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Improvement Of Confocal Scanning Laser ophthalmoscope Images Using Polarimetry

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Abstract

Purpose: Polarimetry has been used to improve imaging in nonophthalmic applications. We have used Mueller-matrix polarimetry to reduce the noise and improve the contrast of retinal fundus images, in the living human eye, taken with a confocal scanning laser ophthalmoscope (CSLO).
Methods: A rotating polarimeter was incorporated into a confocal imaging system, which was used in both microscope (two samples, associated with specular and diffuse reflections) and ophthalmoscope modes (to image the fundus). The spatially resolved Mueller matrix of the sample was calculated using a series of 16 images for independent combinations of polarization states in the polarimeter. Once the Mueller matrix is known, images of the sample for any polarization state can be reconstructed using the Stokes-Mueller matrix formalism. This procedure allows images to be obtained for polarization states that are difficult to produce experimentally. Both the best and the worst images (weighting global contrast and noise) were computed as a function of the polarization state in the incident light.
Results: Images for all the possible incoming polarization states (covering the Poincare sphere) were obtained. In both modes, the best image displays a noticeable improvement with respect to the original. Between the original and the best images, image quality improved 48% and 70% for the specular and diffuse microscope targets, respectively and 45% and 59% for the fundus images in two subjects (for differing best input polarization states). These improvements are better than those for frame averaging. In contrast, the worst images are poorer than the originals. In addition, the contrast across retinal blood vessels was calculated for fundus images and an increase of up to 30% was found.
Conclusion: The quality of images from a confocal system is dependent on the incoming polarization state. An optimum polarization state, which is subject specific, can be chosen for improved fundus imaging. The improvement in CSLO imaging of the fundus is of particular interest to clinical diagnosis.

Keywords: 432 imaging methods (CT, FA, ICG, MRI, OCT, RTA, SLO, ultrasound) • 430 imaging/image analysis: clinical • 500 optical properties