original image. Regional minima are connected pixels

ISSN:2347-7385

with the same intensity value, whose external boundary pixels all have a higher value. Finally the vessels and exudates are removed to separate out the MAs.

$$f_{MA} = f_E - f_v - f_{ex} \quad (7)$$

D. Study of Image Texture

Statistical texture analysis is done using the Matrix containing gray level co-occurrences. The matrix is a collection of how frequently various selective groups of pixel grey levels present in a retinal picture. For an image g(x,y) with N grey levels, the matrix $p(d,\phi)$ for each d and ϕ is given by,

$$p(d,\phi) = \begin{vmatrix} p_{0,0} & p_{0,1} & . & . & p_{0,N-1} \\ p_{1,0} & p_{1,1} & . & . & p_{1,N-1} \\ . & . & . & . & . \\ . & . & . & . & . \\ p_{N-1,0} & p_{N-1,1} & . & . & p_{N-1,N-1} \end{vmatrix} \quad (8)$$

Where

$$p_{i,j} = \frac{number\ \ of\ \ pixel\ \ pairs\ \ with\ \ \text{int}\ ensity\ \ (i,j)}{total\ \ number\ \ of\ \ pairs\ \ considered}$$

p_{ij} is given as the relative number of times gray level pair *(i,j)* occurs when pixels separated by the distance d along the angle ϕ are compared. The values of GLC Matrix P are normalized by the total number of occurrences. The important features extracted from GLCM are contrast, homogeneity, correlation and energy [7,10].

E. Feature Extraction

The Area of blood vessels, Area of exudates, Area of MA, Contrast, Homogeneity, Correlation and Energy are computed for the screening of retinal images through classifier.

<u>*Area of blood vessels*</u>: It is obtained by computing the total number of white pixels in the segmented image.

<u>*Area of exudates*</u>: It is obtained by computing the total number of white pixels in the exudates image.

<u>*Area of MA*</u>: It is obtained by computing the total number of white pixels in the MA image.

<u>*Contrast*</u>: It is computed using the equation,

$$contrast = \sum_{i=0}^{N-1}\sum_{j=0}^{N-1} (i-j)^2 p_{ij} \quad (9)$$

Where p_{ij} are the values in Gray Level Co-occurrence Matrix.

<u>*Homogeneity*</u>: Homogeneity can be calculated using,

$$Homogeneit\quad y = \sum_{i=1}^{N-1}\sum_{j=0}^{N-1} \frac{p_{ij}}{(1+|i-j|)} \quad (10)$$

<u>*Correlation*</u>: It is computed using

$$Correlatio\quad n = \sum_{i=0}^{N-1}\sum_{j=0}^{N-1} \frac{(i-\mu_i)(j-\mu_j)\,p_{ij}}{\sigma_i \sigma_j} \quad (11)$$

Where μi, μj, σi and σj are the mean values and standard deviations of *Pi* and *Pj*.

<u>*Energy(E)*</u>: It is obtained from the co-occurrence matrix as

$$E = \sum_{i=0}^{N-1}\sum_{j=0}^{N-1} p_{ij}^2 \quad (12)$$

The above seven values obtained, collectively form a feature vector of a retinal image.

F. Classification

The Diabetic retinopathy affected images are classified depending on the obtained features by Support Vector Machine classifier [5, 7, 8, and 10]. The classifier is used to group the retinal images as unaffected and diabetic retinopathy affected images based on the feature extracted. The data in the feature values is grouped in to two groups by obtaining an *N* dimensional hyper plane by the classifier for classification.

Depending on the results of area Computation and texture analysis, the system will classify the image as normal or affected. The main distinction between normal retinal image and diabetic retinopathy affected image is the presence and absence of micro aneurysms and exudates.

IV. EXPERIMENTAL OUTCOMES

The front panel which consists of controls and indicators of the LabView flow graph is as given in Fig. 3.

