Arbitrary-Angle Split-Detection Using a Rotational Dove Prism in Adaptive Optics Scanning Light Ophthalmoscopy

Ruth E. Woehlke,[1] Mina Gaffney,[1] Ching Tzu Yu,[2] Hannah M. Follett,[2] Chloe Guillaume,[3] Joseph Carroll,[1,2,3] Robert F. Cooper[1,3]

[1]Joint Department of Biomedical Engineering, Marquette University and Medical College of Wisconsin;
[2]Department of Cell Biology, Neurobiology, and Anatomy, Medical College of Wisconsin;
[3]Department of Ophthalmology and Visual Sciences, Medical College of Wisconsin

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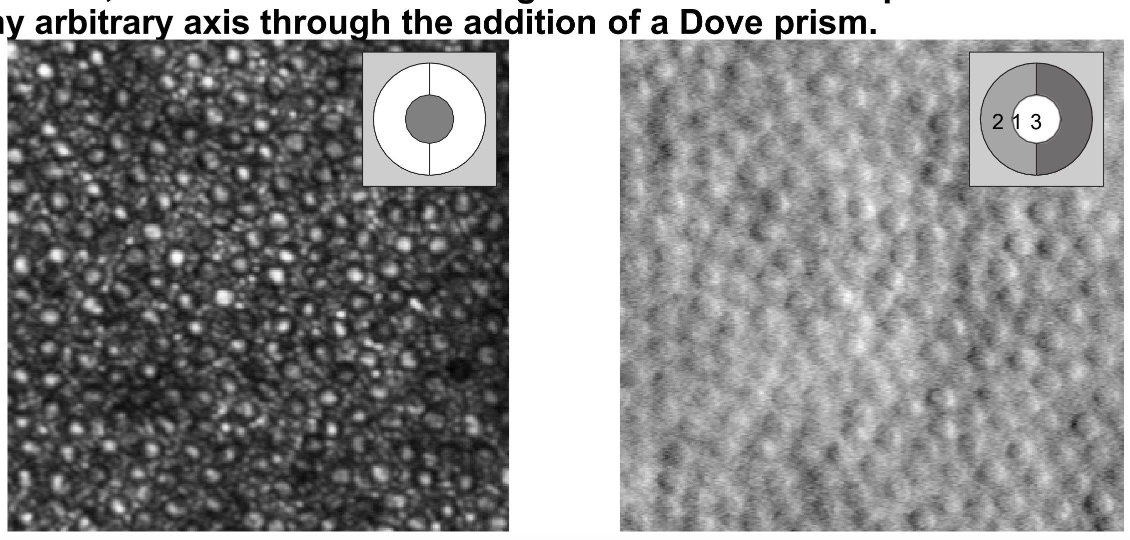
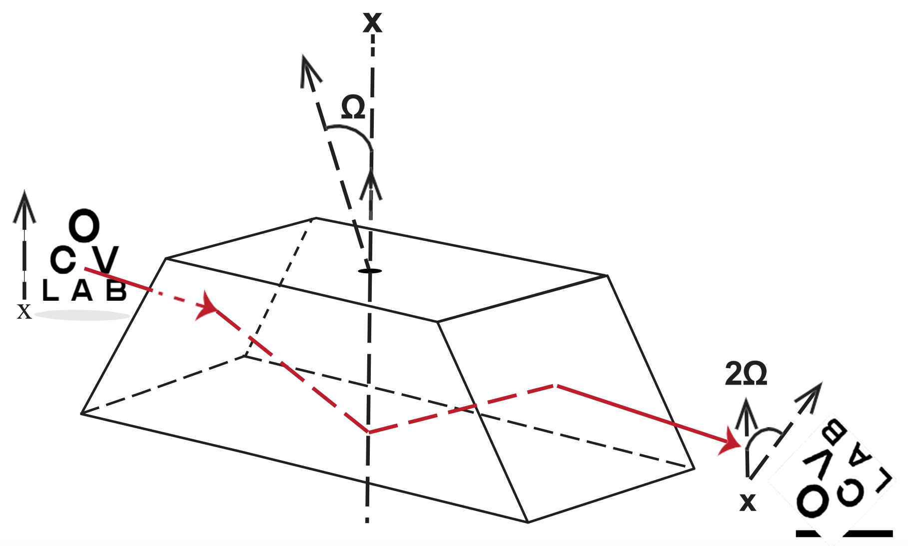
1 Background: The Theory of Light for AOSLO Imaging

