Automatic Classification of diabetic retinopathy levels using Convolution Neural network

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Abstract - Diabetic eye disease is a complexity that affects people having diabetes for a longer time. By affecting the blood vessels it can cause blurry vision or even blindness to the patients. Thus, detecting the eye disease at an early stage can help many of the diabetic patients to get the required treatment and intern increases the survival rate. In the proposed system, the CNN algorithm of machine learning is used to detect the diabetic eye diseased by either using the thermal images. These images are pre-processed by converting them from RGB to GRAY based on which the required features are extracted. To detect the diabetic retinopathy, here the Convolutional Neural Network is used to classify 5 stages of the diseased eye.

Introduction:

Diabetic retinopathy is when damage occurs to the retina due to diabetes, which affects up to 80 percent of all patients who have had diabetes for 10 years or more. The expertise and equipment required are often lacking in areas where diabetic retinopathy detection is most needed. Most of the work in the field of diabetic retinopathy has been based on disease detection or manual extraction of features, but this paper aims at automatic diagnosis of the disease into its different stages using deep learning. This paper presents the design and implementation of GPU accelerated deep convolutional neural networks to automatically diagnose and thereby classify high-resolution retinal images into 5 stages of the disease based on severity.

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 [7]. 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 [7]. 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 [14, 15, 16]. This paper aims at proposing a diabetic retinopathy diagnosis model that automatically learns features which are pivotal in diagnosing the stage of the disease without explicit or manual feature extraction.

Literature Review:

Diabetic retinopathy (DR) staging is important for the estimation of diabetes mellitus (DM) and the evaluation of associated retinopathy; it is also closely related with proper management and prognosis of DR. In order to objectively and accurately determines the diabetic retinopathy stages, the goal of this paper is to introduce an image analysis-based approach to automatically differentiate the 5 stages of diabetic retinopathy based on fundoscopic images. Image analysis has been widely and successfully applied in biomedical field, for example, to objectively differentiate embryonic:

(a) Stage I: No diabetic retinopathy

(b) Stage II: Mild non-proliferative diabetic retinopathy

(c) Stage III: Moderate non-proliferative diabetic retinopathy

(d) Stage IV: Severe non-proliferative diabetic retinopathy

(e) Stage V: Proliferative diabetic retinopathy Hard Exudates Micro-aneurysm or Haemorrhage Pre-retinal Hemorrhage Intra-Retinal Microvascular Abnormality (IRMA) Neovascularization Figure 1.

Fundoscopic images of different stages of diabetic retinopathy. (a) Stage I: No diabetic retinopathy; (b) Stage II: Mild non-proliferative diabetic retinopathy; (c) Stage III: Moderate non-proliferative diabetic retinopathy; (d) Stage IV: Severe non-proliferative diabetic retinopathy; (e) Stage V: Proliferative diabetic retinopathy. 466 developmental stages [5] and classify severity of melanoma and nevi from skin lesions [6]. Deep Learning based Convolution Neural Network (CNN) has recently been proven to be a promising approach for different medical image analysis [7]. Anthimopoulos deployed a deep convolutional neural network for lung pattern classification of interstitial lung diseases [8]. Esteva et al. in their work leveraged deep convolution neural networks for dermatologist-level classification of skin cancer [9]. On the topic of using deep learning algorithm to classify diabetic retinopathy in retinal fundus photographs, large scale medical studies were conducted in the past [10][11]. However, these studies combine several stages together and only aim at building binary classifiers. One of the previous work which also aims to build a five-class severity classifier for diabetic retinopathy using CNNs is given in [12]. However, the results reported in [12] have a lower prediction accuracy, which will be compared to our results later. In this article, we investigate the performance of different deep convolutional neural network architectures when they are deployed to classify the five DR stages. The experiment has been performed based on a total of 166 fundoscopic images extracted from the publicly available Kaggle dataset provided by EyePACS [13]. We find that InceptionNet V3, which is devised with the most advanced convolutional neural network building techniques gives the highest 5-fold cross validation average classification accuracy of 63.23%, compared to traditional AlexNet [14] and VGG16 [15], using only this small number of images.

