TEST Engineering & Management

May – June 2020
ISSN: 0193-4120 Page No. 993 - 997

A Complete Automated Diagnostic Tool for Non-Proliferative Diabetic Retinopathy

S.Sudha, *A.Srinivasan and T.Gayathri Devi
Department of ECE, Srinivasa Ramanujan Centre,
SASTRA Deemed University, Kumbakonam
mcvsudha@src.sastra.edu, srinivasan.a@src.sastra.edu, devigayathri77@src.sastra.edu
***Corresponding Author**

Article Info
Volume 83
Page Number: 993 - 997
Publication Issue:
May - June 2020

Article History
***Article Received**: 11August 2019*
***Revised**: 18November 2019*
***Accepted**: 23January 2020*
***Publication**: 10 May2020*

Abstract:

High blood sugar creates diabetes- related diseases. From nutriment, we get glucose, and insulin the hormone helps to take glucose into cells. If there are problems with insulin ,blood sugar levels will increase. It will cause eye disease, such as Diabetic Retinopathy (DR). In this automated system, fundus image is filtered using median filtering to remove noise, then it is enhanced by the contrast enhancement technique. Pre-processing is preferred to increase image fineness. It is followed by k-means image segmentation to detect non-proliferative stage lesions such as Microaneurysms (Ma), Haemorrhages (He) & Exudates (Ex). Four major distinguishable features are extracted. It uses a Probabilistic Neural network classifier (PNN) for classification, and it detects the severeness of the eye disease. The result showed PNN classifier performed well for the detection, and classification of Microaneurysms (Ma), Haemorrhages and Exudates and got a high percentage of accuracy.

***Keywords:** Image processing, Diabetic Retinopathy, Microaneurysms, Haemorrhages, Exudates, K-means segmentation, Probabilistic Neural network classifier.*

I. INTRODUCTION

When the sugar level is raised, and out of control, it will block the flow of blood through the blood vessels, and eventually, swelling appears in the nerve fibers of the retina. Because of swelling due to blood blockage, blindness will occur. At the initial stage, blood leakage introduces tiny blood spots, which are the microaneurysms in DR. Hemorrhage is introduced by damage in the retinal blood vessels, and there is substantial leakage in the blood vessels. If it progresses, complete vision loss will occur. Initially, blood capillaries in the retina which are abnormal leaks fluid and it is formed as a ring near the macula and later form the patch like yellow structure called exudates. At the advanced stage, a large number of new fragile blood vessels will appear, which are also the abnormal signs in diabetic retinopathy.

As most of the people not finding time to go for medical check-up, this proposed system will help the people to go for self checking and periodic checking is possible with this automated system. Dilating the eyes is not necessary in this proposed system. Diabetic retinopathy not only affect single eye but affect both of the eyes. In case of serious risk factors, patients can go to hospital for taking further advice and treatments. More blood leakage in the retina causes hemorrhages to be developed and eventually patients may have the feel of floaters in the eye vision.

II. RELATED WORKS

Adaptive filter & Biogeography Based Optimization Algorithm is used [1] for the identification, and classification of microaneurysms, hemorrhages, hard exudates, soft exudates and neovascularisation. The proposed system achieved 98.52% accuracy. To reduce workload and provide a decision support system [2], authors reviewed various studies for exudates detection in the early stage of Diabetic Retinopathy.In [3], blood vessels, microaneurysms ,and hard exudates are isolated. Features are extracted, and the support vector machine was used to find out the retinopathy grade. The authors have taken 400 retinal images and obtained a sensitivity of 95% and a detective accuracy of 94%.

In this method, [4] Gabor filter was used for lesion enhancement and segmentation of lesions was done by morphological segmentation. Four different classifiers were used for classification and achieved 98.58% accuracy. The proposed technique [5] used Gaussian matched filter for the detection of initial lesions such as microaneurysms and tree ensemble classifier was trained with 70 features and the mean squared error was evaluated to be 0.0124. In the proposed method [6] Morlet wavelet and the novel vessel segmentation algorithm was applied to detect microaneurysms and got an accuracy of 95% and a sensitivity of 75% & specificity 97%.