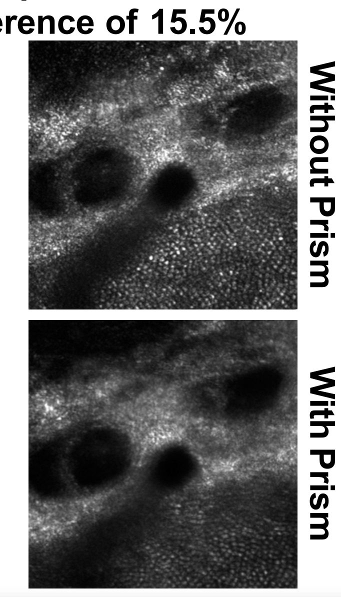
Backscattered light in a point-scanning device can be separated into confocal and non-confocal components; confocal light is often captured through pinhole and non-confocal light captured using a variety of detection schemes [1]. In adaptive optics scanning light ophthalmoscopy (AOSLO), differential phase contrast was achieved by dividing the non-confocal light across two detectors in a 'split-detection' regime [2]. In this approach, the visibility of structures was directly linked to the orientation of the split mirror and the geometry and orientation of the imaged object. As a result, features oriented off-axis to the detectors exhibit significantly decreased contrast [3]. To overcome this, we modified an existing AOSLO to enable split-detection of features along any arbitrary axis through the addition of a Dove prism.



2 Rotating the Normal: Dove Prisms as Image Rotators

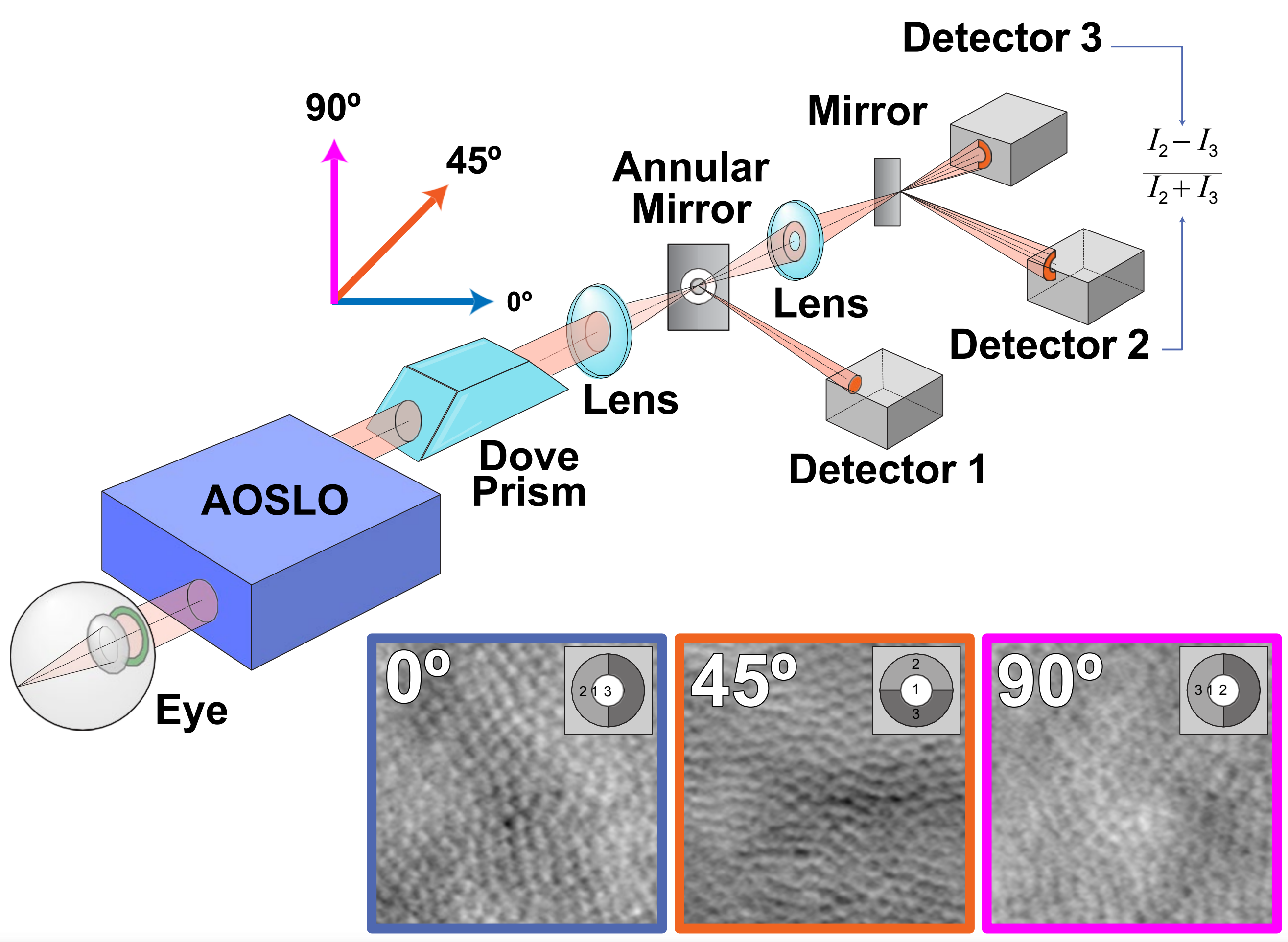
- Dove prisms rotate an image about their optical axis through total internal reflection when light rays travel parallel to the base of the prism [4]
- A prism rotation of Ω results in an image rotation of 2Ω [4]
- Revolution of the prism enables the resolution of features along any arbitrary axis
- Confocal images taken with and without the prism show comparable contrast and brightness (shown right) despite a PMT control voltage difference of 15.5%





