ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 10, Iss 3, 2021

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Optimised deep learning model for the diagnosis of diabetic retinopathy

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In the medical image analysis, the diagnosis of diabetic retinopathy (DR) from fundus images are identified as an open challenge and requires possible solutions. The major stages of the proposed DR are Pre-processing, Segmentation, Feature Extraction, and Classification. In Pre-processing, the retinal fundus images are RGB images, among them the G-channel is selected. Following that, histogram equalization and contrast limited adaptive histogram equalization (HE and CLAHE) are applied. Then the next stage is removing the optic disc (OD) and it is done by Circle Hough Transform (CHT). Then, the Gray Level thresholding is used for removing the blood vessels. Then the Exudates are segmented by the Modified Expectation Maximization (MEM) algorithm. Then Gray Level Co-occurrence Matrix (GLCM) is used for feature extraction. At last, features are classified by the Deep Neural Network with a Butterfly Optimization Algorithm (DNN- BOA) classifier which is used for classifying the several stages of DR. The proposed scheme is implemented on MATLAB 2021a.

Keywords Diabetic retinopathy (DR) . Butterfly optimization algorithm . Deep neural network (DNN) . Histogram equalization (HE) . Modified expectation maximization (MEM) algorithm . Fundus image

1 Introduction

Diabetic Retinopathy (DR) is one of the main diseases of diabetes that happens by microvas- cular retinal changes and the major problem is vision loss. It is caused by damage to the blood vessels in the light-sensitive tissue and develops at the back of the eye [1]. When DR reaches an advanced stage, vision will be lost completely. In the world, the blindness percentage of DR is about 2.7%. There will be no symptoms until it reaches the severe stage. Hence, the diabetes people require regular retina screening for detecting DR in early stages, managing their progression and avoid the blindness risk [2]. Statistical analysis shows that DR affects people over the age of 18 and it is increasing day by day. The risk factors of DR are divided into Modifiable risk factors like blood pressure, smoking and blood glucose level and non- modifiable risk factors like disease duration, age and genetic predisposition [3-5].

1.1 Motivation

Recently, ophthalmologists test the colour fundus images where micro aneurysms screening and detection are processed manually. It needs trained and practiced physicians for performing detection. In manual detection, due to the huge number of patients with diabetes, DR detection is considered to be heavy, time consuming and improper tasks during the screening of large images [6]. Therefore, automated monitoring system was developed for identifying the lesions. It is reveals that the computerized screening system minimizes the work burden compared to the manual screening and it was determined that the automatic screening is non-

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invasive and low cost process. Over the last two decades, numerous approaches have been developed that combine various methods for DR detection [7-9]. Recently, DL approaches that hybrid multi-level representations have been developed for obtaining remarkable performances in medical imaging analysis [10-12]. Therefore, in this work, DL based model DNN-BOA is proposed to provide the better result in diagnosis of DR.

1.2 Contribution

The contributions of the implemented model are:

- The effective DR detection is developed by feature extraction and optimal classification steps. Here, Pre-processing is carried out by HE and CLAHE filters to remove noise.
- Then the OD removal is done by CHT. After removing the OD, Gray Level thresholding is used for removing blood vessels. The Exudates are segmented by the MEM algorithm.
- Then the GLCM is used for extracting features and finally extracted features are classified by the DNN-BOA classifier.
- The implemented model's performance is compared with the other approaches with some metrics.

2 Related works

Some of the recently introduced techniques in DR using different models are listed below:

Hemanth et al. [13] presented a method that comprises of image processing by HE and CLAHE models. Data conversion was employed to overcome from the fitting problem. Then the diagnosis was evaluated by CNN classification. This layer uses the possibility that is returned with the Softmax function. This approach was validated by 400 retinal images with MESSIDOR dataset and achieved certain measures. By DL techniques and image processing approaches this model has shown its betterment when compared to the conventional model.

3 Proposed methodology

In this work, fundus images are obtained by fundus photographs and the major aim of the proposed scheme is to automatically diagnose DR from the abnormality that exists in the fundus images. Many diseases related to the eyes that cause blindness are glaucoma, macular degeneration and DR. Direct detection of fundus image is not enough to detect DR and it needs periodic screening which takes more time. Hence this paper develops an automated method for detecting DR by detecting exudates in retinal image. To efficiently diagnose the eye infection, image processing techniques are used to help ophthalmologists monitor patients. This section discusses the implementation stages of the developed DR model briefly. Figure 1 shows the schematic diagram of the developed model.

The proposed scheme involves phases like pre-processing, removing the OD and blood vessel, segmenting the exudates, feature extraction by GLCM and classification by DNN- BOA. Initially, G-channel is extracted from the input image, then these retinal images are enhanced by filters like HE and CLAHE for colour enhancement. From an enhancement image it is segmented by some techniques. These segmented images are extracted and classified by optimized classifier to improve the accuracy.

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3.1 Pre-processing of fundus images

In this work, the pre-processing is done by G-channel and HE-CLAHE. Pre-processing is a basic approach in the image processing, and it is an essential to improve the image quality because the images with less quality will reduce the performance of the system. In this stage, pre-processing has three phases like G-channel extraction from the input image, noise removal and image enhancement and it is explained in the following section.