A blood vessel segmentation algorithm [7] consists of three stages was proposed. Pre-processing uses histogram equalization and median filter techniques. Mean-C thresholding is used for the segmentation of blood vessels. Further, the morphological closing operation was performed to remove not connected pixels. The results showed that this method achieved 95.5% accuracy. The effective k-means color compression technique was used [8] to find exudates and hemorrhages in fundus images and classified by the fuzzy logic classifier. The performance measure (accuracy) of the detector is increased to 92.3%

Data mining technique [9], such as the decision tree classifier, was used to classify the normal and DR images. For segmenting the retinal blood vessels [10], authors proposed classifiers such as Convolutional Neural Network (CNN) and Random Forest (RF). It is superior to detect features that belong to the retinal images and for the prediction of patterns. In [11], Multiscale Gaussian matched filters were introduced to suppress the noises. This proposed method can determine the accurate filter parameter values for retinal vessel segmentation.

In [12], Mathematical morphology and K-means clustering approach for blood vessel segmentation are proposed. It has got an average accuracy of 95.10%. In [13], authors reviewed the various algorithms used for identifying diabetic retinopathy, and they have compared the results based on multiple metrics. The accuracy of classification was improved [14] by novel hybrid classifier such as m-Mediods modeling combined with Gaussian Mixture Model. Blood vessels and optic disk are eliminated by Gabor wavelet and multilayered thresholding. The authors [15] presented two approaches for microaneurysms detection. A set of pre-processing methods and ensemble methods were described and organized. An approach based on adaptive weighting approach ensembles were also described for microaneurysms detection.

III .PROPOSED METHODOLOGY

In the automated system, the fundus image is improvised using median filtering and then segmented using k-means segmentation. There are 13 features extracted from the resultant image. An extracted feature set is used for training the probabilistic neural network classifier to classify either normal or DR image and to classify lesions either microaneurysms, hemorrhages or exudates. The proposed approach is shown in Fig. 1.

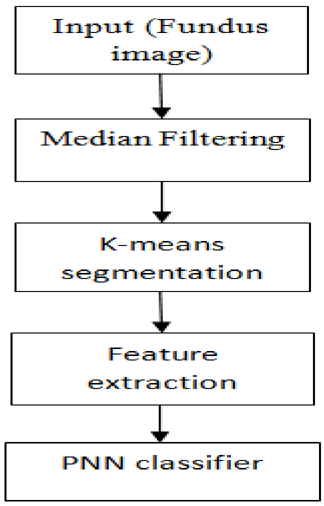


Fig.1.The Proposed method

A. Pre-processing

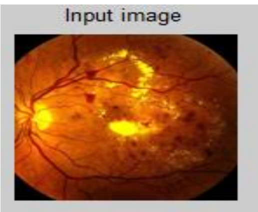
Median filtering not only removing noises but also preserves the critical information in the image. The fundus image and filtered image is shown in Fig. 2 & 3. The steps involved in filtering the image are given below. Fundus image is resized, and filtering must be involved from starting pixel element to last pixel element.

Step 1: A block of 3 × 3 is traversed along the entire part of the image.

Step 2: Arrange the pixels within this block in ascending order and compute the median values

Step 3: Replacing each value of the pixel by the median value calculated from its neighboring elements.

May – June 2020
ISSN: 0193-4120 Page No. 993 - 997



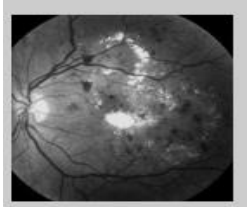


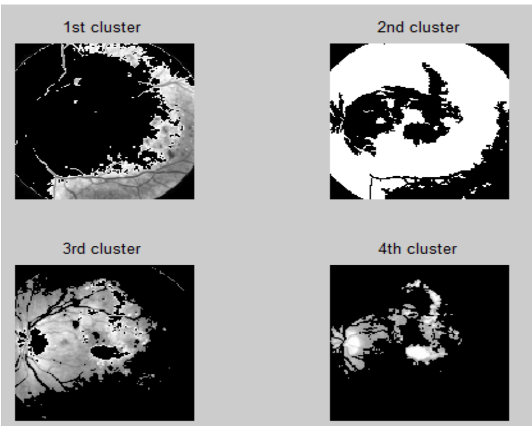
Figure **Fig.2. Fundus image**

Fig. 3. Image after filtering

B. Segmentation

After this pre-processing step, fundus image is segmented using k means segmentation. Input for the segmentation algorithm is the pre-processed fundus image. In this segmentation, clusters are formed in each step based on the distance. The lesion or affected portion may have pixel similarities than that of the unaffected portion. So the early stage lesions, either microaneurysms, hemorrhages or exudates will come under one cluster and the normal part form another set of clusters. The process, such as fixing centroid for clusters, will be repeated in each iteration until there is no change in clusters and its centroid. It is shown in Fig. 4. The steps are:

