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ARTICLE

AN APPROACH FOR IRIS SEGMENTATION AND MACULOPATHY DETECTION AND GRADING OF DIABETIC RETINAL IMAGES

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ABSTRACT

Diabetic macular edema (DME) is a common vision threatening complication of diabetic retinopathy which can be assessed by detecting exudates (a type of bright lesion) in fundus images. Diabetic maculopathy is the major cause of irreversible vision loss due to retinopathy and is found in 10% of the world diabetic population (L. Giancardo-2011). Compulsory mass screening will help to identify the maculopathy at early stage and reduce the risk of severe vision loss. Retinal Image Analysis is a key element in detecting retinopathies in patients. It assists in the automatic detection of pathologies such as diabetic retinopathy (DR), macular degeneration, and glaucoma. Optic Disc (OD), macula and retinal vasculature are all important anatomical structures in the retina (Anantha Vidya Sagar-2007). Diabetic retinopathy is one of the retina problemsin which a diabetic patient suffers from serious vision loss due to the affected macula region of retina. It affects the vision of the person and causes blindness in most severe cases. In this paper, proposing an automatic system for the iris recognition and grading of diabetic maculopathy that will assist the ophthalmologists in detection of the disease. The proposed work first segments the iris if an image andextracts the macula from digital retinal image using the vascular structure and optic disc location. It creates a binary map for possible exudate regions using filter banks and formulates a detailed feature vector for all regions (Anam Tariq-2013). Iris Recognition is one of the most powerful biometrically based technologies for human identification and verification that utilizes the iris patterns which exhibits uniqueness for every individual. In this manuscript, a new algorithm is proposed for iris recognition on distant images. The novelty of this algorithm includes recognition through iris patterns based on both the left and right eye of an individual so as to improve the recognition accuracy and computational efficiency. In this work, iris of retina image is segmented and from fundus retinal images, exudates are detected and classified as soft and hard exudates for grading of maculopathy.

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KEY WORDS
Maculopathy, Fundus images, Retinopathy, Iris recognition, Diabetic macular edema

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INTRODUCTION

Person identification based on iris is becoming a very useful tool rapidly as compared to other biometric security techniques due to its standard epigenetic pattern remains stable. The past development in the field of digital image processing makes it very economical and automated for digital iris images. The classification of spatial iris patterns helps to recognize the individual effectively. The cornea and the eyelid act as a shield for the iris and protect it from adverse environmental effects. These in all inherent properties make iris recognition as the most suitable security solution. The first automated iris recognition concept was given by Flom and Safir in the year 1987 based on the reason that varying the brightness to force pupil to a predetermined size to overcome with the problem of contraction and expansion of pupil. But the image capturing conditions they addressed were not that practical. Then the most widely used methodology was developed by Daugman has used multi-scale quadrature wavelets to extract texture phase features of the iris to generate iris templates and compared the difference between a pair of those by computing their Hamming distance (HD).

The major disease all over the people is diabetes in which the lack of insulin in human body causes high blood sugar in human beings. Long-term diabetes also affects the human retina resulting in a condition known as diabetic retinopathy (DR). This problem damages the retinal blood vessels leading them to leak which finally leads to blindness. DR of any stage develops in nearly all of the patientshavingdiabetesoftype1andabout60%ofthepatients with diabetes of type 2. The percentage of diabetes patients is high in almost every region of the world especially in industrialized countries which makes a high chance of DR sufferers. There are many stages of DR such as no proliferative DR (NPDR), proliferative DR (PDR) and maculopathy or macular edema (ME). NPDR is known as background DR, whereas PDR and ME are the advance stages of DR.Diabetic patient can have different signs of retinopathy such as micro aneurysms, hard exudates, hemorrhage and cotton wool spots (CWS) at different stages of DR. Micro aneurysms are weak dark red spots developed on blood vessels that bulge outward. They are the first detectable change in there tin a due to diabetic retinopathy. In this proposed method, iris segmentation, normalized and noise pattern extraction, exudates detection and classification are performed which will assist ophthalmologist for diagnosis of retinal diseases.

PROPOSED WORK

Iris recognition system

The proposed iris recognition system involves below steps:

1. Pre-processing.
2. Normalized pattern extraction.
3. Noise pattern extraction.

4. Iris segmentation.

Maculopathy detection system

The proposed Maculopathy detection Algorithm involves the following steps:

1. Pre-Processing.
2. Green channel extraction, Contrast enhancement.
3. Segmentation.
4. Optic disk elimination.
5. Retina regions detection.
6. Exudates detection.
7. Exudate classification.
8. Grading.