Stage	Dilated Ophthalmoscopy Observable Findings	Severity
I	No abnormalities	No DR
II	Micro-aneurysms only	Mild non-proliferative DR
III	Any of the following: - micro-aneurysms - retinal dot and blot haemorrhages - hard exudates or cotton wool spots No signs of severe non-proliferative diabetic retinopathy	Moderate non-proliferative DR
IV	Any of the following: - more than 20 intra-retinal hemorrhages in each of 4 quadrants - definite venous beading in 2 or more quadrants - prominent intra-retinal microvascular abnormality (IRMA) in 1 or more quadrants No signs of proliferative retinopathy	Severe non-proliferative DR
V	One or both of the following: - Neovascularization - Vitreous/pre-retinal hemorrhage	Proliferative DR

Table 1. INTERNATIONAL CLINICAL DIABETIC RETINOPATHY & DIABETIC MACULAR EDEMA DISEASE SEVERITY SCALES

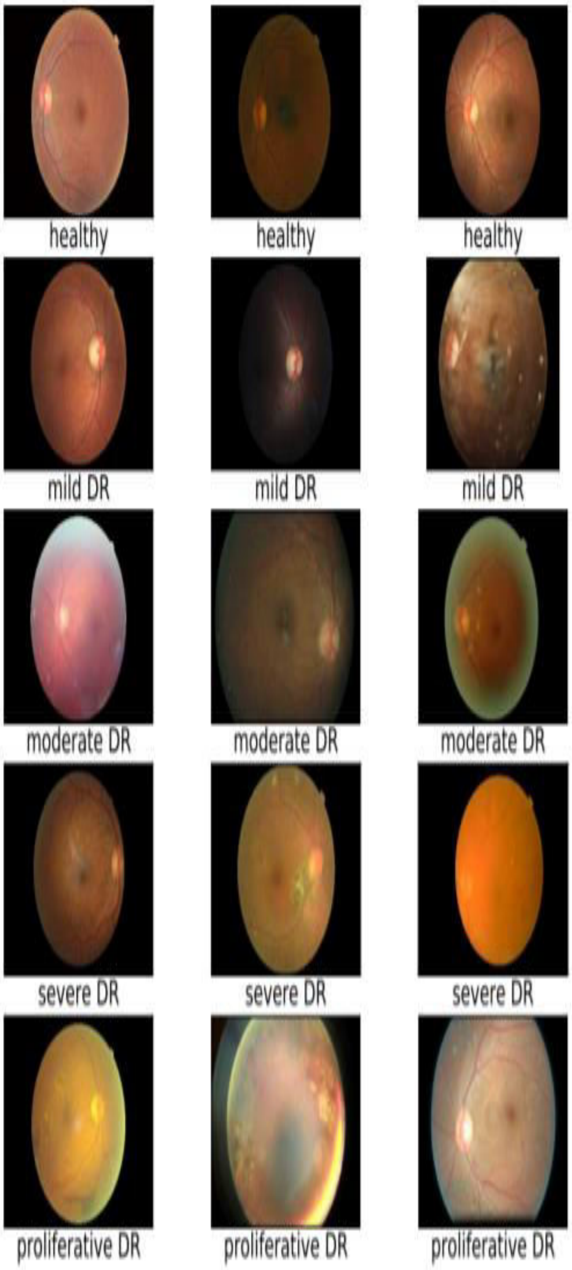

Figure 1 .image sample international clinical diabetic retinopathy & diabetic macular edema disease severity scale images

Methodology:

In order to achieve early diagnosis of diabetic retinopathy major effort will have to be invested into screening programs. Screening is important as up to one third of people with diabetes may have progressive DR changes without symptoms of reduced vision. In current screening programs only color fundus photography is used, and the data are sent to a grading center for reading where expert human readers estimate the disease severity. The main disadvantage is the necessity for qualified experts to grade the images. This is impossible to achieve in countries with a shortage of qualified medical personnel.

The success of screening approach depends on accurate fundus image capture, and especially on accurate and robust image processing and analysis algorithms for detection of abnormalities

Following are some of the image processing algorithms for early detection diabetic retinopathy

1) Preprocessing
2) Localization and segmentation of the optic disk
   a) Characteristics of the optic disk
   b) Optic disk localization
   c) Optic disk segmentation
3) Segmentation of the retinal vasculature
   a) Characteristics of the vasculature
   b) Methods for segmentation of the retinal vasculature
4) Localization and segmentation of retinopathy
   a) Microaneurysms and hemorrhages
   b) soft and hard Exudates
   c) Drusen
   d) Neovascularizations
   e) Glaucoma
   f) Diabetic Macular Edema

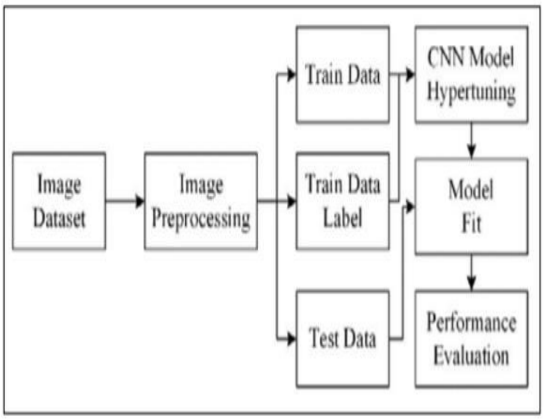

Fig. Proposed System Architecture

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