Feature Extraction Method of Retinal Vessel Diameter

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***Abstract*— Digital image processing is one of the most widely used computer vision techniques, especially in biomedical engineering. Modern ophthalmology is directly dependent on this robust technology, digital image processing to find out the biomarkers analyzing the fundus eye images that are responsible for different kinds of life-threatening diseases like hypertensive retinopathy, Transient Ischemic Attack or sharp stroke. The geometric features like vessel tortuosity, branching angles, vessel diameter, and fractal dimension are considered as the biomarkers for the above-mentioned cardiovascular diseases. Retinal vessel diameter widening has found as the early symptom of transient ischemic attack or sharp stroke. In this paper, a completely new and computer-aided automated method to measure the retinal vessel diameter by employing the Euclidean Distance Transform technique was developed. The proposed algorithm measures the Euclidean Distance of the bright pixels exist on the Region of Interest (ROI). Further, the Vascular Disease Image Set (VDIS) and Central Light Reflex Image Set (CLRIS) of Retinal Vessel Image Set for Estimation of Width database were used to evaluate the performance of the proposed algorithm that measures the vessel diameter. The proposed algorithm obtained 98.1% accuracy for the CLRIS and 97.7% accuracy for VDIS. With further evaluation, validation and enhancement of the method, it can be integrated into the clinical computer-aided diagnostic tool.**

Keywords*— *Image Processing, Segmentation, Feature Extraction, Retinal Vessel Diameter, Hypertensive Retinopathy.

I. INTRODUCTION

Image processing is defined as the application of mathematical operations that are applied in signal processing [1]. In image processing, image or video is given as the input and the image or a group of feature or parameters that are related to the image can be extracted as the output [1]. Digital image processing is being applied to biomedical engineering to diagnose the diseases, plan and supervise that diseases monitor the state of the diseases simultaneously [2]. Some of the life-threatening cardiovascular diseases like hypertensive retinopathy and stroke are related to the changes in the microvasculature features of retinal blood vessels. To diagnose these diseases, analysis of the human fundus eye images has become the key point because of the simple and non-invasive visualization of the microvascular structure of retinal blood vessels [3]–[6].

Some changes in retinal microvascular structure are considered as the symptom of a subsequent vascular incident like Transient Ischemic Attack (TIA) or acute stroke [7]. The ocular funduscopic abnormalities and acute stroke show a close association even-though the vascular risk factors and blood pressure are in control [8]. The study with multiethnic cohort revealed that the retinal arteriolar narrowing found as associative with an increased risk of acute stroke [9]. There found the association with the changes of retinal venular diameter and stroke in Rotterdam cohort study [10] and [11] found the association of retinopathy and venular widening with incident stroke. According to the cohort study of Asian Malay persons, it can be stated that the incident stroke can be predicted by exploring the changes of features of retinal microvasculature [12]. Hypertensive retinopathy that has the association with stroke also can be predicted by analyzing retinal vessel widening [13].

To develop the systems for computing retinal vessel diameter image processing principles are being used widely. Some of the techniques for computing retinal vessel diameter were developed based on graph-theoretic method [14], [15] mask creation [16], Linear Discriminant Analysis (LDA), image gradient segmentation technique (ARG) for vessel edge detection, using active contour [16], [17], Adaptive Higuchi's Dimension [18] and Multi-Step Regression Method (Higher order Gaussian modeling) [19]. [20] developed an algorithm based on supervised learning performed by bagged decision trees and an extended multiresolution Hermite model presented the 100% success rate. This algorithm was evaluated with all four datasets of Retinal Vessel Image Set for Estimation of Width (REVIEW) database and showed the maximum stability with a good standard deviation of the point to point difference for all the datasets [20] . The performance of ESP algorithm of [17], graph-theoretic method of [14], [15], ULDM of [21], deformable model-based algorithm of [22] and Adaptive Higuchi's Dimension based algorithm of [18] were poor and showed less accuracy due to the large deviation of the mean diameter of retinal blood vessel while evaluating with CLRIS and VDIS datasets. Due to the presence of diabetic abnormalities nearby the vessel boundaries, the success rate of [21] on HRIS dataset was degraded. The testing of several algorithms on the VDIS dataset led the resultant to have poor accuracy with a large deviation [3],[21] as the dataset is mostly used in pathological purpose and the images of that dataset are noisy with a lower resolution [3]. The performance of the algorithm of [17] was affected as the edges of the vessels of CLRIS data set are highly blurred [3].

In this study, a new automated method for retinal vessel diameter measurement has been proposed. To evaluate the proposed method the images from Vascular Disease Image Set (VDIS) and Central Light Reflex Image Set (CLRIS) of the Retinal Vessel Image set for Estimation of Width (REVIEW) database were used. REVIEW is another publicly available standard dataset that includes various normal and pathological retinal images for the evaluation of the algorithm for retinal vessel diameter measurement [23].