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Detection of Diabetic Retinopathy Using Retinal Image

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Abstract: Diabetic Retinopathy is a major disease that has affected over 290 million people globally and 69.2 million people in India, the rate of people getting affected will increase exponentially in the coming years. Diabetic Retinopathy is an ailment linked to the fundus of the eye and can have adverse effects on the patient, if at all left undiagnosed respectively.

Our project aims to construct a graphical user interface that can integrate image processing techniques together in order to predict whether the input fundus/retinal image received from the patient is affected with Diabetic Retinopathy or not; if affected, the graphical user interface will display the severity along with the required action needed to be undertaken by the user / patient. This essentially reduces the processing time involved in the process of detecting the disease and also the ophthalmologists can also have our graphical user interface as a backup that can be used for validating or assist in detecting the disease

Keywords: Diabetic Retinopathy, GUI, Convolutional Neural Network, Python.

I. INTRODUCTION

A. Diabetic Retinopathy

Diabetic retinopathy (DR), also known as diabetic eye disease, is when damage occurs to the retina due to diabetes. It can eventually lead to blindness.
It is an ocular manifestation of diabetes. Despite these intimidating statistics, research indicates that at least 90% of these new cases could be reduced if there were proper and vigilant treatment and monitoring of the eyes. The longer a person has diabetes, the higher his or her chances of developing diabetic retinopathy.

Diabetic retinopathy can be diagnosed into 5 stages: mild, moderate, severe, proliferative or no disease. The various signs and markers of diabetic retinopathy include microaneurysms, leaking blood vessels, retinal swellings, growth of abnormal new blood vessels and damaged nerve tissues.

DR detection is challenging because by the time human readers submit their reviews, often a day or two later, the delayed results lead to lost follow up, miscommunication, and delayed treatment.

Clinicians can identify DR by the presence of lesions associated with the vascular abnormalities caused by the disease. While this approach is effective, its resource demands are high. The expertise and equipment required are often lacking in areas where the rate of diabetes in local populations is high and DR detection is most needed.

The need for a comprehensive and automated method of DR screening has long been recognized, and previous efforts have made good progress using image classification, pattern recognition, and machine learning.

The current research in diagnosing diabetic retinopathy has been based on explicit extraction of features like microaneurysms and lesions through which the classification is performed. There has also been research in using machine learning techniques to classify the image as normal or diseased.

This paper aims at proposing a diabetic retinopathy diagnosis model that automatically learns features which are pivotal in diagnosing the disease without explicit or manual feature extraction.

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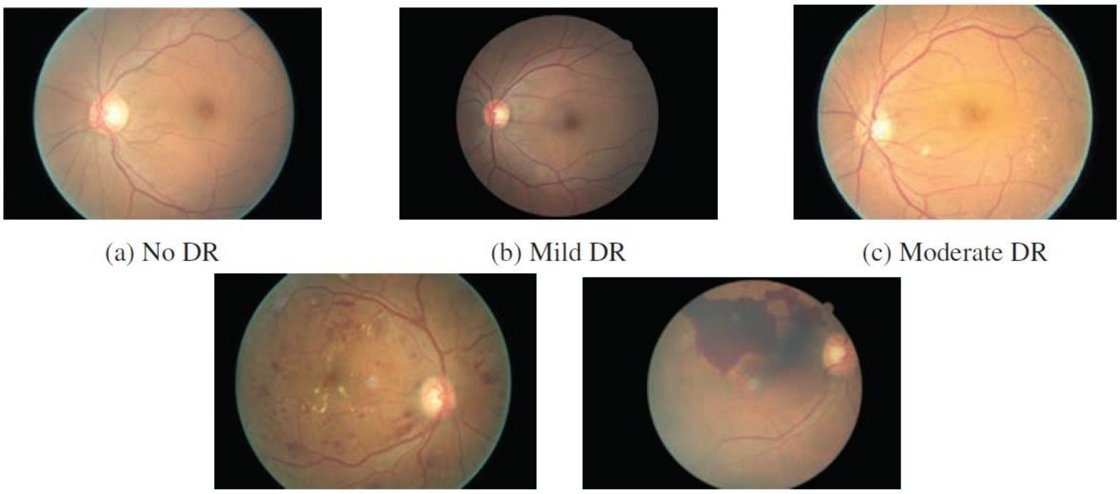


