International Research Journal in Global Engineering and Sciences. (IRJGES)
ISSN : 2456-172X | Vol. 4, No. 2, June-Aug 2019 Pages 107-119
| Cosmos Impact Factor (Germany): 5.195
Received: 02.08.2019 Published:28.08.2019

AUTOMATEDDETECTIONOF DIABETICRETINOPATHYUSING MACHINE LEARNING

[1]Sharanabasavaraj H Angadi, [2]Manjushree Mashal
Professor,Department of computer science and EnggT ech Fortune Technology
RTE Society's Rural Engineering College,Hulkoti-Karnataka
Email: shangadicse@gmail.com

Abstract -Diabetic retinopathy (DR) is a common retinal disease which is unexpected difficulties arising in the progression of a diabetes. Unfortunately, in many cases the patient is not aware of any symptoms until it is too late for effective treatment. Through analysis of evoked potential response of the retina, the optical nerve, and the optical brain center, a way will be paved for early diagnosis of diabetic retinopathy and prognosis during the treatment process. It is a mainly found in middle as well as older age groups. For controlling the progress of the disease, early detection through regular screening and timely intervention will be highly beneficial. Diabetes is a disease which occurs when the pancreas does not secrete enough insulin or the body is unable to process it properly. This disease affects slowly the circulatory system including that of the retina. As diabetes progresses, the vision of a patient may start to deteriorate and lead to diabetic retinopathy. The main stages of diabetic retinopathy are no proliferative diabetic retinopathy(NPDR) and proliferative retinopathy(PDR). The visual impairment can be avoided by detecting DR in its early stage. Segmentation of retinal structures help in the diagnosis of DR. In this work, anatomical structures such as blood vessels, exudates and micro aneurysms in retinal images are segmented and the images are classified as normal or DR images by extracting features from these structures and the Gray Level Co-occurrence Matrix (GLCM). The classifier used is Support Vector Machine (SVM) which gives an average accuracy of 93%.

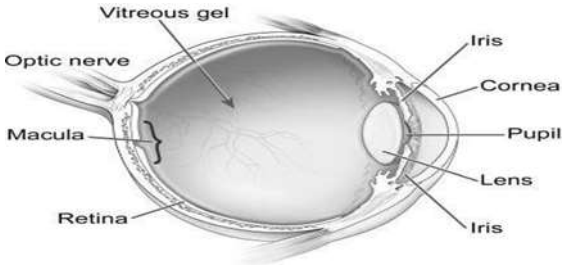
INTRODUCTION

Two common retinal disorders are Diabetic retinopathy (DR) and glaucoma that are major causes of blindness.It is approximated that 220 million people have diabetes mellitus worldwide of which about 10-15% would have had or develop DR. Hence, to prevent eventual vision loss and DR, accurate and early diagnosis of DR is important.Diabetic Retinopathy (DR) is a sight- threatening risk inflicting diabetic patients. Damage in the retina causes diabetes mellitus. Visual loss and blindness are prevented by Early diagnosis and treatment. Retinal images obtainedby the fundus camera are mainly used to obtained the retinal images for diagnose DR. Compared to the manual methods of diagnosis, Automated methods of DR screening help to save time, cost and vision of patients. Classification of Retinal images has been done by various methods. VijayaKumari et al used MDD classifiers retinal images for feature extraction they used propagation through radii method. Classification using fractal measures and clustering techniques was done by Jebarani et al. Image analysis tools are very best tool for effective screening of Diabetic Retinopathy patients for automated detection of various features and stages of Diabetes Retinopathy. In this work, To separate out the blood vessels, exudates and micro aneurysms (MA) segmentation of retinal images can be performed. Presence of DR are indicated by these

International Research Journal in Global Engineering and Sciences. (IRJGES)
ISSN : 2456-172X | Vol. 4, No. 2, June-Aug 2019 Pages 107-119
| Cosmos Impact Factor (Germany): 5.195
Received: 02.08.2019 Published:28.08.2019

segmentations. The features given to the classifier include the areas of these segmented structures and textural features obtained from GLCM. The SVM classifier classifies the input image as normal (not affected by DR) or DR images based on the training done by giving the sample features.

