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Article Title: **Enhanced Prediction of Diabetic Retinopathy Types Using Deep Convolutional Neural Networks**

Enhanced Prediction of Diabetic Retinopathy Types Using Deep Convolutional Neural Networks

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ABSTRACT

Diabetic retinopathy is an eye condition which leads to the loss of eye sight in the person who already has diabetics. There are several stages in detecting the diabetic retinopathy which includes manual medical methods or detected by automatic methods using image processing. In these cases, neural networks are used in detecting the defects caused in the retina of the diabetics. These neural network process as same as human brain, in this methodology Artificial Intelligence (AI) is implemented. In this methodology, the image is pre-processed to improve the image clarity by Gaussian filtering method. The pre-processed image undergoes segmentation using the Fuzzy C-means (FCM) clustering method. By involving these methods, the complexity in detecting the diabetic retinopathy is reduced. The Deep Convolutional Neural Network (DCNN) method is implemented in which data is compared to find the defect. The pooling layer samples the image to speed up computation, and the fully connected layer provides the final prediction. In the Convolutional Neural Network, the data to the compared is already processed and stored. This paper provides excellent specificity and sensitivity for classifying images as having or without diabetic retinopathy. This paper is implemented using Python Google Colab software.

Keywords: Gaussian filtering, Image segmentation, Fuzzy C-means (FCM), Deep Convolutional Neural Network (DCNN), Artificial Intelligence (AI).

1 Introduction

Diabetic Retinopathy is an eye defect that occurs in the retina part of any diabetic patient. The manual analysis of these stages may not be easy and accurate [1]. The proliferative diabetic retinopathy stage is the dangerous stage in this defect, which must be detected accurately to prevent the critical state. As per many studies and researches, Deep Convolutional Neural Network (DCNN) based approaches are more effective to detect this eye defect. The DCNN process follows classifying the patient's retinal images and involving deep study under machine learning techniques [2]. Comparatively, the automated system detection gives more accurate results than dealing with the manual methods. Especially using machine learning techniques in the detection of diabetic eye diseases [3].

To enhance the performance of the diagnosis, the features of the image must be made clear before involving it into to machine learning methodology. The unwanted messages and information like extra columns, additional detailing and clinical descriptions must be removed. On the other hand, the relevant data must be present, without these data, the diagnosis may not be accurate [4]. The image which is given as input has the features like exudates, vessels, retina, and nerves. These are the main features to be considered for the diagnosis of diabetic retinopathy. In preprocessing, the pixels of the images are resized to a standard size for making the images uniform and to detect the features accurately. By this method of preprocessing, the data analysis becomes simpler and accurate [5].

The pre-processed image next undergo the process called segmentation. Some of the pre-processed image may have low brightness, low lighting and contrast that may not give a perfect DR evaluation. Thus, the further processing is carried out based on the pixels in the processed image [6]. The data is artificially clustered to form two regions as healthy region and the infected region. In the image segmentation, deep learning is involved as it is strong enough to solve the binary classification problem, which checks whether the patient is defected or not [7]. On the other way, some datasets which are predefined are used for the development of AI algorithm for the process of segmentation in the detection of DR in the retinal photographs [8]. The result after the clustering process is known as the segmented image.

After the process of segmentation, the classification of images are done based on neural networks. Deep learning method is often used for image classification as it gives higher accuracy. In the image classification method, the classification layers play a vital role. Further learning on this process may increase the optimization of the analysis [9]. The data are create, train and test to evaluate the classification procedure. This learning algorithm can be supervised or unsupervised as the data and the DR classification techniques are already loaded. The features exacted from multi fractal spectra of the retina vessel are used for the diabetic retinopathy classification. This classification method can be used for both the DR stages like non proliferative DR and the proliferative DR [10].

Therefore, this paper includes the segmentation method and DCNN classification that will be used to detect diabetic retinopathy accurately. By using the Gaussian filtering, the speckle noise present in ultrasound images or MRI images is completely removed. The FCM method, deploys to extracts specific features from picture pixels. The DCNN classification gives the probability of a class the image belongs to. The final step produces the output image to detect the stage of the defect. Overall, the proposed work was developed using the Python Google Colab software.

2 Recent Works

Vidhya *et al* [2020] [11] have presented the deep learning architecture implemented on the Raspberry pi for the automatic detection of the Diabetic Retinopathy (DR). As large databases

from KAGGLE is involved with ImageNet architecture, convolutional neural network method gives the accurate solution. This algorithm is inbuilt in Raspberry pi kit. Testing images are given to the trained model and the images are classified and then the accuracy or calculated. This deals with all the four categories in the DR detection from affected to non-affected. As the system uses raspberry pi alone for the implementation, it is cost-effective and also it save the time consuming in the process of detection. Some of the results may not be accurate as the accuracy rate detected is only 92%.