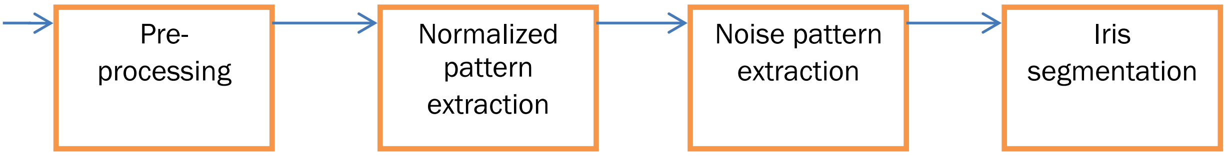

Fig. 1: Block diagram of iris segmentation

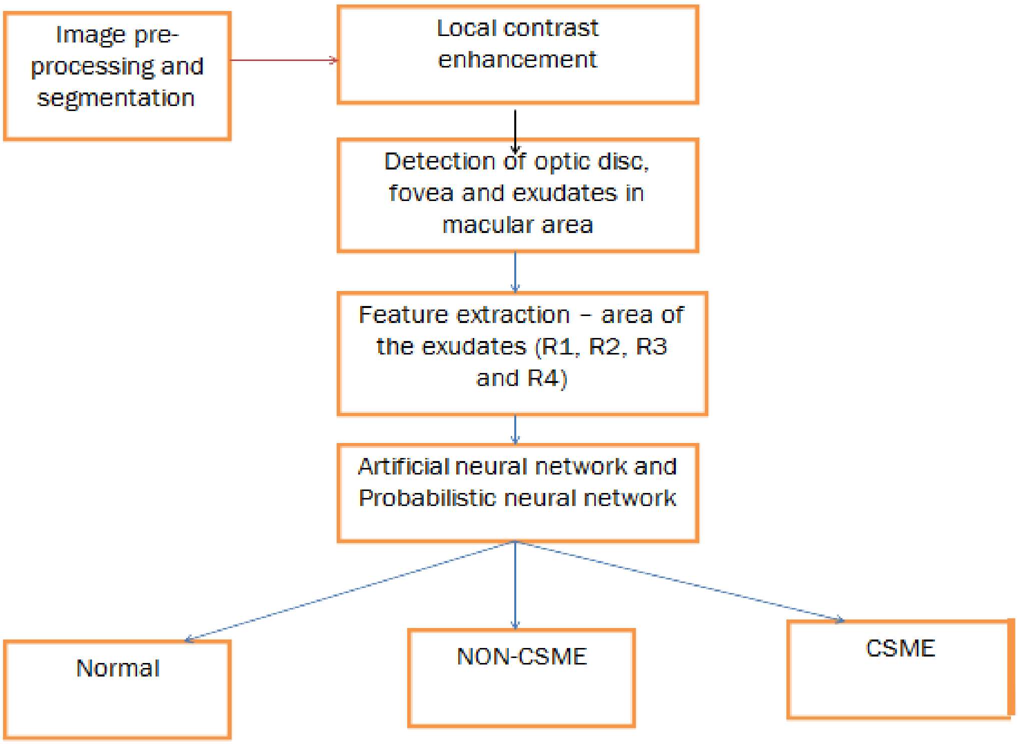

Fig. 2: Block diagram of maculopathy detection

METHODS

Iris Segmentation

The Hough transform is a computer vision algorithm that can be used to find the parameters of simple geometric objects, such as lines and circles, present in an image. The circular Hough transform can be used to deduce the radius of the pupil and iris regions and center coordinates of the pupil and iris regions. An automatic segmentation algorithm based on the circular Hough transform is employed by Wildes. Initially, an edge map is generated by calculating the first derivatives of intensity values in an eye image and then threshold the result. From the edge map, votes are cast in Hough space for the parameters of circles passing through each edge point. These parameters obtained are the Centre coordinates X c and Y c, and theradius r, which are able to define any circle according to the equation. A maximum point in the Hough space will correspond to the radius and Centre coordinates of the circle best defined by the edge points. Wildes et al. and Kong and Zhang also make use of the parabolic Hough transform to detect the eyelids, approximating

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the upper and lower eyelids with parabolic arcs, which are represented as to performing the preceding edge detection step, Wildes et al. bias the derivatives in the horizontal direction for detecting the eyelids, and in the vertical direction for detecting the outer circular boundary of the iris. The motivation for this is that the eyelids are usually horizontally aligned, and also the eyelid edge map will corrupt the circular iris boundary edge map if using all gradient data. Taking only the vertical gradients for locating the iris boundary will reduce influence of the eyelids when performing circular Hough transform, and not all of the edge pixels defining the circle are required for successful localization. Not only does this make circle localization more accurate, it also makes it more efficient, since there are less edge points to cast votes in the Hough space.