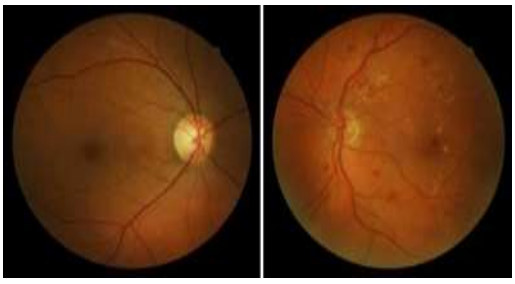
I THE RETINA



•The retina is a multilayered, light sensitive neural tissue lining the inner eye ball. Light is focused onto the retina and then transmitted to the brain through the optic nerve.
•The macula is a highly sensitive area in the center of the retina, responsible forcentral vision. The macula is needed for reading, recognizing faces and executing other activities that require fine, sharp vision.
•The vitreous – clear gel fills the back of the eye and sits in front of the retina.
•Occurs when elevated blood sugar levels cause blood vessels in the eye to swell and leak into the retina.

II DIABETIC RETINOPATHY DIABETIC RETINOPATHY DEFINITION

A complication of diabetes and a leading cause of blindness is refered to as Diabetic retinopathy. Diabetes damages the light-sensitive tissue at the back of the eye and tiny blood vessels inside the retina.
Healthy Retina Diabetic Retina



THE STAGES OF DIABETIC RETINOPATHY

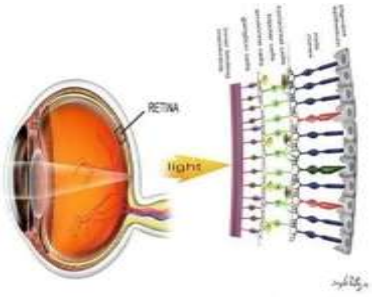
Diabetic retinopathy has four stages:
1.Nonproliferative Mild Retinopathy. It is the earliest stage of DR, in which microaneurysmsoccur.Small areas of balloon-like swelling in the retina's tiny blood vessels are found in retina.
2.Nonproliferative Moderate Retinopathy. Progressesing the disease causes, some blood vessels are get blocked.
3.Nonproliferative Severe Retinopathy. Many blood vessels are blocked, depriving several areas of the retina with their blood supply send signals to the body to grow new blood vessels for nourishment.

International Research Journal in Global Engineering and Sciences. (IRJGES)
ISSN : 2456-172X | Vol. 4, No. 2, June-Aug 2019 Pages 107-119
| Cosmos Impact Factor (Germany): 5.195
Received: 02.08.2019 Published:28.08.2019

4.Proliferative Retinopathy. It is the advanced stage, the signals sent by the retina for nourishment increase the growth of new blood vessels. This condition is called proliferative retinopathy. These new blood vessels are fragile and abnormal. Inside of the eye, they grow along the retina and surface of the clear, vitreous gel. These blood vessels do not cause symptoms or vision loss. However, If they leak blood, severe vision loss and even blindness can result.

- **RISK FOR DIABETIC RETINOPATHY**

Type 1 and Type 2 diabetes patients are at risk. That's why everyone should comprehensive dilated eye exam is necessary at least once a year. Between
45 to 50 percent of Americans diagnosed with diabetes have some stage of diabetic retinopathy. If you have diabetic retinopathy, your doctor can give the treatment to prevent its progression.



During pregnancy, diabetic retinopathy is riskfor women with diabetes. To protect vision, every pregnant woman with diabetes should have a comprehensive dilated eye exam as soon as possible.