Siddharekh *et al* [2019] [12] have implemented a prediction system for the detection of the Diabetic Retinopathy. The process used for the detection is mining method, where the images can be easily retrieved from the database specified. In the mining process, even the lost data can be retrieved easily. The two types of classifications involved here are neural network (NN) and naïve bayes (NB). Based on the analysis, neural network method is more convenient when compared to the naïve bayes algorithm. Being time-efficient, less memory storage required are reason for the high usage of the neural network for data accuracy. The major drawback is it is not much easier to change or update any loaded data in the mining process, once entered will retain throughout the process.

Shivani *et al* [2017] [13] have focused developing a hardware to detect the problem of DR. The process is involved by examining the fundus image of the retina of the defected patient. The fundus image is taken by the fundus camera which use the principle of reflex-free indirect ophthalmoscopy. After the capturing of the image, the processing is done on the image captured. The specific algorithm used is, the cup to disc ratio, which refers to the diameter of the cup in the retina, divided by the diameter of the whole nerve head. As benefit, this process can not only to use to detect the defect of DR, but also can detect the stages of the defect and it is time-efficient. The drawback is the process of cupping also includes other parameters like age factors, for this the data gathering may be time consuming.

Hamza *et al* [2022] [14] have proposed a multi-stream network for implementing deep network in detecting DR. Most of the existing convolutional techniques are concentrated only in the detection of the DR, but it is vital in detecting the stages of severity accurately. Thus, this multi-stream deep networking is included in the CNN methodology. The analysis named as Principal Component Analysis (PCA) algorithm is involved in order to learn about the inter-class and intra0class elements in the images of the retina captured by the fundus camera. This learning make this process more useful and it also reduces the feature dimensionality, by this making the process simpler to handle. The drawback is, if the accuracy need to be increased, then the dataset need to be increased exponentially, that makes the dataset more complex.

Tinuk *et al* [2020] [15] have introduced the data augment technique to improve the efficiency of CNN in DR detection. As CNN is a type of artificial intelligence method, the image processing and the detection of data will be very accurate and highly effective. When CNN is assigned with large dataset, it works efficiently but deal with small datasets, the performance

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speed is affected. By using the data augmentation method, the process of low speed is overcome. The augmentation method used is Contrast Limited Adaptive Histogram Equalization (CLAHE). By using specific data augment method, the accuracy, sensitivity will be enhanced. The defect is, not all method of data augmentation will result in the accurate results and sometimes they may change the original data, which cannot be retrieved back easily.

3 Proposed Work Explanation

Figure 1 represents the flow diagram of the implementation and prediction of diabetic retinopathy using neural networks.