Segment iris

Performs automatic segmentation of the iris region from an eye image. Also isolates noise areas such as occluding eyelids and eyelashes.

Find circle

Returns the coordinates of a circle in an image using the Hough transform and Canny edge detection to create the edge map.

Linecoords

Returns the x y coordinates of positions along a line.

Find line

Returns the coordinates of a line in an image using the linear Hough transform and Canny edge detection to create the edge map.

Hough circle

Takes an edge map image, and performs the Hough transform for finding circles in the image.

Add circle

A circle generator for adding (drawing) weights into a Hough accumulator array. NONMAXUP - Function for performing non-maxima suppression on an image using an orientation image. It is assumed that the orientation image gives feature normal orientation angles in degrees (0-180).

Ajdgamma

Adjust image gamma. Image gamma value in the range 0-1 enhance contrast of bright regions, values > 1 enhance contrast in dark regions. HYSTHRESH - Function performs hysteresis threshold of an image. CANNY - Function to perform canny edge detection.

Fig. 3: Original input image

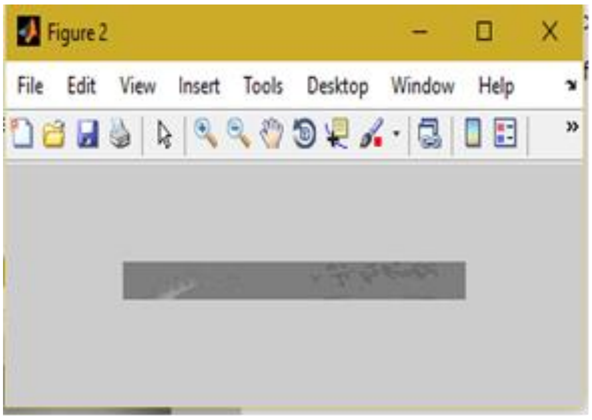

Fig. 4: Normalized Pattern

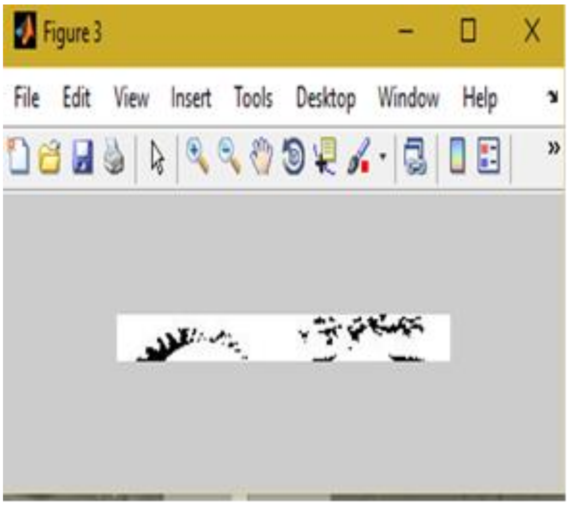

Fig. 5: Noise pattern

Fig. 6: Segmented Iris

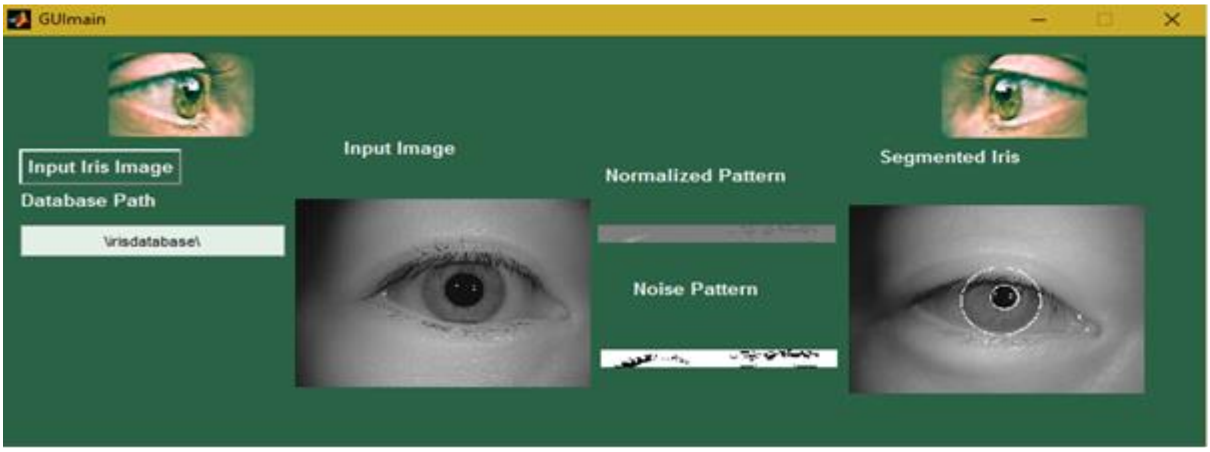

Fig. 7: Iris Segmentation GUI

Maculopathy detection

Image pre-processing