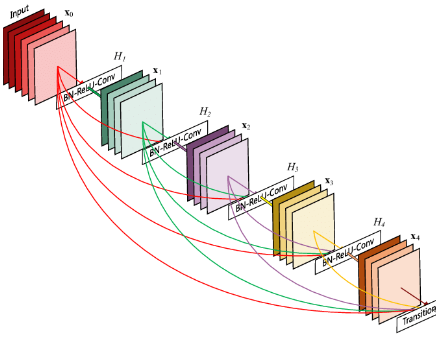
(a) No DR (b) Mild DR (c) Moderate DR

(d) Severe DR (e) Proliferative DR

Fig 1: Stages of diabetic retinopathy (DR) with increasing severity

B. Convolutional Neural Networks

Convolutional networks (ConvNets) have recently enjoyed a great success in large-scale image and video recognition which has become possible due to the large public image repositories, such as ImageNet, and high-performance computing systems, such as GPUs or large-scale distributed clusters. In particular, an important role in the advance of deep visual recognition architectures has been played by the ImageNet Large-Scale Visual Recognition Challenge (ILSVRC) (Russakovsky et al., 2014), which has served as a testbed for a few generations of large-scale image classification systems, from high-dimensional shallow feature encodings to deep ConvNets (Krizhevsky et al., 2012). The performance of convolutional neural networks in these competitions was the motivation behind adopting CNN for this research. A Convolutional Neural Network (CNN) is comprised of one or more convolutional layers (often with subsampling step) and then followed by one or more fully connected layers as in a standard multilayer neural network. The architecture of a CNN is designed to take advantage of the 2D hierarchical structure of an input image (or other 2D input such as a speech signal). This is achieved with local connections and tied weights followed by some form of pooling which results in translation invariant features. Another benefit of CNNs is that they are easier to train and have many fewer parameters than fully connected networks with the same number of hidden units. CNNs also consider the hierarchical representation of images while training by stacking multiple trainable stages on



each other.

Fig. 2. An illustration of a 5-layer Dense block

II. THE DATASET

The dataset consists of 574 labeled high-resolution colour fundus retinal images belonging to five classes corresponding to the five stages of the disease. The test set consists of 5357 images out of which 574 have been utilized for this paper. The images have been open-sourced by EyePACs, a free platform for retinopathy screening. A trained clinician has rated the presence of diabetic retinopathy in each image on a scale of 0 to 4. The images in the dataset come from different models and types of cameras, which can affect the visual appearance of left and right retinas. Some images are shown as

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one would see the retina anatomically (macula on the left, optic nerve on the right for the right eye). Others are shown as one would see through a microscope condensing lens (i.e., inverted, as one sees in a typical live eye exam).