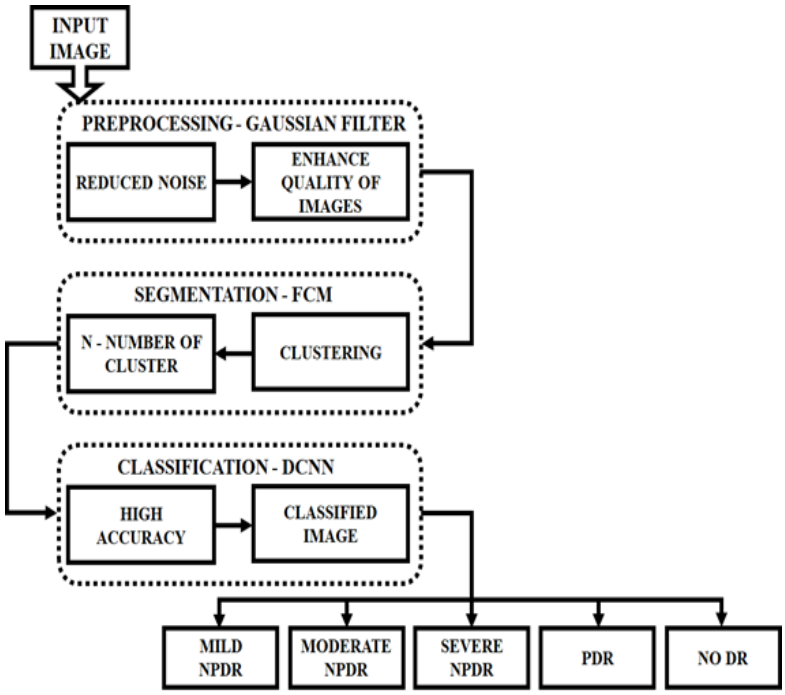

Figure 1: *Architecture of proposed system*

As the block diagram represents, the image is first pre-processed to remove all the unwanted distortion. For this removal of unwanted signals one of the spatial processing techniques known as Gaussian filtering method is used. After the filtering process, the pre-processed image is segmented with a predefined section of segments using the Fuzzy C-means (FCM) clustering algorithm. This image segmentation is done to make the process more reliable and time efficient. At last, the classification is done under the Deep Convolutional Neural Network (DCNN) method to classify the category of diabetic retinopathy, which is done by image processing and fetching the data from the CNN and compared with the data predefined.

3.1 Process flow diagram

Figure 2 indicates that the process flow diagram of proposed model

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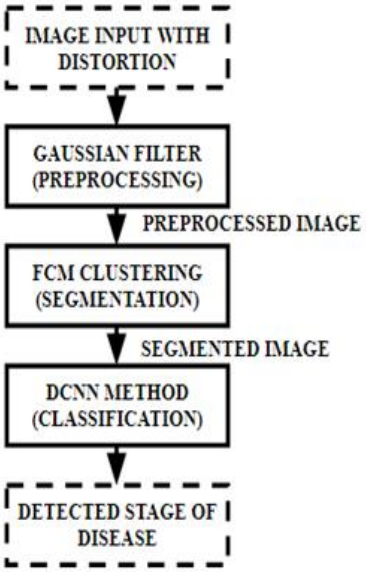

Figure 2: *Flow diagram of proposed methodology*

This method implements the prediction of diabetic retinopathy types based on deep convolutional neural networks. The normal image of the suspected retina of the patient is fed into the Gaussian filter, where all the unwanted distortion is removed. This preprocessed image is send to the FCM clustering, here the segmentation is done in term of pixels. Then the segmented image is send into the DCNN method for the classification. This classification is done by pre-loaded data. By means of classification, the stage of the disease is detected.

3.2 Pre-processing

The input image dataset is entered into the preprocessing stage by using the Gaussian filter. Image processing refers to the analysis or algorithms applied to an image dataset. A Gaussian filter is both a linear filter and a low-pass filter that is passed through each pixel of the region of interest to get the desired effect. A Gaussian filter is used to remove the noise present in the input image. Additionally, it was used to blur the image and enhance image equality.

3.3 Segmentation

Image segmentation is a commonly used technique in image processing and analysis to partition an image into multiple parts or regions, often based on the characteristics of the pixels in the image. The filtered image followed the process of segmentation. The gray scale images are converted to binary data. Fuzzy C-means (FCM) is a method of clustering which allows one piece of data to belong to two or more clusters. After that, Fuzzy c-means clustering gets the features specified in the pixels and divides the data into N clusters, with each data point in the dataset to some extent belonging to each cluster.

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3.3 Classification of DCNN

DCNN is the type most commonly used to identify patterns in images and video. This classifier is made up of three main types of layers. The first layer is the convolution layer, which filters the image to detect features of the image. The convolutional layer is followed by a pooling layer, which gradually reduces the size of the image while keeping only the most important information. Finally applied at the end to the outputs of the fully connected layers specifies the class the image belongs to, for example, is it a tumor or not. Which results in very high accuracy in image recognition problems and automatically detects the important features without any human supervision.

4 Results and Discussion

The result shows the output obtain by implementing the proposed method in the detection of proliferative-DR by using DCNN method.

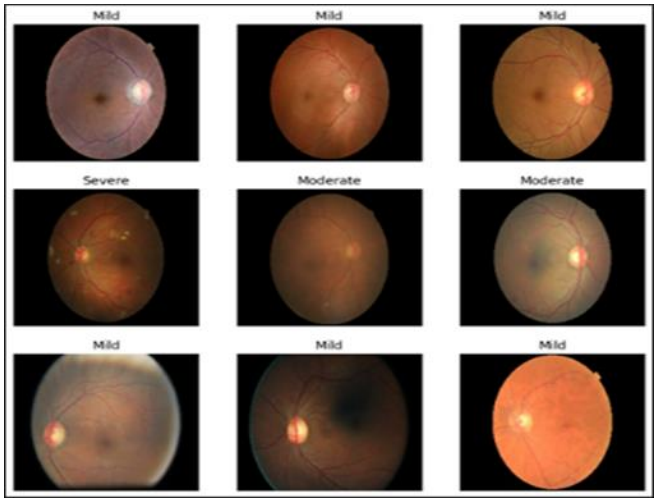

Figure 3: *Input Image Set*

Figure 3 represents input image set loaded to the neural network which is unclear with distortion and unwanted features