DIABETIC RETINOPATHY CAUSE VISION LOSS

Retinal Blood vessels are damaged from diabetic retinopathy can cause vision loss mainly in two ways:

1.Fragile, abnormal blood vessels are develop in the retina and leak blood into the center of the eye, vision is blurred. This is proliferative retinopathy and is the fourth and most advanced stage of the disease.

2.Macula is the part of the eye where sharp, straight-ahead vision occurs, but Fluid can leak into the center of the macula, makes the macula swell, blurring vision. This condition is called macular edema.

International Research Journal in Global Engineering and Sciences. (IRJGES)
ISSN : 2456-172X | Vol. 4, No. 2, June-Aug 2019 Pages 107-119
| Cosmos Impact Factor (Germany): 5.195
Received: 02.08.2019 Published:28.08.2019

DIABETIC RETINOPATHY SYMPTOMS

Diabetic retinopathy is asymptomatic in early stages of the disease As the disease progresses symptoms may include

- Blurred vision
- Floaters
- Fluctuating vision
- Distorted vision
- Dark areas in the vision
- Poor night vision
- Impaired color vision
- Partial or total loss of vision

RETINAL DIAGNOSTIC TESTS

- Fundus Photography
- Fluorescein Angiography (FA)
- Optical Coherence Tomography (OCT)
- Ocular Ultrasonography
- Electroretinography (ERG)

III PROPOSED METHODOLOGY

The framework for the proposed methodology is given in Figure 1. The input retinal images undergo segmentation to detect blood vessels, exudates and microaneurysms separately. Texture analysis using GLCM is done simultaneously. Then features such as area of blood vessels, area of exudates, area of MA, energy, entropy, contrast and homogeneity are extracted and fed to SVM which classifies the images as normal or abnormal based on the presence of DR.

International Research Journal in Global Engineering and Sciences. (IRJGES)
ISSN : 2456-172X | Vol. 4, No. 2, June-Aug 2019 Pages 107-119
| Cosmos Impact Factor (Germany): 5.195
Received: 02.08.2019 Published:28.08.2019

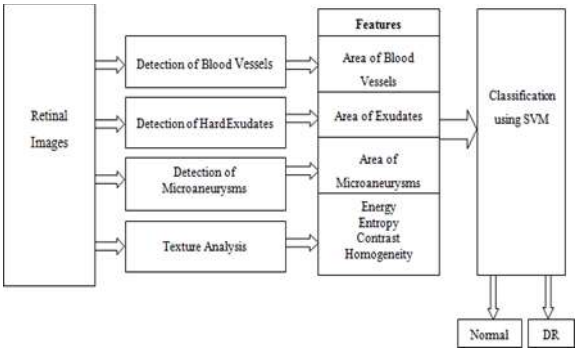


Fig. 1 Proposed Methodology

There are 5 methods for proposed methodoly

- Databases
- Segmentation of retinal structure
- Texture analysis
- Feature extraction
- Classification

DATABASES

Publicly available databases such as DRIVE, DIARETDB1 and MESSIDOR are used in this work. The 40 color images of the retina are found in DRIVE database [6], with 565 x 584 pixels and 8 bits per color channel, represented in TIFF format.

These images were originally captured from Canon CR5 nonmydriatic 3 charge-coupled-device (CCD) cameras at 450 field of view (FOV), and were initially saved in JPEG format.The 40 images were divided into a training set and a testing set.89 colour fundus images are found in DIARETDB1 database[7].among 89 images 84 contain mild non-proliferative signs of the diabetic retinopathy, and 5 are normal which are not signs of the diabetic retinopathy.50 degree Field-Of- View digital fundus camera are used to capture images with varying imaging settings. The MESSIDOR database [8] consists of 1200 images captured using a color video 3CCD camera on a Topcon TRC NW6 non-mydriaticretinograph with a 45 degree field of view. The images were captured using 8 bits per color plane at 1440 x 960, 2240 x 1488 or 2304 x 1536 pixels. Two diagnoses have been provided in this database by the medical experts for each image such as retinopathy grade and risk of macular edema.

