

Biological Applications of Spectral Polarization-Difference Imaging

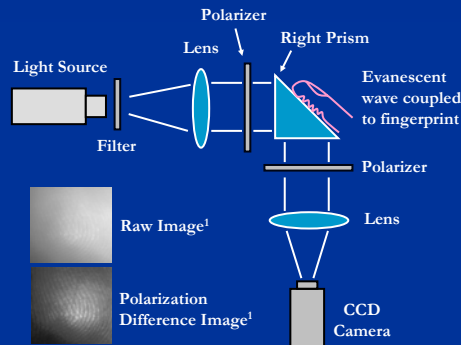
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Overview

We are investigating the effectiveness of polarization and wavelength filtering of images to detect faint or invisible targets in turbid (highly scattering) media. Applications include noninvasive skin cancer detection, fingerprint identification, and environmental sensing. We also wish to learn more about how certain animals navigate and communicate using polarized light. Our experiments involve relatively simple imaging and image processing techniques. We typically use LabVIEW IMAQ software and optical elements such as linear polarizers, liquid crystal variable retarders, spectral filters, and CCD cameras.

Fingerprinting with Polarized Total Internal Reflection



Refs. 1,2

General Procedure

- Use LabVIEW IMAQ to take two images: one with parallel polarizers (I_{\parallel}) and one with crossed polarizers (I_{\perp}).
- Use an affine transformation to calculate a polarization-difference image (PDI):

$$\Delta I = I_{\parallel} - I_{\perp}$$

$$PDI = 255 \cdot \frac{\Delta I - \Delta I_{\min}}{\Delta I_{\max} - \Delta I_{\min}}$$

(max and min refer to pixel intensities)

This transform utilizes the entire grayscale spectra of the 8-bit images and prevents intensity clipping.⁶⁻⁸

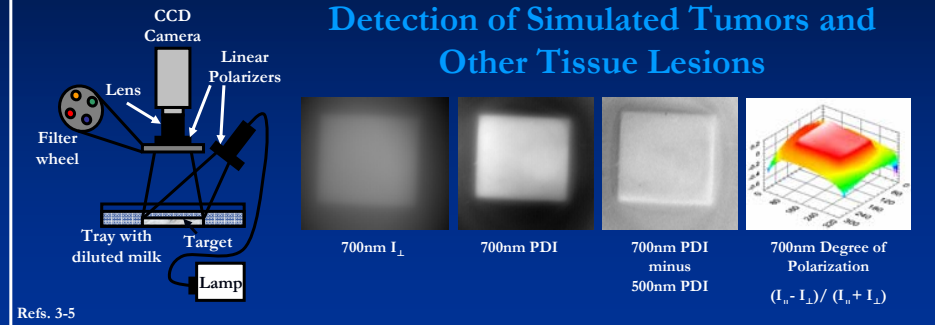
- Repeat at different wavelengths and subtract results for final spectral polarization-difference image (SPDI)

(variations of this algorithm are also used)

Acknowledgement

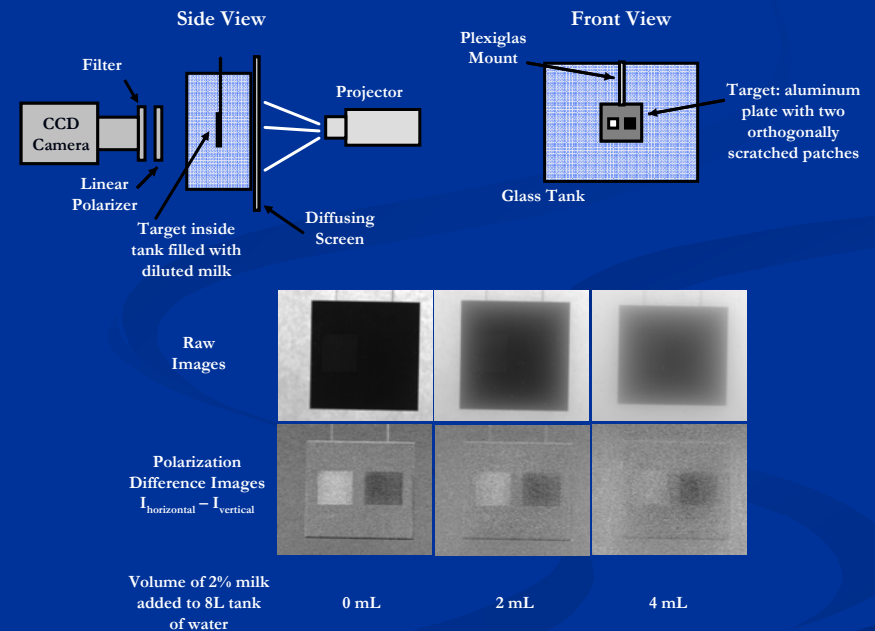
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Detection of Simulated Tumors and Other Tissue Lesions



Refs. 3-5

Animal Vision and Environmental Sensing



Refs. 6-8

References

1. A. Doctor, New York State Center for Advanced Technology in Ultrafast Photonics at CUNY, www.cunyphotonics.com (we borrowed their images—we'll have our own soon)
2. A.M. El-Saba, *Proceedings of SPIE Vol. 5432* (SPIE, Bellingham, WA, 2004).
3. J.H. Ali *et al*, *Optics Letters*, 25 (17), 1303 (2000)
4. S. G. Demos, H. B. Radousky, and R. R. Alfano, *Optics Express*, 7 (1), 23 (2000)
5. K. Yemelyanov *et al*, *Proceedings of SPIE Vol. 5158* (SPIE, Bellingham, WA, 2003).
6. M. P. Rowe *et al*, *Optics Letters* 20 (6), 608 (1995).
7. J. S. Tyo *et al*, *Applied Optics* 35 (11), 1855 (1996).
8. J. S. Tyo *et al*, *J. Opt. Soc. Am. A* 15 (2), 367 (1998).