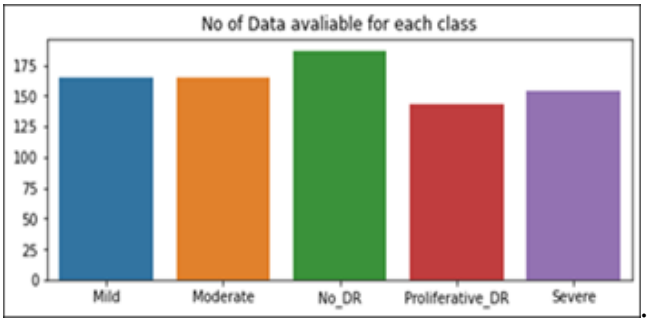

Figure 4: *Data distributed in each class*

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Figure 4 represents Data distributed in each class by which the images are detected and then classified.

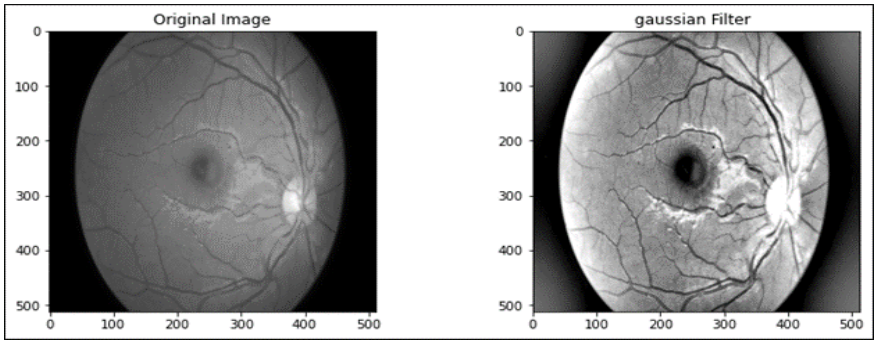

Figure 5: *Image after Gaussian filtering*

Figure 5 represents image after Gaussian filtering which enhances the feature of the retina by pre-

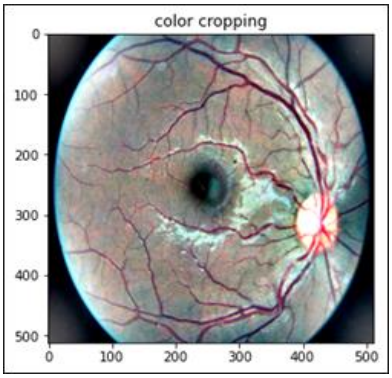

Figure 6: *Colour cropped image*

Figure 6 represents colour cropped image occurring after the method of pre-processing

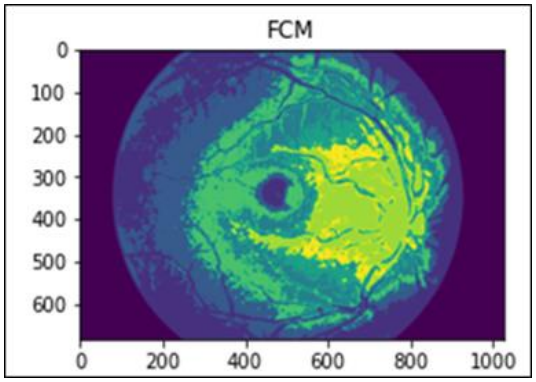

Figure 7: *Segmented Image*

Figure 7 represents segmented image by the process of FCM

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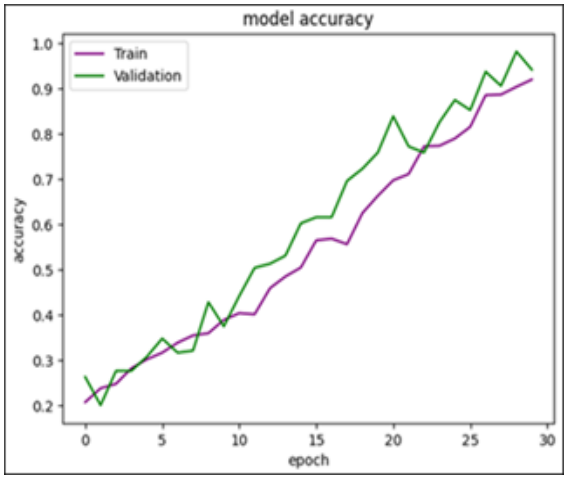