There is dissimilarity in the colour of the fundus images of different patients. This dissimilarity is strongly related to the person's skin pigmentation and iris colour. Other reasons like intrinsic attribute of lesions, decreasing colour dispersion at the lesion periphery and lighting disparity, etc. This may result colour of the lesion of some images to be lighter than the background colour. Under these conditions, there is every possibility that these lesions may erroneously be classified as background colour. Therefore, colour normalization is necessary to be performed.

Pre-processing consists of the following steps

1. The RGB image is converted to a green channel or grayscale image.
2. Adjust the intensity values in the image, using 'imadjust' function.

Below Figures shows (a) the original image (b) the Green channel image after intensity values adjustment.

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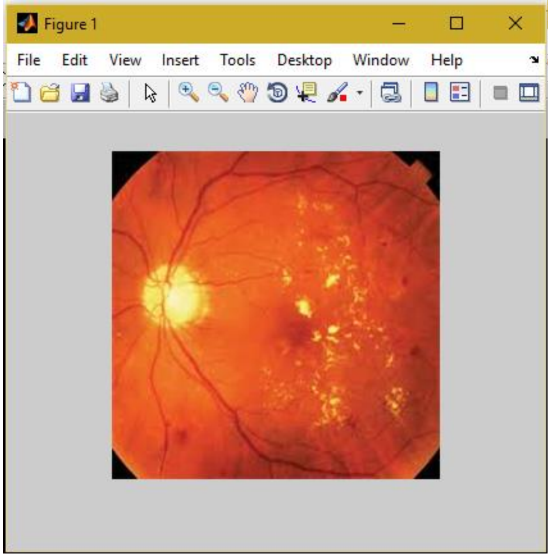


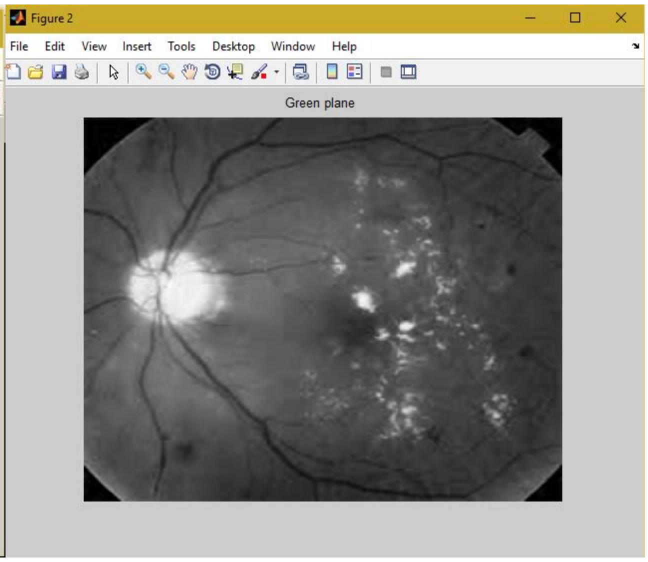


Fig. 8: Original image **Fig. 9:** Adjusted Green plane image

Image segmentation

Exudate detection

The exudate identification is done by assigning a score for each exudate candidate. The exudate candidates are selected by running an 8-neighbour connected component analysis. This is implemented in two ways to assign this score, one based on Kirsch's Edges and the other based on Stationary Wavelets. Both methods seek to take advantage of the higher inner and outer edge values of exudates in comparison to non-exudate structures.