III. METHODOLOGY

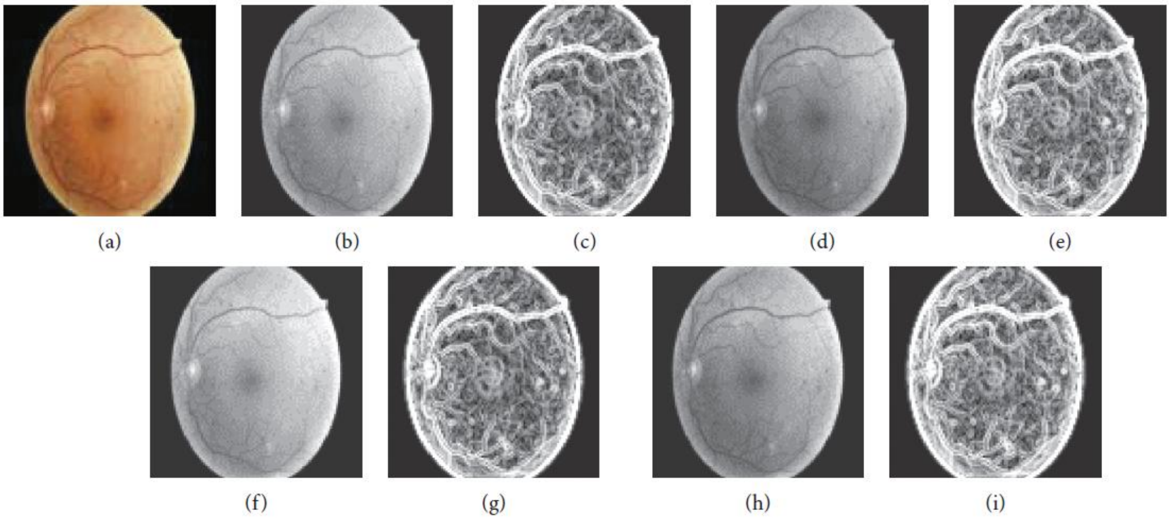

Fig 3: Resized (100 ×100), preprocessed, and entropy images of the retinal image.
(a) Color. (b) Gray level. (c) Entropy of (b).
(d) Green component (e) Entropy of (d). (f) UM of (b). (g) Entropy of (f). (h) UM of (d). (i) Entropy of (h).

1) Data pre-processing

Due to non-standard image resolutions, the training images could not be utilized directly for training. The images were scaled down to a fixed resolution size of 512x512 pixels to form a standardized dataset. Training images of resolution 512x512 pixels on all three colour channels demanded high memory requirements. Due to this limitation, the images were converted to a single channel. After several experiments, it was found that green channel images retained information better than the other channel images. In order to enhance the contrast of the image evenly across pixels, histogram equalization technique was applied on the images. In order to prevent the convolutional neural network from learning the inherent background noise in the image, each image was normalized using Min-Max normalization.

a) Normalization: As our dataset contains many features, and some of the features have some extreme values, we do not know how our overall data is distributed. In this context, we used Normalization on all the attributes except the label of our whole dataset. It is the process of rescaling one or more attributes to the range of 0 to 1. It helps to get an overall idea over the distribution of our dataset.

$xnew = x - xminxmax - xmin$ ……… (1)

b) Standardization: Data standardization is the process of rescaling one or more attributes so that they have a mean value of 0 and a standard deviation of 1. As some of the attributes of this DIARETDB1 dataset have higher ranges, this overall process minimizes that difference between the maximum and minimum value and gives a better visualization of the data points than before.

$xnew=x-\mu\sigma$ ……… (2)

2) Training

The CNN was initially pre-trained on 10,290 images until it reached a significant level. This was needed to achieve a relatively quick classification result without wasting substantial training time. After 120 epochs of training on the initial images the network was then trained on the full 78,000 training images for a further 20 epochs. Neural networks suffer from severe over-fitting, especially in a dataset such as ours in which the majority of the images in the dataset are classified in one class, that showing no signs of retinopathy. To solve this issue, we implemented real-time class weights in the network. For every batch loaded for back-propagation, the class-weights were updated with a ratio respective to how many images in the training batch were classified as having no signs of DR. This reduced the risk of over-fitting to a certain class to be greatly reduce

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3) Convolutional Neural Network.

Convolutional neural network (CNN) is used for the feature learning of referable DR in this study. We construct a CNN model to simultaneously process the entropy images of luminance (gray level) and the green component after processing by UM as shown in Figure 2. For each channel, 4 convolutional layers are with 5 × 5 kernels, and the numbers of filters are 32, 64, 64, and 128 in successive layers. Maximum pooling, rectified linear unit activation function, and dropout (set to 0.3), to prevent overfitting, are used. After flattening from the two channels, the fully connected layers are linked to statistically determine the detection of referable DR, proposed referable DR detection method is coded by TensorFlow software with Python. ,cross-entropy loss function and the Adam algorithm with learning rate 0.0001 are adopted for training the network.

IV. IMPLEMENTATION DETAILS

The various data pre-processing techniques were performed using keras and the Python library OpenCV. To speed up the process of training the above convolutional neural network, the entire training process was performed with Intel core i5 processor and 8GB RAM. To design and train the deep network above, the Python libraries tensorflow were utilized.