- Assign the number of clusters
- Find the centroid of each cluster
- Compute the distance between the neighbor pixel and centroid pixel.
- Grouping is formed based on the distance calculation.
- Repeat steps 2-4 with the new value of centroid.
- Stop if there are no more pixels to create a group or otherwise no change in the value of the centroids.



4.Output of K-means segmentation.

C. Feature Extraction

For training and testing classifier, features are taken out from the segmented image. In this proposed method, novel hybrid features are used to increase the accuracy of PNN classification. The hybrid features are 1.colour features, 2. statistical features, 3. Texture features, and 4. Shape features. Totally thirteen features are extracted. The 13 features are 1.Mean, 2. Standard deviation, 3. Energy, 4. Homogeneity, 5. Contrast, 6. Correlation 7. Area, 8.Perimeter 9.Eccentricity, 10.Major axis length, 11. Minor axis length, 12. Solidity & 13. Gray level dependency matrix (GLDM).

D.Classification of lesions using PNN classifier

We have taken 800 fundus images for training the PNN classifier, and 400 fundus images are tested. The schematic diagram of PNN classifier is shown in Fig. 5. There are 13 feature inputs for classifying the four categories of fundus input image 1. Microaneurysms 2. Hemorrhage 3. Exudates 4. Normal fundus image.

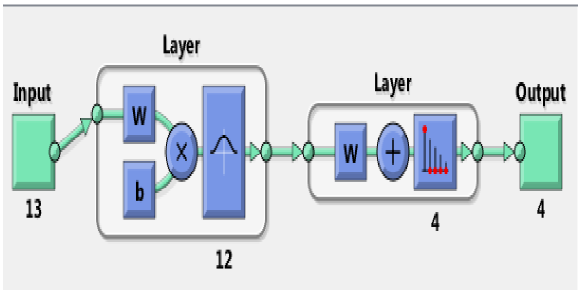
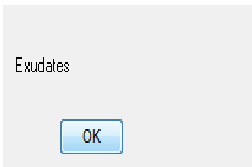


Fig.5. Schematic diagram of proposed PNN classifier

The PNN classifier will assign input fundus image into the normal class or abnormal class such as image with Microaneursyms, Hemorrhages &Exudates. Detection of the disease and severity level is shown in Fig. 6 & Fig. 7 respectively.



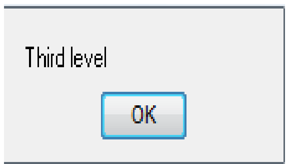


Fig. 6.Classifier output Fig. 7.Severity of the disease

IV. RESULTS AND DISCUSSION

May – June 2020
ISSN: 0193-4120 Page No. 993 - 997

The proposed system is aimed at detection of microaneurysms, hemorrhages & exudates in non-dilated fundus images. The images are taken from diabetic retinopathy patients from various hospitals. The outputs for different input fundus images are shown in Fig. 8. Sensitivity and specificity values are calculated using the following equations.

Sensitivity = True positive/ (True positive + False negative) (1)

Specificity=True negative/(True negative+ False positive) (2)