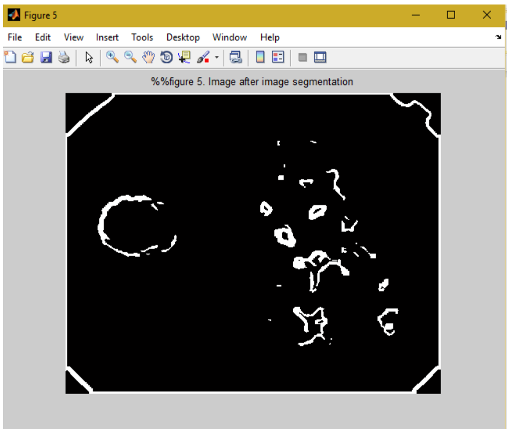
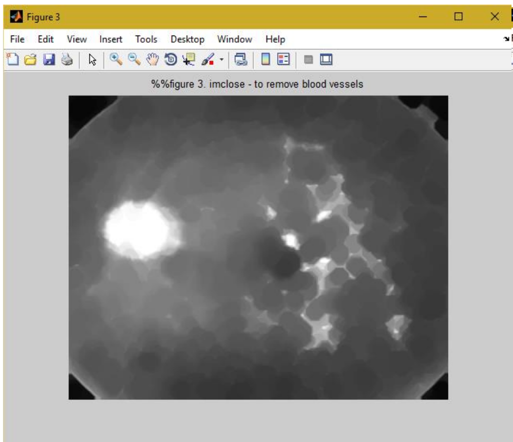


Fig.10: Image after Segmentation

Detection of optic disc

In the proposed work there is a need of removing optic disk from eye image to get good results. The optic disc is the exist point of retinal nerve fibers from the eye and the entrance and exist point for the retinal blood vessels. It seems to be similar intensity, colour and contrast to other features on the retinal image. While blood vessels of the retina also appear with very high contrast as the optic disc, the second channel of the input image with morphological erosionoperator on the intensity channelwill help to eliminate the blood vessels which may remain in the optic disc region. An octagonal structuring element with a fixed radius of fifteen (SE - morphological structuring element) was used.



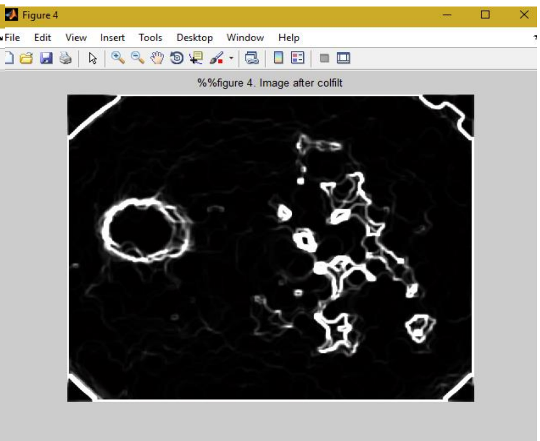
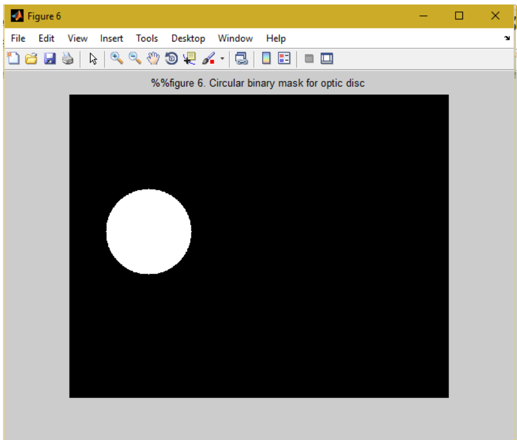


Fig. 11: Image after blood vessel removal **Fig 12:** Image after morphological filtering