SEGMENTATION OF RETINAL STRUCTURES

Detection of Blood Vessels: The segmentation of retinal blood vessels is done by the method proposed by Selvathi et al [9].The feature vector of a pixel consists of the intensity of its eight-connected neighbours. The extracted features are given to the SVM for classification based segmentation. Detection of Exudates and Microaneurysms: Morphological operators are used for the detection of exudates and MA in this work. The morphological operators extract relevant structures of the image by probing the image with another set of known shape

International Research Journal in Global Engineering and Sciences. (IRJGES)
ISSN : 2456-172X | Vol. 4, No. 2, June-Aug 2019 Pages 107-119
| Cosmos Impact Factor (Germany): 5.195
Received: 02.08.2019 Published:28.08.2019

called structuring element (SE).

The common morphological operations are erosion, dilation, opening and closing. Erosion computes the minimum of each pixel's neighbourhood and Dilation computes the maximum of each pixel's neighbourhood. The steps for the detection of exudates using morphological operators are given as follows. Green channel of the retinal image is extracted from the colored image. First median filtering is applied to the green image. Then morphological reconstruction is done to obtain the background image, which is subtracted from the original image. This is followed by applying Kirsch's edges [11]. Kirsch's edges helps to capture the edges of the exudates.

TEXTURE ANALYSIS

Texture means repeating patterns of local variation of pixel intensities. It gives information about the arrangement of surface pixels and their relationship with the surrounding pixels [13]. Statistical texture analysis is based on Gray Level Co-occurrence Matrix (GLCM). The commonly extraced textural features from GLCM are contrast, homogeneity, correlation and energy.

FEATURE EXTRACTION

The feature vector used for classification consists of seven features obtained from segmentation of retinal structures and texture analysis. These features are the area of blood vessels, area of exudates, area of MA, contrast, homogeneity, correlation and energy.

Area of blood vessels is determined by finding the total number of white (vessel) pixels in the vessel- segmented image. Similarly area of exudates and area of MA are determined by finding the number of white pixels in the exudates image and MA image respectively. Contrast is a measure of the intensity contrast between a pixel and its neighbor over the whole image.

PROPOSED WORK

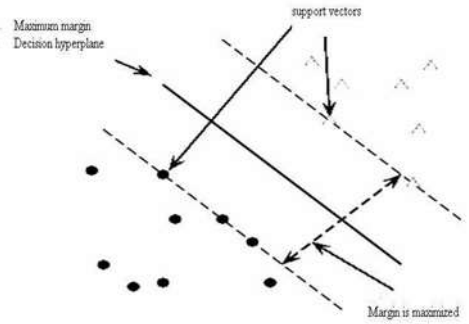
In this paper, an automated approach for classification of the disease diabetic retinopathy using fundus images is presented. In order to diagnose the disease diabetic retinopathy, a number of features such as area , mean and standard deviation of the preprocessed images are extracted to characterize the image content. Support vector machine (SVM) training process is applied to analyze training data to find an optimal way to classify images into their respective classes namely PDR, NPDR or Normal. Experimental results show that the classification accuracy can provide a better result. The paper is organized as follows:

1. The Preprocessing of Images are presented in Section
2. Feature extraction method is given in Section
3. SVM Modeling technique for image classification is described in Section
4. Implementation procedure is reported in Section
5. Results and Discussion are given in Section
6. Finally, conclusion and future work are given in Section
7. Figure 1 illustrates the block diagram of the proposed system for diagnosis of DR .

International Research Journal in Global Engineering and Sciences. (IRJGES)
ISSN : 2456-172X | Vol. 4, No. 2, June-Aug 2019 Pages 107-119
| Cosmos Impact Factor (Germany): 5.195
Received: 02.08.2019 Published:28.08.2019

In this work, classification based on the extracted features is done by using SVM classifier. For training, fifty images (25 normal and 25 DR images) along with their corresponding ground truths are used. For testing, a set of one hundred and fifty images (75 normal images and 75 DR images) are taken and their features are calculated. Then these features are used by the SVM for classifying the images into Normal and DR images.