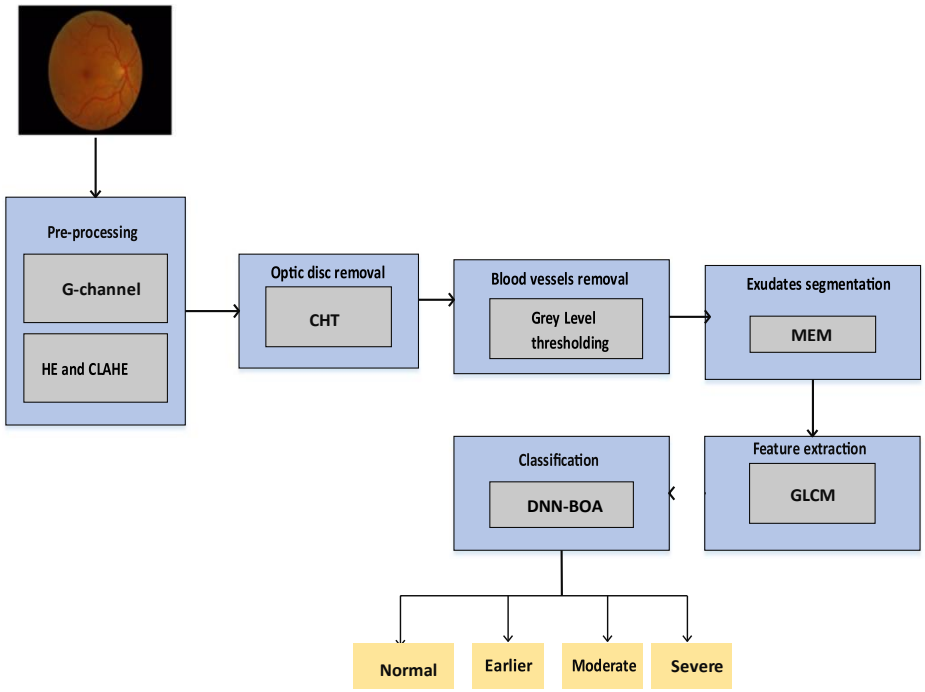

Fig. 1 Schematic diagram of the developed model

4 Results and discussion

The performance analysis developed DR model is discussed in this section. The entire implementations have been processed on a system with 8 GB RAM and Intel Core i5 CPU with 3.0 GHz speed. To implement the proposed scheme, MATLAB 2020a is utilized. The developed model's performance is compared with the KNN, SVM, DNN and DBN.

4.1 Dataset details

4.1.1 Diaretdb1 dataset

This dataset is a public dataset that comprises of 89 colour fundus images out of which 84 has mild NPDR signs of DR and the 5 images are set as a normal image by Ophthalmologists.

Particularly, 41 images are bright lesions and 45 images are dark lesions. The resolution is about 1500 × 1152 pixels and the angle of vision is 50^0. The images are divided into 28 images for training and 61 images for testing. Figure 3 shows the sample representation of DR images using DIARETDB1 of various classes like the healthy retina, Mild, Moderate, Severe NPDR and PDR.

$$n + nlog(n))$$

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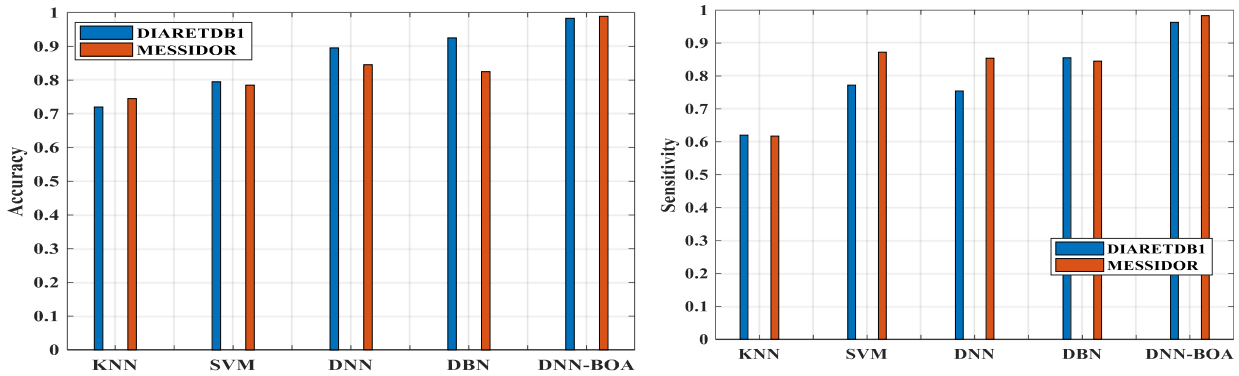

a) Accuracy b) Sensitivity

Fig. 7 Accuracy and sensitivity performance of different approaches for two different datasets

Variation source	Sum of square	df	Square value for mean	F-value	*P* value
Between groups	0.56981	3	0.2217	45.86	3.15409e-06
Within groups	0.05389	16	0.00452		
Total	0.37265	19			

5 Conclusion

This work developed a model for the automatic diagnosis of DR, and it involves 4 major processes. Initially pre-processing is used for removing the noise in images by HE and CLAHE filters. The OD has to remove and then blood vessels and exudates are removed completely because they look same as the fundus. Then GLCM features are used for extracting the feature and the extracted feature are classified using DNN-BOA classifier which is used to classify the several stages of DR. The implementation of the proposed scheme is implemented on MATLAB 2021a. The performance of the implemented method and other approaches like KNN, SVM, DNN and DBN are compared on some measures on DIARETDB1 and MESSIDOR datasets. The accuracy of the developed scheme is 0.983 and 0.989 respectively. The proposed scheme reduces the computation time and increases the accuracy of the system. Thus, the developed scheme shows its betterment in all the cases. In the future, some more features like edema and red lesions can be extracted, and the accuracy of the model can be further increased using other image processing approaches. However, the features extracted by the proposed architecture occupies huge dimension which increases the processing time of proposed architecture which is also considered as major demerit. This can also be rectified in future by introducing an efficient metaheuristic algorithm for better performance.

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