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Retinal Image Analysis for Disease Screening through Local Tetra Patterns

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Abstract

Age-related Macular Degeneration (AMD) and Diabetic Retinopathy (DR) are the most prevalent diseases responsible for visual impairment in the world. This work investigates discrimination potential in the texture of color fundus images to distinguish between diseased and healthy cases by avoiding the prior lesion segmentation step. It presents a retinal background characterization approach and explores the potential of Local Tetra Patterns (LTrP) for texture classification of AMD, DR and Normal images. Five different experiments distinguishing between DR - normal, AMD - normal, DR - AMD, pathological - normal and AMD - DR - normal cases were conducted and validated using the proposed approach, and promising results were obtained. For all five experiments, different classifiers namely, AdaBoost, c4.5, logistic regression, naive Bayes, neural network, random forest and support vector machine were tested. We experimented with three public datasets, ARIA, STARE and E-Optha. Further, the performance of LTrP is compared with other texture descriptors, such as local phase quantization, local binary pattern and local derivative pattern. In all cases, the proposed method obtained the area under the receiver operating characteristic curve and $f - score$ values higher than 0.78 and 0.746 respectively. It was found that both performance measures achieve over 0.995 for DR and AMD detection using a random forest classifier. The obtained results suggest that the proposed technique can discriminate retinal disease using texture information and has potential to be an important component for an automated screening solution for retinal images.

Keywords: Retinal image analysis, diabetic retinopathy (DR), age-related macular degeneration (AMD), computer aided diagnosis (CAD), local tetra patterns (LTrP).

1. Introduction

1.1. Motivation

Age-related Macular Degeneration (AMD) and Diabetic Retinopathy (DR) are the two most prevalent causes of visual impairment [1]. Patients with advanced levels of these retinal diseases are also reported to have a poor quality of life and reduced levels of emotional, social, and physical well-being. As indicated by the World Health Organization (WHO) [2], the global number of people with visual impairment was estimated to be 285 million in 2010 and may rise to 592 million by 2035. It is estimated that early diagnosis would prevent vision loss in 80% of cases.

A retinal fundus image contains crucial information for the detection and grading of various eye diseases. Hence, an assessment of color fundus image is a deciding factor in the diagnosis of eye diseases for choosing the suitable treatment option for patients. Manual disease detection and grading of images generated in large scale screening programs is an inefficient utilization of ophthalmologist's time [3]. The emerging computer-aided technologies provide an opportunity to improve the health-care facility of the population by helping them minimize the number of unnecessary visits to medical experts [4]. Further, automating the early detection of eye disease has the potential to reduce the healthcare costs associated with the treatment which would save millions of dollars every year. Thus, computer-aided decision-making techniques could offer an economical alternative to image interpretation and validation as a means of reducing workload, errors due to fatigue and decrease observational oversight. Additionally, they would produce an accurate report with improved speed, consistency, reproducibility and reduced variability in classification criteria.

This paper presents a Computer Aided Diagnosis (CAD) tool capable of discriminating between the fundus image with DR and AMD signs (abnormal) and without pathology (healthy). Most of the CAD tools analyze the fundus images for presence of lesions characterizing DR or AMD. Lesions indicative to DR are microaneurysms, exudates, hemorrhages and cotton wool spots, whereas those for AMD are drusens [5]. Figure 1 illustrates and highlights the signs of these diseases as compared to healthy retina. In the lesion based approaches, the accuracy of disease classification depends on the accuracy of abnormality detection, which condition their ability of disease classification on the individual lesion segmentation results. On the other hand, texture based approaches do not require a lesion segmentation step and directly map fundus images to retinal

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