IV SVM MODELING TECHNIQUE FOR CLASSIFICATION



After the feature extraction methods, the extracted features of images are given as inputs to Svm. Svm is used to classify the group of eye images as either affected or normal depending

International Research Journal in Global Engineering and Sciences. (IRJGES)
ISSN : 2456-172X | Vol. 4, No. 2, June-Aug 2019 Pages 107-119
| Cosmos Impact Factor (Germany): 5.195
Received: 02.08.2019 Published:28.08.2019

on the feature values. Support vector machines (SVMs) are a set of related supervised learning methods used for classification and regression.A Support VectorMachine (SVM) performs classification by constructing an N dimensional hyper plane that optimally separates the data into two categories. The input space is mapped into a high dimensional feature space. Then, the hyper plane that maximizes the margin of separation between classes is constructed. The points that lie closest to the decision surface are called support Vectors and directly affect its location. When the classes are no separable, the optimal hyper plane is the one that minimizes the probability of classification error.The optimal hyper plane that separates clusters of vector in such a way that cases with one category of the target variable are on one side of the plane and cases with the other category are on the other side of the plane which is the goal of SVM modeling.Hyper plane that are near to vector are the support vectors.

IMPLEMENTATION PROCEDURE

The evaluation of the proposed automated diagnosis system of diabetic retinopathy have been performed by using a set of 250 images which is a combination of normal, pdr and npdr affected images.

PREPROCEESING

The original image which is of size 1280*1024 is converted to gray scale image. After that, adaptive histogram equalization is applied to improve the contrast of the image. Then DWT is applied to reduce the size of the image into half as 640*512. Then Matched filter response is applied to reduce the noise in the image. Finally, Fuzzy means clustering is applied to segment the blood vessels in the image.

FEATURE EXTRACTION AND MODELING USING SVM

After preprocessing of images is completed, Support vector machine is used to discriminate the various categories. Classification parameters are calculated using support vector machine learning. The training process analyzes training data to find an optimal way to classify images into their respective classes. The training data should be sufficient to be statistically significant. Features such as Area, Mean, Standard Deviation are calculated for each image. The support vector machine learning algorithm is applied to produce the classification parameters according to calculated features. The derived classification parameters are used to classify the images. Theimage content can be discriminated into the various categories in terms of the designed support vector classifier.

SCREENING OF DIABETIC RETINOPATHY

A screened fundus is considered as a true positive (TP) if the fundus is really abnormal and Similarly, a true negative (TN) means that the fundus is really normal and the procedure also classified it as normal. A false positive (FP) means that the fundus is really normal, but the procedure classified it as abnormal. A false negative (FN) means that the procedure classified the screened fundus as normal, but it really is abnormal.
Sensitivity is the percentage of abnormal fundus. Sensitivity =T +FN,where T=TP/TP Specificity is the percentage of normal funduses classified as normal by the procedure. Specificity =S + FP,where S=TN/TN. The higher the sensitivity and higher specificity values,

International Research Journal in Global Engineering and Sciences. (IRJGES)
ISSN : 2456-172X | Vol. 4, No. 2, June-Aug 2019 Pages 107-119
| Cosmos Impact Factor (Germany): 5.195
Received: 02.08.2019 Published:28.08.2019

the better the procedure.

V RESULTS AND DISCUSSION

The results for each step explained in the proposed method are discussed in this section. The blood vessel segmentation results for sample images of the DRIVE database are shown in Fig. 2 and Fig. 3.