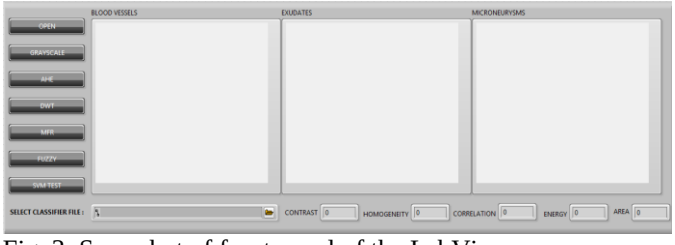

Fig. 3: Snap shot of front panel of the LabView

ISSN:2347-7385

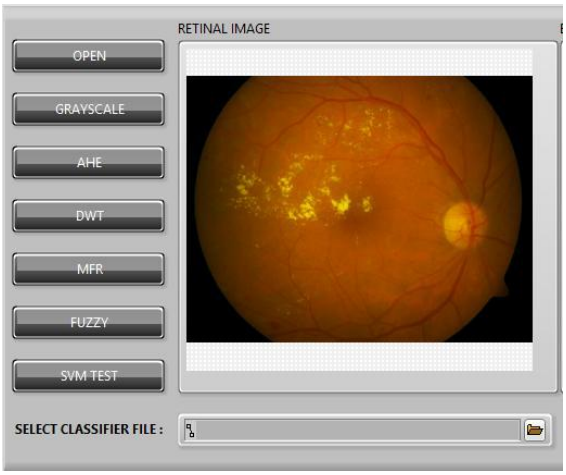

Fig.4: Retina after opening of an image

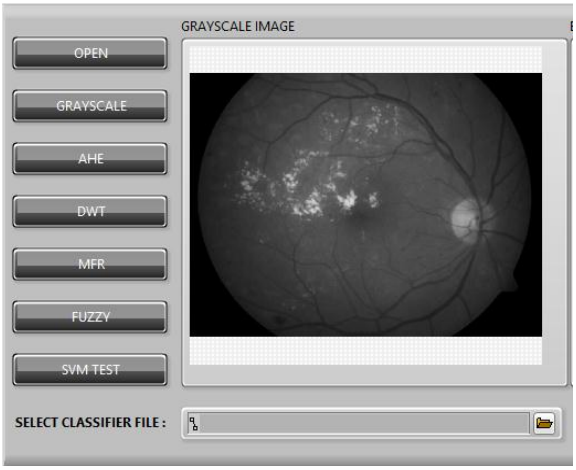

Fig. 5: Snap shot of retina after green channel extraction

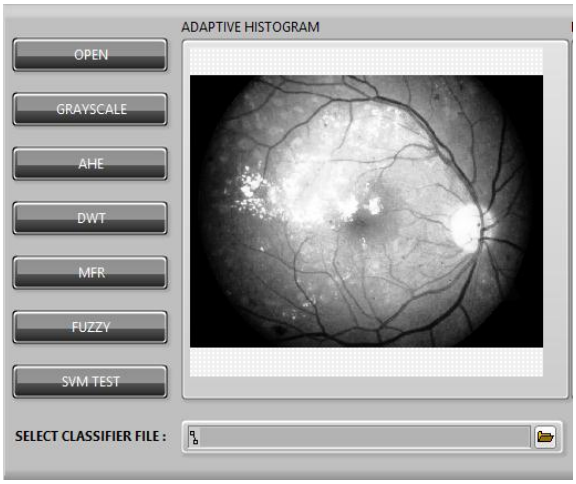

Fig. 6: Snap shot of retina after adaptive histogram equalization

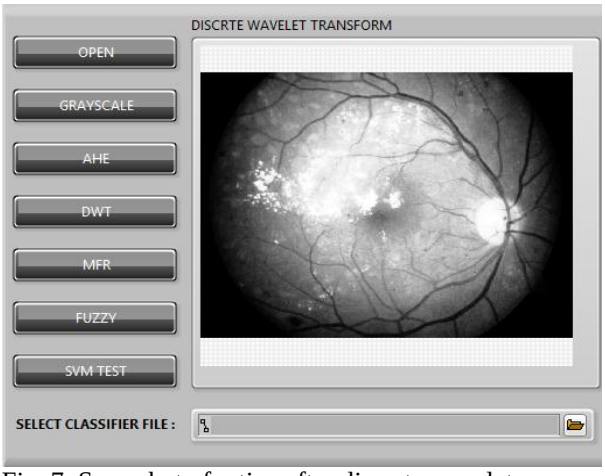

Fig. 7: Snap shot of retina after discrete wavelet transform

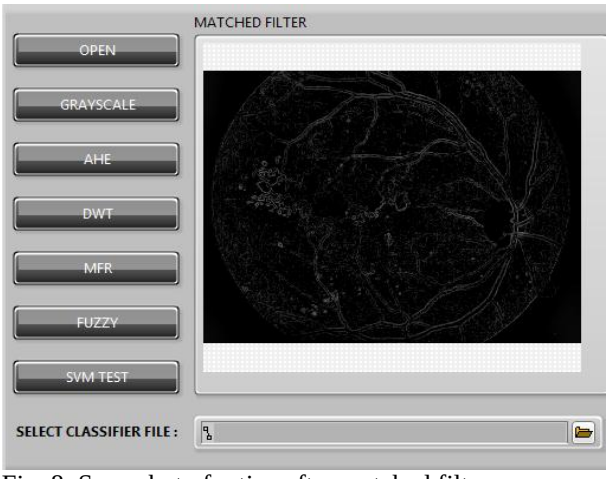

Fig. 8: Snap shot of retina after matched filter response

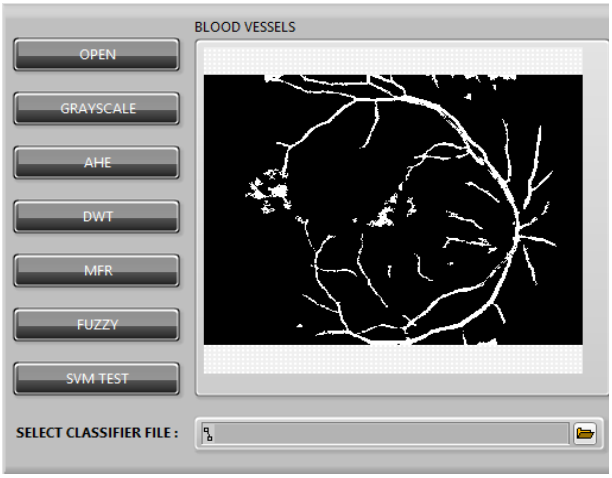

Fig.9: Snap shot of retina after fuzzy c-means clustering which shows segmented blood vessels

ISSN:2347-7385

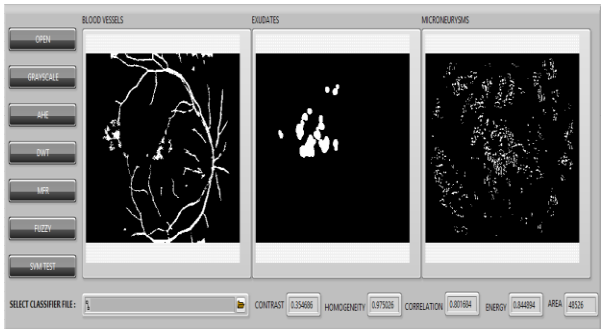

Fig. 10: Snap shot of retina after which showing segmentation of blood vessels

Classification using LabView

The parameters like Sensitivity and Specificity are used to grade the screening of diabetic retinopathy images. Sensitivity may be obtained as the Probability of a positive result in the test given that the patient is ill. Specificity is defined as Probability of a negative result in the test given that the patient is well.

The image is classified as 'Normal' if it does not contain any exudates and microaneurysms. The image is classified as 'Moderate' if it contained only microaneurysms and not the exudates. The image is classified as 'Severe' if it contains both microaneurysms and exudates.