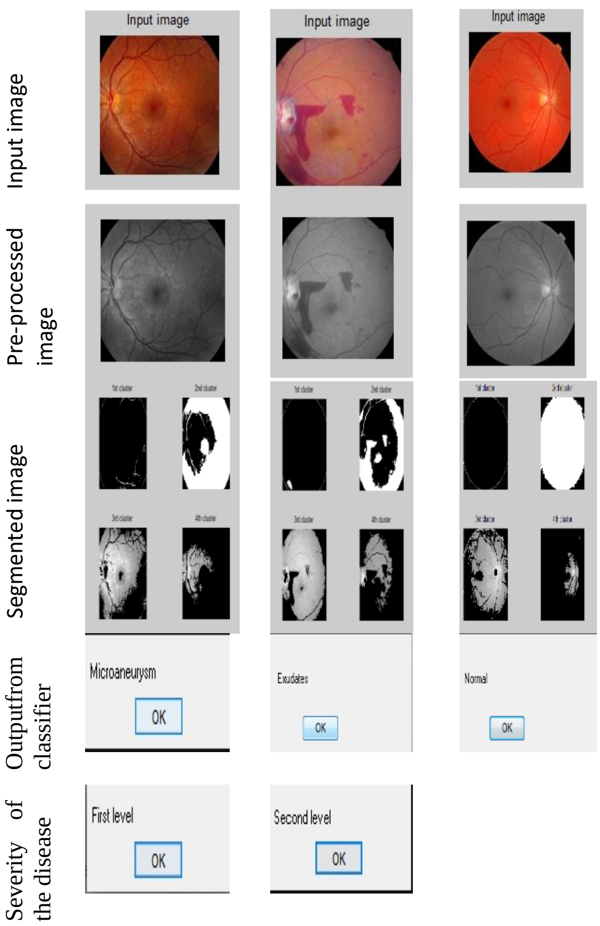


Fig. 8. Outputs for various input fundus images.

Classification accuracy for the total number of input fundus image is shown in Table I & the probabilistic neural network classifier (PNN) accuracy for training and testing stages is shown in Fig. 9. The accuracy of the PNN classifier is calculated by

PNN Classifier accuracy is given by equation (3)

$$\text{Accuracy} = \frac{\textit{Total No of correct test outputs}}{\textit{Total No of test inputs}} \times 100 \qquad (3)$$

TABLE I: CLASSIFICATION ACCURACY OF PNN CLASSIFIER

s.no	Input Images	Training		Testing		*Accuracy (%)*
		No of trained Inputs	*No of correct trained outputs*	*No of test inputs*	*Test o/p*	
1.	Normal	200	200	90	87	96
2.	Microaneurysms	200	200	110	104	94.5
3.	Hemorrhages	200	200	120	118	98.3
4.	Exudates	200	200	80	75	93.7

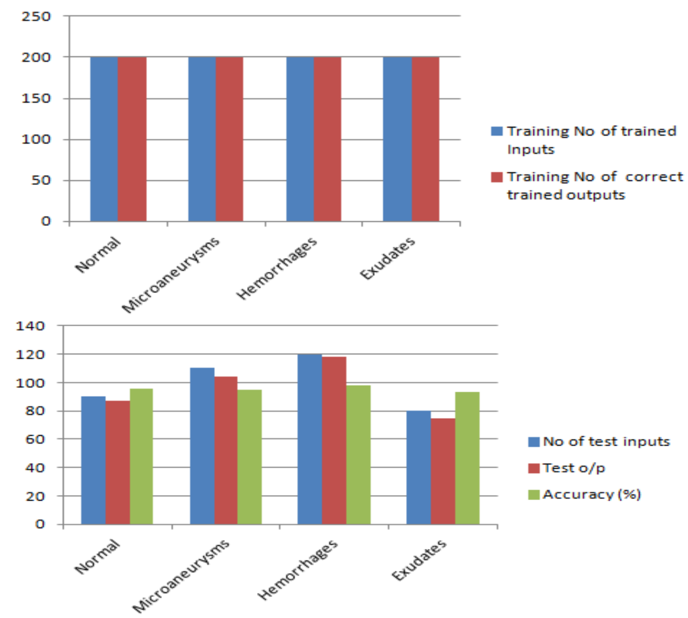


Fig. 9: Classifier accuracy for training and testing stages

The accuracy, specificity ,sensitivity and its average value are shown in Table II. The accuracy of classification is assessed as 96%, and the sensitivity & specificity values are 95.5% & 96.6%, respectively are shown in Fig. 10.

