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An Automatic Detection and Classification System of Five Stages for Hypertensive Retinopathy Using Semantic and Instance Segmentation in DenseNet Architecture

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Abstract: The stage and duration of hypertension are connected to the occurrence of Hypertensive Retinopathy (HR) of eye disease. Currently, a few computerized systems have been developed to recognize HR by using only two stages. It is difficult to define specialized features to recognize five grades of HR. In addition, deep features have been used in the past, but the classification accuracy is not up-to-the-mark. In this research, a new hypertensive retinopathy (HYPER-RETINO) framework is developed to grade the HR based on five grades. The HYPER-RETINO system is implemented based on pre-trained HR-related lesions. To develop this HYPER-RETINO system, several steps are implemented such as a preprocessing, the detection of HR-related lesions by semantic and instance-based segmentation and a DenseNet architecture to classify the stages of HR. Overall, the HYPER-RETINO system determined the local regions within input retinal fundus images to recognize five grades of HR. On average, a 10-fold cross-validation test obtained sensitivity (SE) of 90.5%, specificity (SP) of 91.5%, accuracy (ACC) of 92.6%, precision (PR) of 91.7%, Matthews correlation coefficient (MCC) of 61%, F1-score of 92% and area-under-the-curve (AUC) of 0.915 on 1400 HR images. Thus, the applicability of the HYPER-RETINO method to reliably diagnose stages of HR is verified by experimental findings.

Keywords: retinal fundus images; diabetic retinopathy; hypertensive retinopathy; deep-neural network; semantic and instance-based segmentation; transfer learning; perceptual-oriented color space; DenseNet architecture; loss function

1. Introduction

The most common cause of retinal damage is hypertensive retinopathy (HR). By 2025, 1.56 billion people are projected to suffer from hypertension. Besides that, nearly 66% of people who are affected by hypertension reside in developing or impoverished countries, where the lack of sufficient healthcare services to identify, manage and handle hypertension exacerbates the issue [1]. Hypertension triggers nosebleeds, vision loss and headaches. Moreover, long-term hypertension can cause permanent damage to the lungs, heart, kidneys and eyes. Among all these consequences, hypertensive retinopathy (HR) is perhaps the most common cause of cardiovascular disease, which results in death. As a result, it is recognized as a worldwide community health hazard. The risk of HR can be reduced if hypertension is identified and treated early. It is difficult to diagnose hypertensive retinopathy in the early stages due to the lack of advanced imaging technology and proficient ophthalmologists [2].

Hypertensive retinopathy (HR) is a retinal deformity caused by elevated blood pressure in general. The appearance of arteriolar narrowing [3], arteriovenous nicking, retinal