Class	No. of Training images	No. of Testing images	No. of correctly classified images
Normal	35	14	10
Mild	35	14	11
Severe	35	14	10

Table 1: Classification results in LabView

True Positive = 11, False Positive = 4, True Negative = 10, False Negative = 3

Sensitivity = TN/(TN+FP) = 78.57%
Specificity = TP/(TP+FN) = 71.42%

V. CONCLUSION

In this paper, how the modern tool like LabView can be used for diagnosis of Diabetic retinopathy is presented. The Hardware implemented system may be used to assist ophthalmologists for early detection of DR. The working of the system is tested for the two publicly available databases and the correctness is ensured by computing Sensitivity and specificity. The recognition of the severity of the defect includes two stages: In the initial step the retinal image acquired is processed to get the segmented image containing the blood vessels, exudates and MA and in the second stage classification through SVM is performed. The proposed system can act as a stand alone tool for analysis of DR using retinal image processing. Further the testing may be carried out on the real time images acquired through fundus camera.

REFERENCES

[1] Clara I. Sanchez, Agustin Mayo, Maria Garcia, Maria I.Lopez and Roberto Hornero, "Automatic Image Processing Algorithm to Detect Hard Exudates based on Mixture Models", Proceedings of the 28th IEEE EMBS Annual International Conference New York City, USA, Aug 30-Sept 3, 2006.

[2] Jestin V.K, Anitha J and Jude Hemanth, "Texture feature extraction for retinal image processing" in International Conference on Computing, Electronics and Electrical Technologies (ICCEET), pp. 548-551, 2012.

[3] Istvan Lazar and Andras Hajdu, "Retinal microaneurysm detection through local rotating cross-section profile analysis" in IEEE transaction on medical imaging, Vol. 32, No. 2, pp. 400-407, February 2013.

[4] S. Kavitha, K. Duraiswamy, "Automatic Detection of Hard and Soft Exudates in Fundus Images Using Color Histogram Thresholding", European Journal of Scientific Research, ISSN 1450-216X Vol.48 No.3, 2011, pp.493-504.

[5] Mahendran.G, Dhanashekar.R, Narmadha Devi.K.N "Recognition of Retinal Exudates for Diabetic Retinopathy and its Severity Level Assessment" IJECEAR Vol. 2, SP-1, Feb. 2014.

[6] Priya.R, Aruna.P, Lecturer (Selection Grade), Associate Professor, "Review of automated diagnosis of diabetic retinopathy using the support vector machine", in international journal of applied engineering research, dindigul Volume 1, No 4, 2011.

[7] Dr.Chandrashekar. M. Patil, "An Approach for the Detection of Vascular Abnormalities in Diabetic Retinopathy", International Journal of Data Mining Techniques and Applications, Vol:02, pp. 246-250, December 2013,.

[8] Selvathi.D, N.B.Prakash, Neethi Balagopal,"Automatic Detection of Diabetic Retinopathy for Early Diagnosis using Feature Extraction and Support Vector Machine", International Journal of Emerging Technology and Advanced Engineering, ISSN 2250-2459, Volume 2, Issue 11, November 2012.

[9] Gonzalez, R. C., and Woods, R. E., Digital image processing, 2nd edition. Prentice Hall, New Jersey, 2001.

[10] A.Sopharak,B.Uyyanonvara,S.Barman and T.H.Williamson, "Automatic detection of diabetic retinopathy exudates from non-dilated retinal images using mathematical morphology methods" in Computerized Medical Imaging and Graphics, Vol. 32, pp. 720–727, 2009.

[11] Microaneurysms in diabetic retinopathy. Br. Med. J. 3(5774):548–549,1971. http://www.jstor.org/pss/25415740.

[12] Diabetic Retinopathy. Retrieved from: http://www.hoptechno.com/book45.htm. Last accessed on 17th January 2009.

[13] Kumar, A., Diabetic blindness in India: the emerging scenario. Indian J. Ophthalmol. 46(2):65–66, 1998.

[14] Acharya, U. R., Tan, P. H., Subramaniam, T., Tamura, T., Chua, K. C., Goh, S. C., Lim, C. M., Goh, S. Y., Chung, K. R., and Law, C., Automated identification of diabetic type 2 subjects with and without neuropathy using wavelet transform on pedobarograph. J. Med. Syst. 32(1):21–29, 2008

[15] Di Wu, Ming Zhang, J.-C. L., and Bauman, W. 2006. On the adaptive detection of blood vessels in retinal images. In *IEEE Transactions on Biomedical Engineering*, volume 53.