TABLE II: SENSITIVITY & SPECIFICITY VALUES OF PNN CLASSIFIER

May – June 2020
ISSN: 0193-4120 Page No. 993 - 997

Sensitivity values for Diabetic Retinopathy images in (%)				*Specificity (%)*	*Overall accuracy (%)*
Ma	*He*	*Ex*	*Average*		
94.5	98.3	93.7	95.5	96.6	95.6

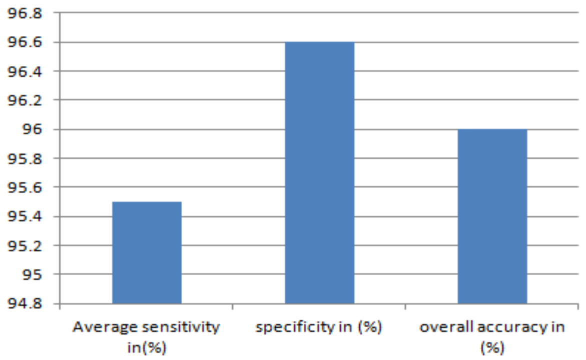


Fig. 10: The sensitivity & specificity of PNN classifier

V. CONCLUSIONS AND FUTURE ENHANCEMENTS

The automated system will detect and identify normal and diabetic retinopathy images. It is common algorithm for detecting all kinds of lesion such as microaneurysms, hemorrhages & exudates. Also, this algorithm will work well for non-dilated fundus images. Here we have taken hybrid features that improve accuracy and reduces false detection rate. The eficiency can be enhanced further by adding features that are scale-invariant, shifting invariant, rotation invariant and low illumination invariant. This will help the Diabetic Retinopathy patients to have self diabetic control and they can go for self eye-screening and further treatments. Neovascular detection can also be included to identify late-stage diabetic retinopathy.

REFERENCES

[1] R. Adalarasan and R. Malathi. Automatic Detection of Blood Vessels in Digital Retinal Images using Soft Computing Technique. Materials Today: Proceedings 5 (2018) 1950–1959
[2] Shilpa Joshi, P.T. Karule. A review on exudates detection methods for diabetic retinopathy. Biomedicine & Pharmacotherapy 97 (2018) 1454–1460.
[3] Enrique V. Carrera, Andr´es Gonz´alez. Automated detection of diabetic retinopathyusing SVM. 978-1-5090-6363-5/17/$31.00 © 2017 IEEE.
[4] Javeria Amin, Muhammad Sharif. A method for the detection and classification of diabetic retinopathyusing structural predictors of bright lesions. Journal of Computational Science 19 (2017) 153–164.
[5] M.M. Habib , R.A. Welikala . Detection of microaneurysms in retinal images using an ensemble classifier. Informatics in Medicine Unlocked 9 (2017) 44–57
[6] Malihe Javidi , Hamid-Reza Pourreza. Vessel segmentation and microaneurysm detection using discriminative dictionary learning and sparse representation. computer methods and programs in biomedicine 139 (2017) 93–108.
[7] Jyotiprava Dash, Nilamani Bhoi. A thresholding based technique to extract retinal blood vessels from fundus images. Future Computing and Informatics Journal 2 (2017) 103-109
[8] Md. Jahiruzzaman, A. B. M. Aowlad Hossain. Detection and Classification of Diabetic Retinopathy Using K-Means Clustering and Fuzzy Logic. 978-1-4673-9930-2/15/$31.00 ©2015 IEEE.
[9] Ketki S. Argade, Kshitija A. Deshmukh. Automatic Detection of Diabetic Retinopathy using Image Processing and Data Mining Techniques. 978-1-4673-7910-6/15/$31.00 ©20 15 IEEE
[10] Shuangling Wang , YilongYin . Hierarchical retinal blood vessel segmentation based on feature and ensemble learning . Neurocomputing 149 (2015) 708–717.
[11] K.S. Sreejini , V.K. Govindan. Improved multiscale matched filter for retina vessel segmentation using PSO algorithm. Egyptian Informatics Journal (2015) 16, 253–260.
[12] Gehad Hassan, Nashwa El-Bendary. Retinal blood vessel segmentation approach based on mathematical morphology. Procedia Computer Science 65 (2015) 612 – 622.
[13] Arslan Ahmad, Atif Bin Mansoor. IMAGE PROCESSING AND CLASSIFICATION IN DIABETIC RETINOPATHY: A REVIEW. EUVIP 2014 978-1-4799-4572-6/14/$31.00 ©2014 IEEE.
[14] M. UsmanAkram a,n, ShehzadKhalid. Detection and classification of retinal lesions for grading of diabetic retinopathy. Computers in Biology and Medicine 45(2014)161–171
[15] Bálint Antal, András Hajdu. Improving microaneurysm detection in color fundus images by using context-aware approaches. Computerized Medical Imaging and Graphics 37 (2013) 403–408.