Figure 8: *Graph of accuracy*

Figure 8 represents the graph of accuracy obtained after the process of segmentation

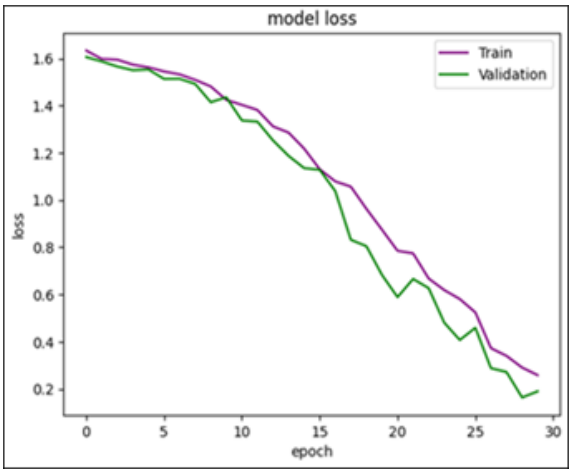

Figure 9: *Graph of loss*

Figure 9 represents the graph of loss obtained after the process of segmentation

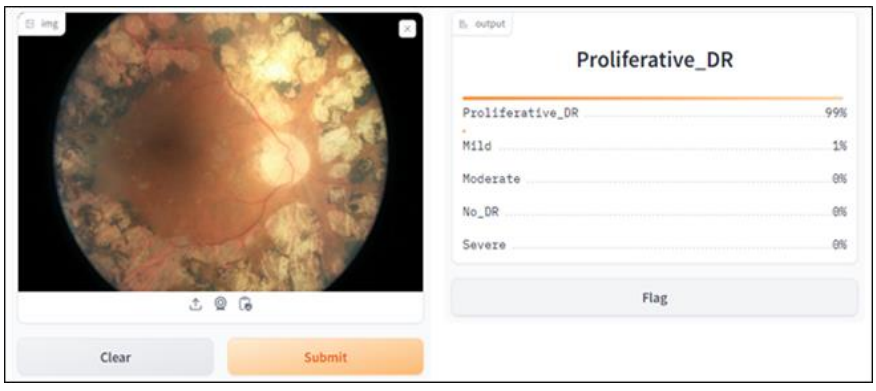

Figure 10: *Predicted output 1*

Figure 10 represents the output predicted for first case where the prediction of proliferative-DR is 99%

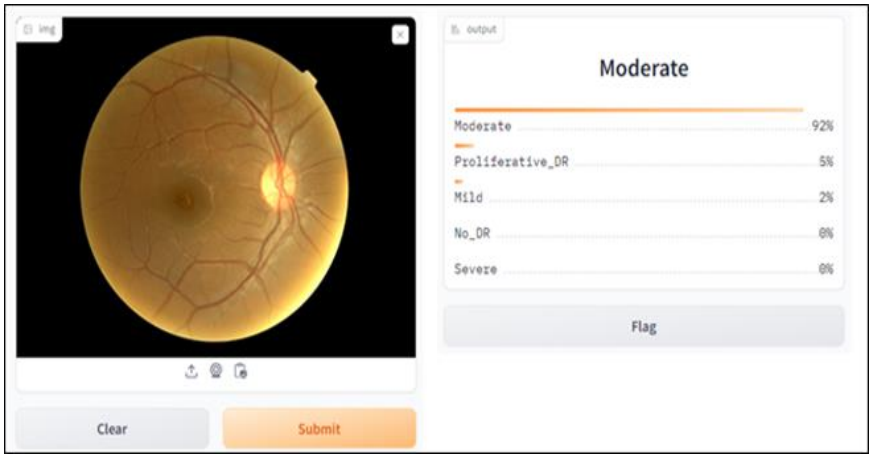

Figure 11: *Predicted output 2*

Figure 11 represents the output predicted for second case where the prediction of proliferative-DR is 5%

5 Conclusion

Diabetic retinopathy is caused by the increase of sugar level in the blood, which results in the damage of the retina in the eye. The method of pre-processing is done to remove the distortion, only to produce the higher accuracy image to detect the disease clearly. Then, the segmentation is done for the pre-processed image and then the classification is done based on the Deep Convolutional Neural Networks (DCNN). Using this methodology, it was successfully identified that the type of disease affected. If a patient undergo regular screenings, the outcome provides an assessment of the progression of the condition, this information helps to determine the appropriate treatment and management approach.

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