CALIFORNIA STATE SCIENCE FAIR
2012 PROJECT SUMMARY

Name(s)

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Project Number

S1402

Project Title

A Novel Approach Applying Image Processing Techniques on Retinal Images for Vessel Extraction

Abstract

Objectives/Goals

Develop and implement an accurate image processing algorithm to address challenges in vessel extraction for retinal images in order to help the diagnosis and prevention of retina-related blindness.

Methods/Materials

Major steps include edge detection, false edge removal, vessel junction restoration, and vessel labeling.

(1) Edge detection: Apply Canny Edge Detector to the input image to establish a baseline upon which our algorithm will further improve.

(2) False edge removal: Remove misidentified segments by Canny Detector. Our program creates a histogram of frequency vs. pixel-count, which looks like a y=1/x curve whose vertex point is used as the threshold to remove objects with fewer pixels.

(3) Vessel junction restoration: Fix broken junctions introduced by Canny Detector. At a broken junction, track and find the direction of a vessel. Extend the vessel in the opposite direction for a certain length. If another vessel is found, bridge the gap and restore the vessel junction. Our experiments produce good results with a length extension up to nine sigma (the standard deviation used in the directive of Gaussian).

(4) Vessel labeling: A typical vessel is represented as two parallel edges. This step fills the interior pixels of a vessel. The challenge is to distinguish the area within a vessel and the area between two different vessels that are parallel to each other. Our algorithm traces the opposite direction of the gradient vector (the inward direction) to find the pairing edge of the same vessel.

Results

We run our algorithm in MATLAB against the twenty test images in the DRIVE database. The average accuracy is 92.78% with a standard deviation of 0.54%. The accuracy rate ranks 3rd among six published methods, including supervised methods (i.e. methods that require training). Excluding the supervised methods, our algorithm's accuracy ranks second. In addition, our algorithm runs efficiently and takes 8 to 10 seconds per image on a laptop with an Intel Core i5 at 2.3 GHz.

Conclusions/Discussion

This project develops an effective junction restoration algorithm and a novel vessel labeling method. Combined with Canny Edge Detector, our algorithm produces a high average accuracy rate of 92.78%, and the accuracy rate is very consistent from image to image (with 0.54% standard deviation). Our algorithm also runs efficiently, taking less than 10 seconds per image on a home computer.

Summary Statement

This project develops an effective junction restoration algorithm and a novel vessel labeling method to accurately and efficiently extract vessels from retinal images to help the diagnosis and prevention of retina-related blindness.

Help Received

Dr. Chang advised on the basic principles behind Canny Edge Detector. Parents purchased MATLAB licenses for students to use.