Author(s)
Principal: Young Kwon
Presenting: Young Kwon, M.D.
Contributing: Michael D. Abramoff, MD PhD
Wallace L.M. Alward, MD
Emily C. Greenlee, MD
Lesya M. Shuba, MD PhD
Chan Y. Kim, MD PhD and John H. Fingert, MD PhD

Abstract Title:
Automatic cup-to-disc segmentation from stereo color fundus photographs using pixel feature classification algorithm

Purpose:
To evaluate a novel computer image processing algorithm for cup-to-disc (C/D) segmentation from stereo color fundus photographs

Design:
Consecutive case series

Participants:
101 eyes of 70 glaucoma subjects

Main Outcome Measures:
Correlation of linear C/D ratio to reference standard

Methods:
101 stereo color optic disc photographs taken by a fixed stereo-base fundus camera (Nidek 3Dx) from 70 consecutive patients from the Univ of Iowa Glaucoma Service were studied. Cases were chosen based on image quality of the photographs. Each set of stereoscopic photographs was digitized, viewed stereoscopically using hand-held stereoscope, and computer-aided planimetry was performed to delineate disc and cup margins by 3 glaucoma faculty experts and 3 glaucoma fellows in a masked fashion. The reference standard for cup and disc boundaries was determined from the 3 glaucoma faculty drawings using a “majority win” strategy for each pixel. Linear C/D ratio (square root of area cup-to-disc ratio, or LCDR) was calculated from the each of the optic discs based on the reference standard.

Categorized pixels and LCDR from the fellows were compared to the reference standard.

Feature vectors were calculated for each pixel in the image, including color-opponency at multiple scales, Gabor and Gaussian wavelet filters, and mathematically simulated simple and complex cells (derived from primate visual cortex). Optimal set of features was selected by calculating the accuracy of various combination of features against the reference standard using 51 randomly selected stereo images as training, and the remaining 50 as testing set. Using the optimal features, the algorithm then classified all pixels in each stereo image into cup, rim, or background (outside disc margin). LCDR was calculated from each classified image and was compared to that of the reference standard.

Results:

The LCDR correlations between the 3 fellows and reference standard were 0.74 (95% CI: 0.67-0.84), 0.84 (CI: 0.77-0.89), and 0.90 (CI: 0.85-0.93). The LCDR correlation between the pixel feature classification algorithm and reference standard was 0.92 (CI: 0.88-0.94). In general, there was good agreement of the C/D boundaries determined by the algorithm and reference standard.

Conclusion:

The performance of the disc segmentation and LCDR calculation of the algorithm was comparable to glaucoma fellows. Pixel feature classification of stereo optic disc photographs can be optimized to detect disc and cup margin without human input, and holds promise as a clinical tool for objective, quantitative optic disc analysis.