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PII: S0169-2607(15)30258-3
DOI: http://dx.doi.org/doi:10.1016/j.cmpb.2016.03.001
Reference: COMM 4096

To appear in: *Computer Methods and Programs in Biomedicine*

Received date: 13-10-2015
Revised date: 26-2-2016
Accepted date: 1-3-2016

Please cite this article as: Nagendra Pratap Singh, Rajeev Srivastava, Retinal blood vessels segmentation by using Gumbel Probability Distribution Function based matched filter, *<![CDATA[Computer Methods and Programs in Biomedicine]]>* (2016), http://dx.doi.org/10.1016/j.cmpb.2016.03.001

Retinal blood vessels segmentation by using Gumbel Probability Distribution Function based matched filter

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Abstract

Background and Objective: Retinal blood vessel segmentation is a prominent task for the diagnosis of various retinal pathology such as hypertension, diabetes, glaucoma, etc. In this paper, a novel matched filter approach with the Gumbel probability distribution function as its kernel is introduced to improve the performance of retinal blood vessel segmentation.

Methods: Before applying the proposed matched filter, the input retinal images are pre-processed. During pre-processing stage principal component analysis (PCA) based gray scale conversion followed by contrast limited adaptive histogram equalization (CLAHE) are applied for better enhancement of retinal image. After that an exhaustive experiments have been conducted for selecting the appropriate value of parameters to design a new matched filter. The post-processing steps after applying the proposed matched filter include the entropy based optimal thresholding and length filtering to obtain the segmented image.

Results: For evaluating the performance of proposed approach, the quantitative performance measures, an average accuracy, average true positive rate (ATPR), and average false positive rate (AFPR) are calculated. The respective values of the quantitative performance measures are 0.9522, 0.7594, 0.0292 for DRIVE data set and 0.9270, 0.7939, 0.0624 for STARE data set. To justify the effectiveness of proposed approach, receiver operating characteristic (ROC) curve is plotted and the average area under the curve (AUC) is calculated. The average AUC for DRIVE and STARE data sets are 0.9287 and 0.9140 respectively.

Conclusions: The obtained experimental results confirm that the proposed approach performance better with respect to other prominent Gaussian distribution function and Cauchy PDF based matched filter approaches.

Keywords: Matched filter, Gumbel probability distribution function, Retinal blood vessels segmentation, Entropy based optimal thresholding.

1. Introduction

The retinal blood vessel's structure contains the important information which is helpful for the detection and diagnosis of various retinal pathology such as hypertension [1] glaucoma [2],diabetes [3], [4], [5]. The ophthalmologist scans the retina of the patients by using high resolution fundus camera and then probing the situation of retinal blood vessels to diagnose the retinal diseases [6]. In some cases it is found that the retinal blood vessels have low contrast with respect to their background. So it is difficult to diagnose the retinal disease. Therefore, it is necessary to apply suitable image segmentation technique for accurate detection of retinal blood vessels. These techniques are based on the image features such as the cross-sectional profiles, uniform intensity regions and edges. The intensity of the retinal blood vessel changes smoothly, so normal edge based models such as gradient operators [7], [8], [9], Robert's and Krisch differential operators [10], Prewitt operators [11], Sobel operators [12] are not suitable to identify them accurately.

The author Fraz et al. [13] classify the retinal blood