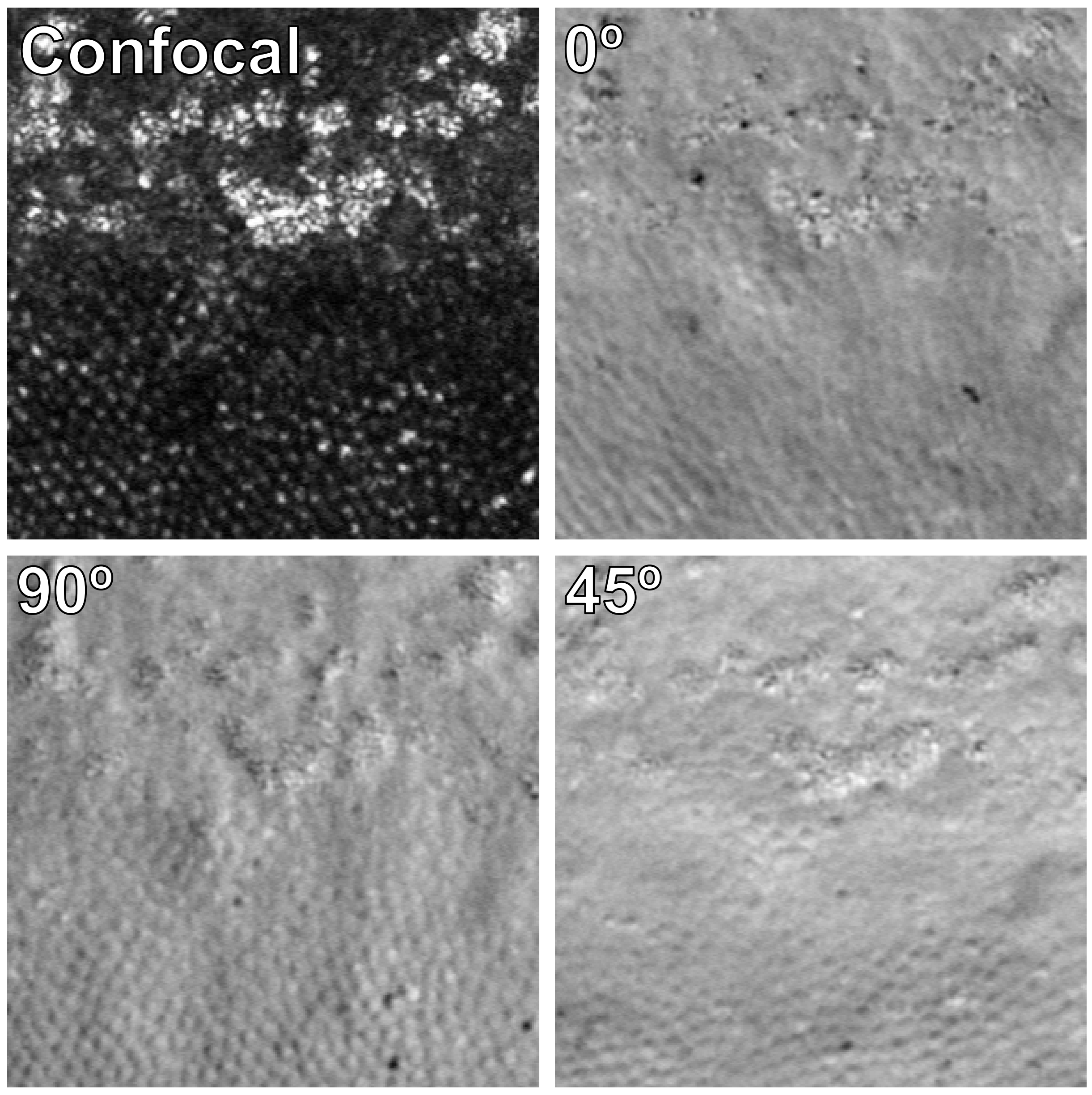
3 Bending Light: Implementation of the Dove Prism in AOSLO