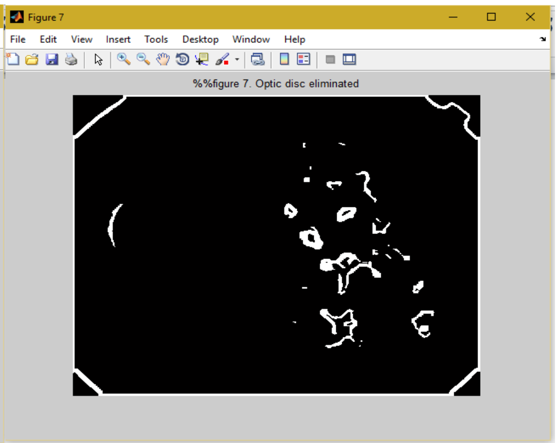


Fig. 13: Circular mask on optic disk **Fig. 14:** Optic Disk eliminated image

Detection of fovea

Here is the concept of detecting Fovea in input image. Fovea is close to the Centre of the macula which responsible for our central, sharpest vision. The Centre of the fovea is normally located at a distance of nearly 2.5 times the diameter of the optic disc of retina image, from the Centre of the optic disc.It is the very darkest part of the retina images which some images are not obvious to human eyes due to very high lighting or being covered by lesions.

After detecting the optic disc, the macula region can be determined by setting an area of restriction in the vicinity of the image Centre, as determined by the optic disc Centre. Two circle binary masks from the Centre of the optic disc are draw and the restriction area is set as 478x216 pixels to identify as the macula region. Once the macula region is identified, the location of the minimum of this region was taken as the Centre of the fovea. Below Figure shows the detection of fovea.

Detection of exudates

Retinal exudates are very bright patterns in colour fundus images and they are well contrasted with respect to the background.The shape and size of the exudates vary considerably and their borders are mostly irregularduring the progress of the disease. There are other features such as optic disc and blood vessels in the images that cause difficulty to detect exudates. They have high level variation and brightness patterns as compare to the exudates.Morphological image processing techniques are used for detection of exudates. Dilation and erosion are the two fundamental morphological operations. Closing and opening are applied extensively for detecting the exudates. The algorithm developed uses a morphological operation to smooth the background, allowing exudates to be seen clearly. Two types of structuring elements (SE) are used. They

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are octagon SE used to remove the vessels from the image and disk-shaped SE used to identify the exudates.

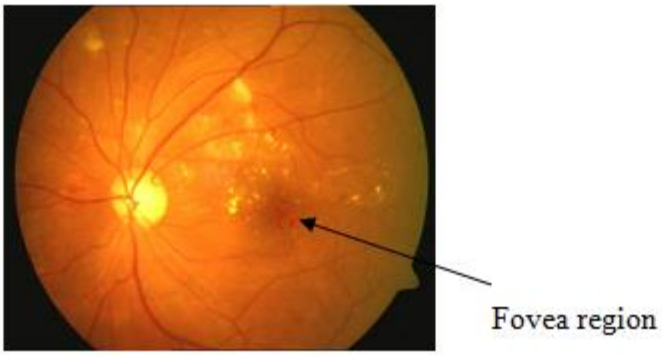
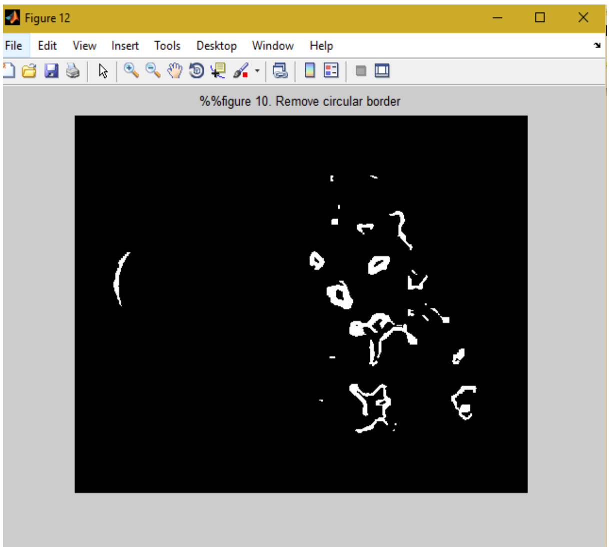