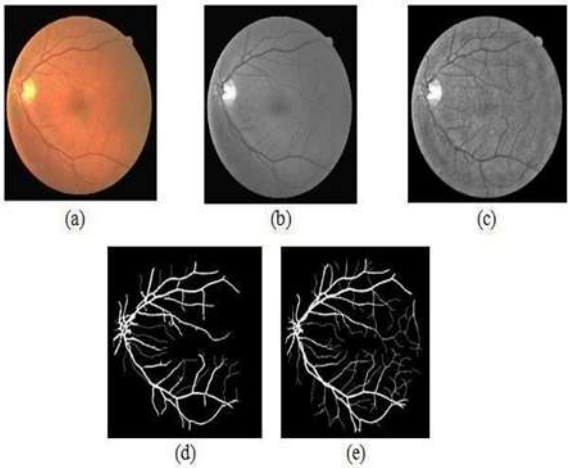


Fig. 2 Detection of blood vessels (a) Original image (b) Green channel image (c) Enhanced image (d) Segmented image (e) Ground truth image

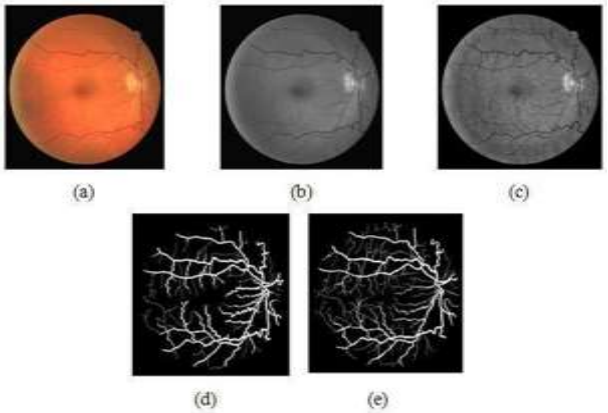


Fig. 3 Detection of blood vessels (a) Original image (b) Green channel image (c) Enhanced image (d) Segmented image (e) Ground truth image.

The results for exudates segmentation for sample images of the DIARETDB1 database are given in Fig. 4 and Fig. 5.

International Research Journal in Global Engineering and Sciences. (IRJGES)
ISSN : 2456-172X | Vol. 4, No. 2, June-Aug 2019 Pages 107-119
| Cosmos Impact Factor (Germany): 5.195
Received: 02.08.2019 Published:28.08.2019

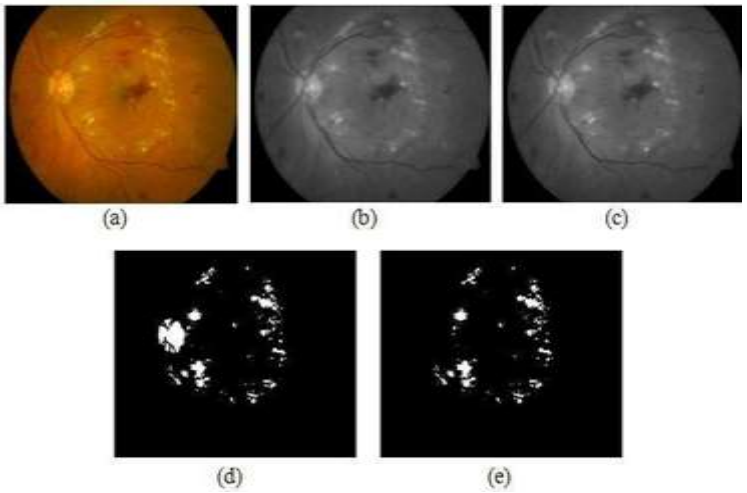


Fig. 4 Detection of exudates (a) Original image
(b) Median filtering (c) Background image (d) Exudates and optic disk (e) Exudates image .