V. RESULT

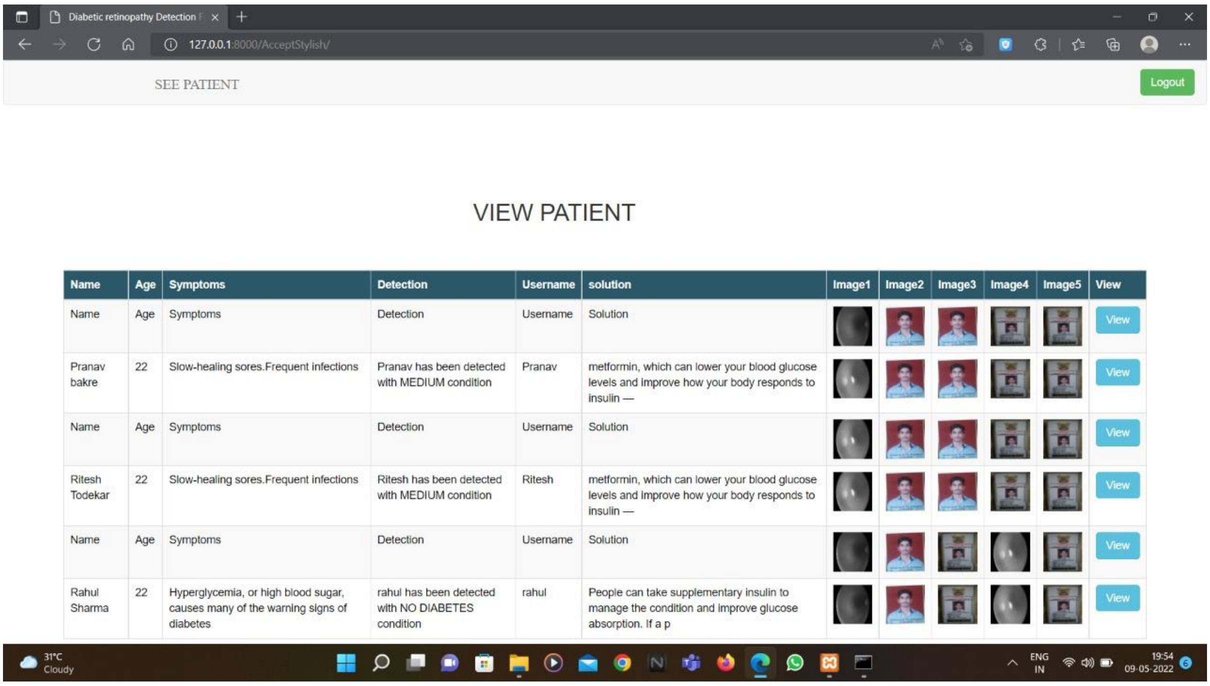

Fig 4: Snapshot of Result

5,000 images from the dataset were saved for validation purpose. For this five-class problem we define specificity as the number of patients correctly identified as not having DR out of the true total amount not having DR and sensitivity as the number of patients correctly identified as having DR out of the true total amount with DR.

VI. CONCLUSION

The main objective of this research is to build an automated system model that can successfully detect the early non-proliferative Diabetic Retinopathy (DR) symptoms among diabetes patients. DR is a disease that cannot be cured. To forestall permanent vision loss optical laser analysis is typically effective but it hampers the retina. Since decisive symptoms do not accumulate until the disease turns into inexorable, initial discovery via screening is mandatory. Therefore, this research proposed an automated method to diagnosing and detect early stages of diabetic retinopathy e.g., microaneurysms, exudates, cotton wool spots, etc. based on CNN.

This paper presents the design, architecture and implementation of deep convolutional neural networks for automatic detection and classification of diabetic retinopathy from color fundus retinal images. It also discusses the quadratic kappa metric used to evaluate the prediction results. This research involves CNN model and designing their architectures.

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VII. FUTURE SCOPE

• Fine tuning the current network parameters to obtain a greater accuracy on single channel images.
• Using all the channels instead of a single channel enabling the network to learn more features thereby decreasing over-fitting through increasing complexity of data.
• Working with alternate image pre-processing techniques to improve noise reduction

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