Fig. 15: Detection of Fovea Region



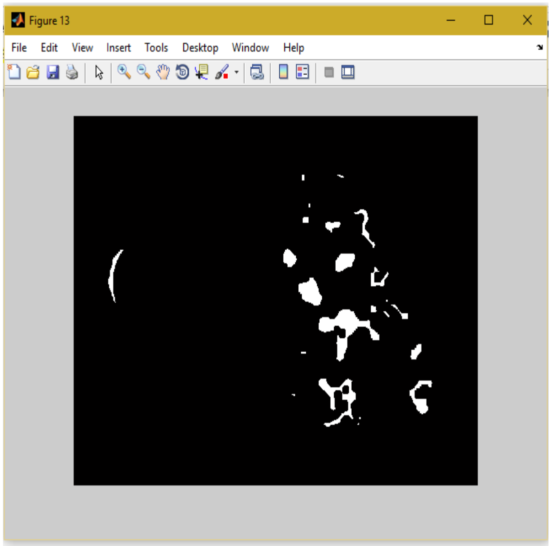


Fig. 16 : Circular boarder removal

Fig. 17 : Exudates image

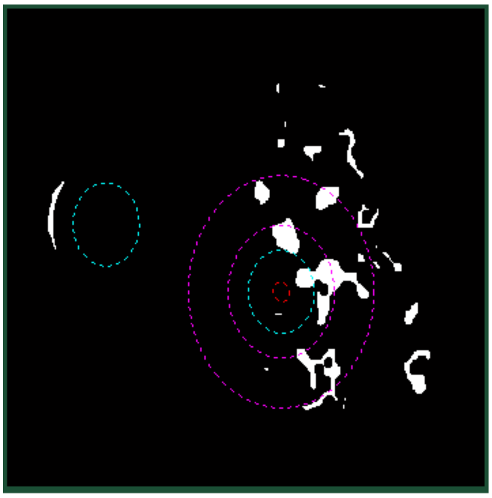


Fig. 18 : Exudates in macula region

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Detection of exudates

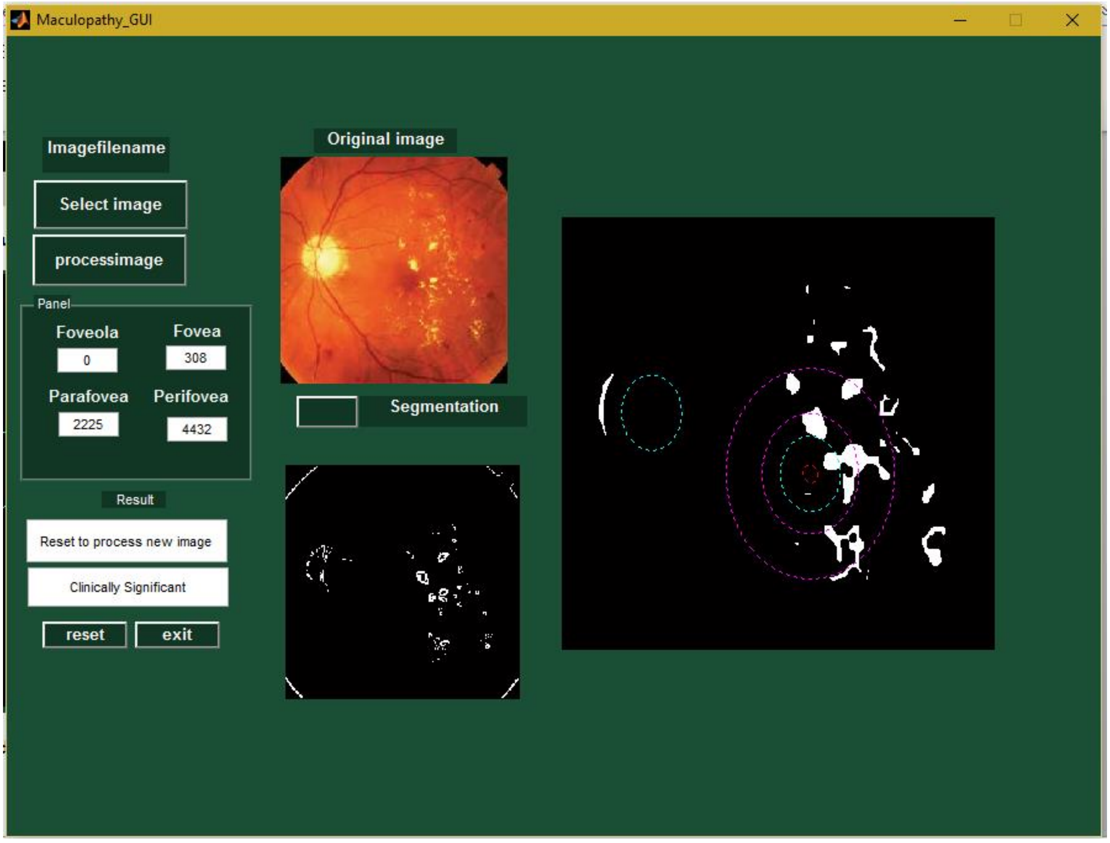

Fig. 19: Maculopathy detection GUI

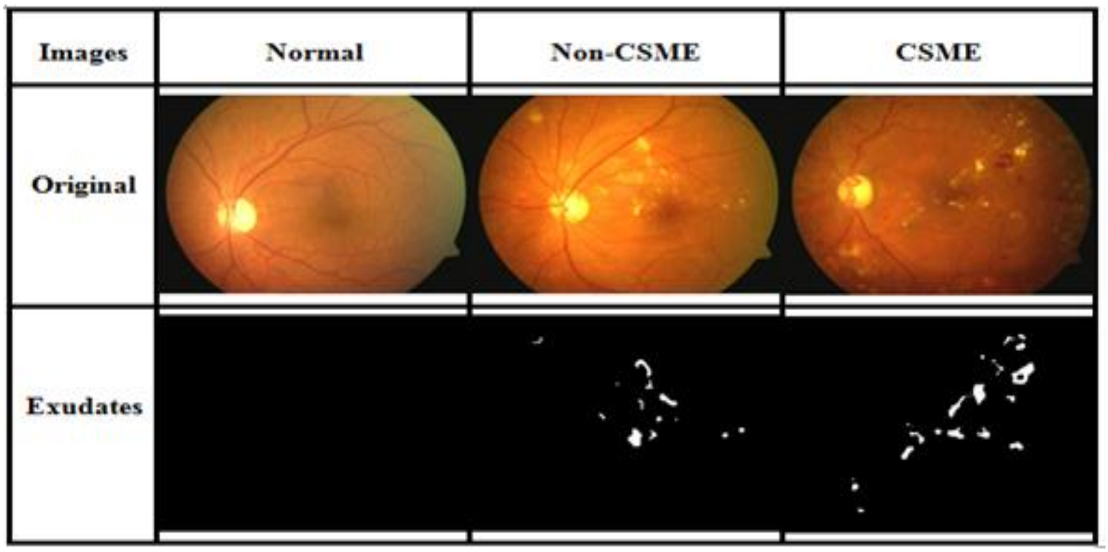

Fig. 20: Original images and Exudates results for the three classes

RESULTS

For the proposed work a data base of 50 samples is used for training and testing the classifiers. These samples are divided into 90% training and 10% for testing. The performance measures such as sensitivity, specificity and positive predictive accuracy are used to evaluate the performance of the systems. The terms used to measure the test performance are as follow:

(TP)- True positive: abnormal subjects with positive test results and are correctly diagnosed.
(TN)- True negative: normal subjects with negative results and are diagnosed correctly.

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(FP)- False positive: normal subjects with negative test results and diagnosed wrongly as abnormal subjects.
(FN)- False negative: abnormal subjects with positive results and diagnosed wrongly as normal subjects.
The sensitivity, specificity and positive predictive accuracy are computed as below.
Sensitivity = TP / (TP + FN)
Specificity = TN / (TN + FP)
PPA = TP / (TP + FP)

CONCLUSION

Diabetic maculopathy (DM) is caused from the prolonged diabetes retinopathy and is a leading cause of blindness. It happens whenthe retinal blood vessels are get damaged and the exudates leakage area increases, deposit very close to the fovea. Hence, an automatic system for identification of normal, Non-CSME and CSME fundus eye image is proposed. For the proposed work iris segmentation and normalized pattern, noise pattern extraction gives more clear information about the iris area and pupil area. Firstly, Iris segmentation is done andthen maculopathy detection is performed. The features from the raw images are extracted using image processing techniques, and fed into the feed-forwardneural network and probabilistic neural network classifiers for classification. We have concluded that feed-forward neural network classifier perform better than probabilistic neural network classifier with an accuracy of more than 96% of correct classification, sensitivity of more than 96% and specificity of 100%. The accuracy of the system can further be improved using proper input features such as microaneurysms and Hemorrhages, and the size of the training data.

CONFLICT OF INTEREST
The authors declare no conflict of interest

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None

FINANCIAL DISCLOSURE
None

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