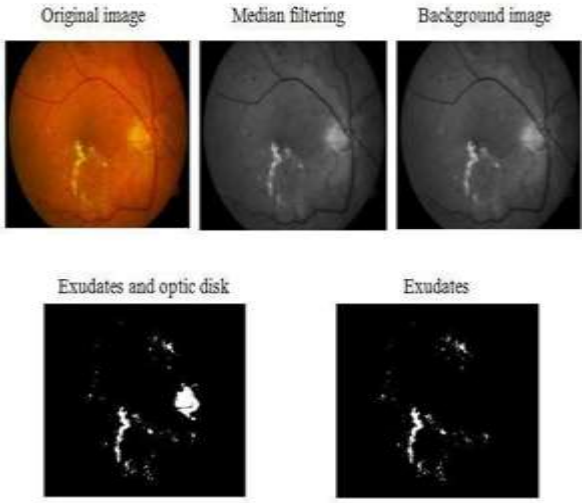


Fig. 5 Detection of exudates (a) Original image
(b) Median filtering (c) Background image (d) Exudates and optic disk (e) Exudates image .
The microaneurysms segmentation results for sample images of DIARETDB1 and MESSIDOR databases are shown in Fig. 6 and Fig. 7.

International Research Journal in Global Engineering and Sciences. (IRJGES)
ISSN : 2456-172X | Vol. 4, No. 2, June-Aug 2019 Pages 107-119
| Cosmos Impact Factor (Germany): 5.195
Received: 02.08.2019 Published:28.08.2019

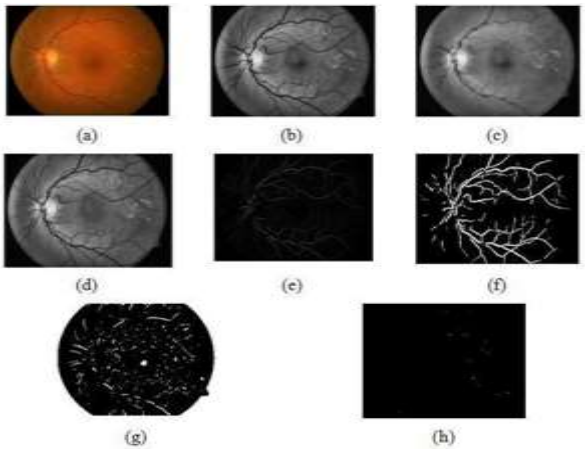


Fig. 6 Segmentation of Microaneurysms (a) Original image (b) Adaptive histogram Equalization (c) Closing (d) Filling (e) Difference image (f) Binarized image (g) Extended minima transform (h) Microaneurysm image.

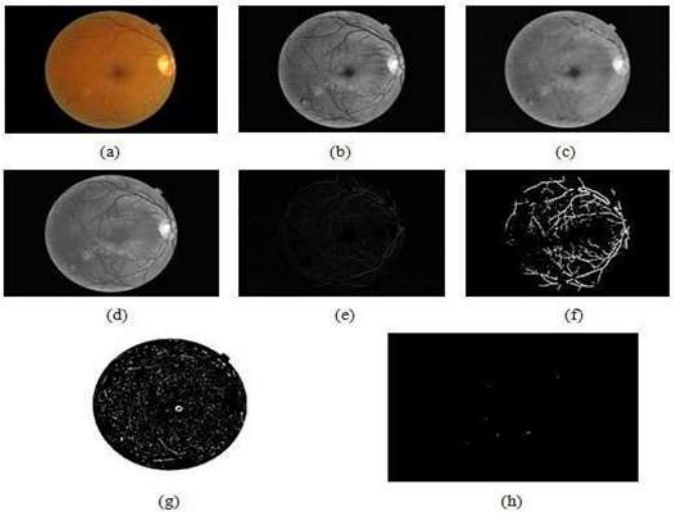


Fig. 7 Segmentation of Microaneurysms (a) Original image (b) Adaptive histogram Equalization (c) Closing (d) Filling (e) Difference image (f) Binarized image (g) Extended minima transform (h) Microaneurysm image.

From the segmented images of these retinal structures, the area of blood vessels, exudates and MA are calculated by finding the total number of blood vessels, exudates and MA respectively. The textural features such as contrast, homogeneity, correlation and energy are also calculated from the GLCM. All these 7 features together form a feature vector of an image.