- A Dove prism was placed in the detection arm of an animal-centric AOSLO [5]
- The method was validated by imaging five 13-lined ground squirrels with and without retinal pathologies at both inner and outer retinal foci
- Three sets of images of the retina were acquired with prism rotations of 0º, 45º, and 90º, equating to final image orientations of 0º, 90º, and 180º respectively
- Both image modalities at each prism rotation were aligned using previously described strip-wise registration software [6]



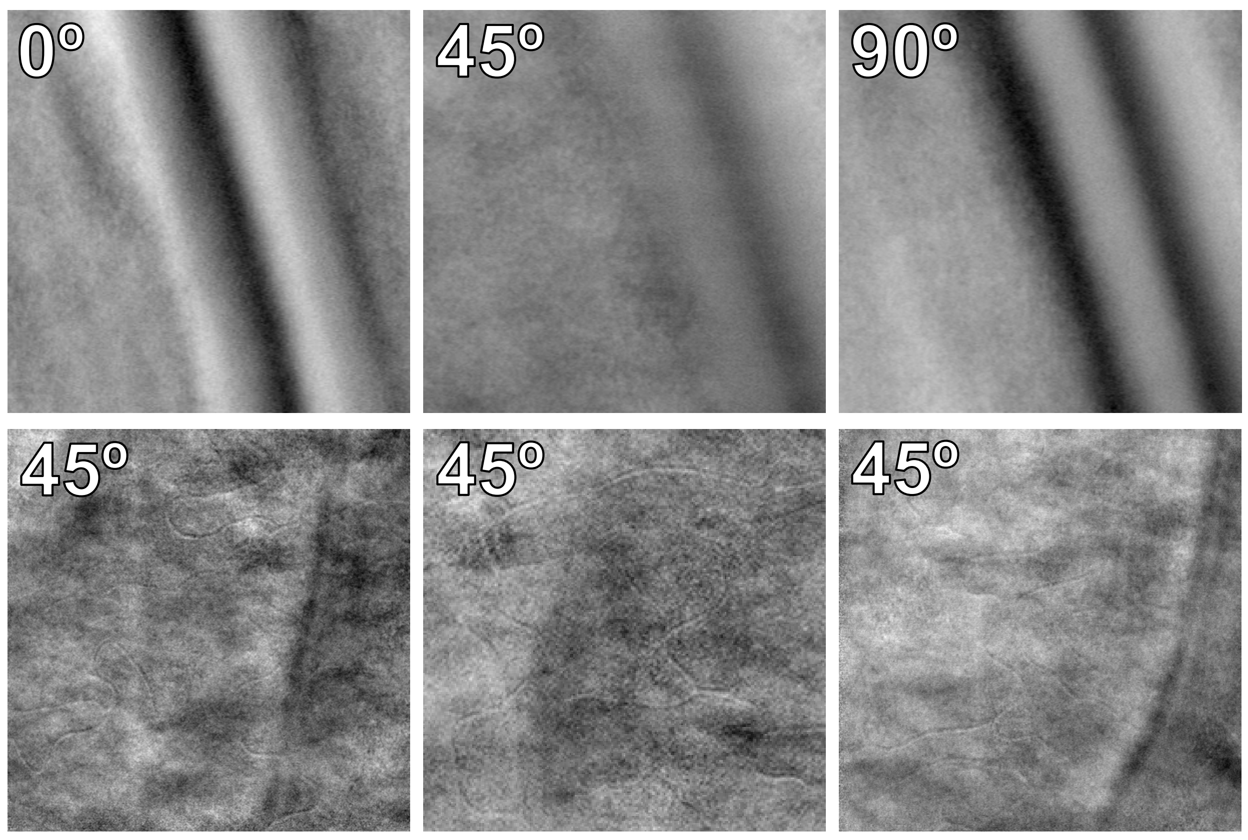
4 Prism Rotations for Morphological Changes

- As expected, confocal images demonstrated minimal changes in appearance as a function of prism rotation
- Split detection images showed marked changes in appearance (0º, 45º, 90º, below); changing the prism angle revealed topographical differences
- All split detection images exhibited similar image quality and contrast (RMS: 21.8 ± 3.5)



5 Uncovering the Unseen: Resolution of Off-Axis Features

- Inner retinal images revealed previously hidden off-axis structures
- This relationship was observed in both small and large inner retinal features
- Enables accurate calculations of vascular morphology and width



6 Conclusions and Future Directions

- Dove-prism enhanced split-detection can resolve features regardless of their orientation to the detector
- Use of a Dove prism allows for reduced complexity and cost compared to other approaches
- Future work will examine the use of a Dove prism for split detection in humans and fully explore its' use for any prism rotation

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