Convexity shape constraints for retinal blood vessel segmentation and foveal avascular zone detection

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Abstract

Diabetic retinopathy (DR) has become a major worldwide health problem due to the increase in blindness among diabetics at early ages. The detection of DR pathologies such as microaneurysms, hemorrhages and exudates through advanced computational techniques is of utmost importance in patient health care. New computer vision techniques are needed to improve upon traditional screening of color fundus images. The segmentation of the entire anatomical structure of the retina is a crucial phase in detecting these pathologies. This work proposes a novel framework for fast and fully automatic blood vessel segmentation and fovea detection. The preprocessing method involved both contrast limited adaptive histogram equalization and the brightness preserving dynamic fuzzy histogram equalization algorithms to enhance image contrast and eliminate noise artifacts. Afterwards, the color spaces and their intrinsic components were examined to identify the most suitable color model to reveal the foreground pixels against the entire background. Several samples were then collected and used by the renowned convexity shape prior segmentation algorithm. The proposed methodology achieved an average vasculature segmentation accuracy exceeding 96%, 95%, 98% and 94% for the DRIVE, STARE, HRF and Messidor publicly available datasets, respectively. An additional validation step reached an average accuracy of 94.30% using an in-house dataset provided by the Hospital Sant Joan of Reus (Spain). Moreover, an outstanding detection accuracy of over 98% was achieved for the foveal avascular zone. An extensive state-of-the-art comparison was also conducted. The proposed approach can thus be integrated into daily clinical practice to assist medical experts in the diagnosis of DR.

Keywords: Diabetic retinopathy; Blood vessel segmentation; Convexity shape prior; Foveal avascular zone detection