The features of 25 normal images and 25 DR images are given for training the SVM classifier. For testing, the features extracted from 75 normal images and 75 DR images are fed to the SVM. The analysis is done with different combinations of features as input to the classifier. and its graphical representation is shown in Fig. 8. The details about the classification results with all the features are tabulated in Table 2.From Table 2, it is observed that 90% classification accuracy has been obtained for normal images whereas the DR images

International Research Journal in Global Engineering and Sciences. (IRJGES)
ISSN : 2456-172X | Vol. 4, No. 2, June-Aug 2019 Pages 107-119
| Cosmos Impact Factor (Germany): 5.195
Received: 02.08.2019 Published:28.08.2019

gave an accuracy of 86%, giving 88% average accuracy. Thus the abnormality detection is done with higher accuracy.

Classes	No.of Training Images	No.of Correctly Classified Images	Classificatio n Accuracy (%)
NORMAL	60	54	90
DR	60	52	95
AVG Accuracy	60	53	93

V CONCLUSION

Prolonged diabetes leads to DR, where the retina is damaged due to fluid leaking from the blood vessels.Usually,the stage of DR is judged based on blood vessels, exudes, hemorrhages, micro aneurysms and texture. In this paper, we have discussed different methods for features extraction and automatic DR stage detection.

In this work, the SVM classifier is trained through supervised learning for the features extracted to classify the retinal images. The retinal images used in this work are obtained from the publicly available DRIVE, DIARETDB1 and MESSIDOR databases. There are two modules in this work, one that performs image segmentation which includes the segmentation of vessels, exudates and MA and other one that performs classification using SVM. The average classification accuracy obtained is 93%. The developed system will provide a second opinion to the ophthalmologist to do accurate diagnosis.

REFERENCES

[1] VijayaKumari V, SuriyaNarayanan N (2010),"**Diabetic Retinopathy-Early Detection Using Image Processing Techniques",** International Journal on Computer Science and Engineering 2(2): 357-361.
[2] Berrichi Fatima Zohra, Benyettou Mohamed (2009) **Automated diagnosis of retinal images using the Support Vector Machine (SVM)**. Faculte des Science.Department of Informatique, USTO.
[3] Neera Singh, Ramesh Chandra Tripathi (2010),"**Automated Early Detection of Diabetic Retinopathy Using Image Analysis Techniques",** International Journal of Computer

International Research Journal in Global Engineering and Sciences. (IRJGES)
ISSN : 2456-172X | Vol. 4, No. 2, June-Aug 2019 Pages 107-119
| Cosmos Impact Factor (Germany): 5.195
Received: 02.08.2019 Published:28.08.2019

Applications 8(2): 18-23.
[4] JebaraniSargunar PN, Sukanesh R (2009),"**Exudates Detection and Classification in Diabetic Retinopathy Images by Texture Segmentation Methods",** International Journal of Recent Trends in Engineering 2(4): 148-150.
[5] Jonathan Goh, Lilian Tang, George Saleh, Lutfiah Al turk, Yu Fu, Antony Browne (2009) "**Filtering Normal Retinal Images for Diabetic Retinopathy Screening Using Multiple Classifiers",** International Conference on Information Technology and Applications in Biomedicine 1-4.
[6] DRIVE Database,:http://www.isi.uu.nl/Researc h/Database/DRIVE
[7] DIARETDB1 Database, http://www2.it.lut.fi/project/imageret/diaretdb1/
[8] MESSIDOR Database, http://messidor.crihan.fr/download.php
[9] Selvathi D, NeethiBalagopal (2012),"**Detection of Retinal Blood Vessels using Curvelet Transform",** IEEE International Conference on devices, Circuits and Systems 325-329. doi: 10.1109/ICDCSyst.2012.6188730
[10] Pierre Soille (2002) ,"**Morphological Image Analysis"**, Principles and Applications. 2nd Edition. Springer