Chapter 17

Detection and Classification of Diabetic Retinopathy Using Image Processing Algorithms, Convolutional Neural Network, and Signal Processing Techniques

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ABSTRACT

Diabetic retinopathy (DR) affects blood vessels in the retina and arises due to complications of diabetes. Diabetes is a serious health issue that must be considered and taken care of at the right time. Modern lifestyle, stress at workplaces, and unhealthy food habits affect the health conditions of our body. So the detection of lesions and treatment at an early stage is required. The detection and classification of early signs of diabetic retinopathy can be done by three different approaches. In Approach 1, an image processing algorithm is proposed. In Approach 2, convolutional neural network (CNN-VGG Net 16) is proposed for the classification of fundus images into normal and DR images. In Approach 3, a signal processing method is used for the detection of diabetic retinopathy using electro retinogram signal (ERG). Finally, the performance measures are calculated for all three approaches, and it is found that detection using CNN improves the accuracy.

INTRODUCTION

Diabetes is the main cause of unhealthy body conditions and it affects the regular activity of our body. The failure of absorption of glucose from food raises the level of blood sugar and it will lead to diabetes. Glucose is the main source of energy for each cell's functionality. High blood sugar arises due to a lack of insulin or the absence of production of enough insulin. Insulin, a hormone produced naturally by the pancreas and it helps to separate glucose from nutriment and also preserves glucose in the liver in the form of glycogen for later use. There are various causes of diabetes: unhealthy lifestyle, timely work, unbalanced diet, emotional stress, hereditary disease, etc. So as age progress, everyone has to undergo medical screening at least once a year. People do not find time to go for clinical testing as it is a time-consuming process. But the evolution of automated systems helps working and non-working age groups to take the self-test at home and it consumes only less time. Therefore it is necessary to propose automated eye testing & detection of signs at the early stage so that eye blindness can be prevented. The two stages of Diabetic Retinopathy include Non-Proliferative Diabetic Retinopathy (NPDR) and Proliferative Diabetic Retinopathy (PDR). Diabetic Retinopathy at the early stage is NPDR and the advanced stage is PDR. In the early stage, different visual lesions will appear in the fundus image which includes Microaneurysms, Hemorrhages, and Hard and Soft exudates. As the damage in the blood vessels proceeds new blood vessels will start to grow in the back part of the eye (retina) but the new blood vessels are very fragile so they can easily break and leak blood in the eye.

Microaneurysms-This is the preliminary sign of Diabetic Retinopathy. It occurs mostly with the appearance of small size red dots surrounded by bright yellowish areas. Since it is very small, its size is about 10-100 μm. It is appeared in the retina due to capillary widening or blood leakage in the back of the eye.

Hemorrhages –This is damage in the retina and it arises due to a considerable amount of blood leakage in the retina. It occurs with various shapes like circular shaped and flame-shaped hemorrhages and the size is larger than Microaneurysms. There are dot and blot hemorrhages that appear mainly in deep layers of the retina.

Exudates - The reaction of bio-chemical materials due to high blood sugar leaks yellowish like lipids and proteins in the retina. It is irregular in shape and the size is large. There are hard and soft exudates.

Cotton Wool Spots – It is otherwise called soft exudates. It appears either white-colored spongy-like circular or non-circular-shaped structures in the retina. This will also be created due to the reaction of biochemical materials in the retina. All the early-stage lesions are shown in Figure 1.

Diabetes affects almost all functions in our body. It affects the eyes and can lead to eye-blindness if the eyes are not properly treated. This eye disease is called Diabetic Retinopathy (DR). This chapter proposes three approaches to detect Diabetic Retinopathy: 1) Image Processing, 2) Deep convolutional neural network, and 3) signal processing. All approaches have their uniqueness and efficiency in detecting and classifying diabetic retinopathy. A fundus camera, either portable (hand-held) or non-portable, helps to take fundus images. Fundus images act as input for approaches 1 and 2, whereas the third approach utilizes recorded Electro Retinogram Signal (ERG). Image processing and Deep learning techniques do not consider the visual functionality of each retinal cell. In image processing, fundus images are pre-processed by green channel extraction and wiener filtering. Wiener filtering is used to deblur the fundus images. After pre-processing, lesions are segmented using k-means segmentation. Then features like texture and Scale-Invariant Feature Transform (SIFT) are extracted. These features are used to train and test cascaded rotation forest classifier. The deep convolutional neural network (approach 2) extracts

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