Conference 7187: Biomedical Applications of Light Scattering III

Saturday-Monday 24-26 January 2009 • Part of Proceedings of SPIE Vol. 7187
Biomedical Applications of Light Scattering III

7187-01, Session 1

Diffuse optical spectroscopy of melanoma-simulating silicone phantoms

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Currently the only method for positively identifying malignant melanoma involves invasive and often undesirable biopsy procedures. Available ex-vivo data indicates increased vascularization in the lower regions of excised melanoma, as compared to dysplastic nevi. The ability to interrogate this region of tissue in-vivo could lead to useful diagnostic information. Using a newly developed fiber based superficial probe in conjunction with a steady-state frequency-domain photon migration (SSFDPM) system, we can probe the upper 1-2 mm of tissue, extracting functional information in the near infrared (650-1000 nm) range. To test the resolution and detection range of the superficial probe in this context, deformable silicone phantoms have been fabricated that simulate normal skin with melanocytic lesions. These phantoms consist of a two-layered matrix with the optical properties of normal light skin, containing several cylindrical inclusions that simulate highly absorbing pigmented lesions such as melanoma. These inclusions are varied in depth, diameter, and optical properties in order to fully test the probe's detection capabilities. It was found that, depending on absorption, we can typically probe to a depth of 1.0-1.5 mm in an inclusion, likely reaching the site of angiogenesis in an early-stage melanoma. Additionally, we can successfully interrogate normal tissue below lesions 1.5mm deep when absorption is about 0.4/mm or less. This data indicates that the superficial probe shows great promise for non-invasive diagnosis of pigmented lesions.

7187-02, Session 1

Multispectral absorption and scattering mapping in layered phantoms and in vivo

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Modulated imaging (MI) uses spatially modulated light in a non-contact geometry to provide quantitative maps of absorption and scattering in diffusive media. The absorption and scattering quantities can be used to calculate tissue biochemical information, such as concentrations of oxy- and deoxy-hemoglobin, lipids and water, and tissue structural integrity. In this work, we are concerned with layered tissue structures in which tissue absorption and scattering may differ between distinct stratified layers of tissue, such as skin. We explore layered tissue models to extract and map information from individual layers in phantoms and tissue. We show that layered models allow for extraction of optical properties from individual layers that would otherwise be combined when fitting with homogeneous models that do not account for layered structure.

7187-03, Session 1

Experimental observation of polarization, angular and azimuth properties of low coherence enhanced backscattering spectroscopy

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Low Coherence Enhanced Backscattering Spectroscopy (LEBS) is a technological breakthrough which allows for spectroscopic measurements of enhanced backscattering (EBS) from tissue. The technique has shown great promise for detecting several types of cancer. A high sensitivity of these measurements for detecting cancer is due to the LEBS peak having a reduced penetration depth that is tunable to correspond with the epithelial layer thickness, in addition to wavelength-resolved measurements, reduced speckle, and more than 100-fold broadening in tissue as compared to conventional enhanced backscattering which is obtained with laser sources. Two of the vital elements for measuring LEBS spectroscopy are white light illumination with a reduced spatial coherence length (Lsc) and the capability of wavelength resolved measurements. Here we report the design of an LEBS spectroscopy system which is capable of measuring the peak in four Dimensions. The LEBS peak is characterized from polystyrene microsphere solutions in water to determine its properties as a function of backscattering angle, azimuth, wavelength, and spatial coherence length of illumination. The properties of LEBS as a function of the azimuth angle have heretofore never been explored experimentally. Furthermore, the system is capable of determining optical properties for a range of selected depths, which is highly advantageous in layered media such as tissue.

7187-04, Session 1

Relationship of low-coherence enhanced backscattering spectroscopy measurements to optical properties of scattering media

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Low-coherence Enhanced Backscattering Spectroscopy (LEBS) is a technique used to measure subtle changes in micro-architecture of random scattering media such as biological tissues. The technique makes use of the coherent interference of time reversed light paths through the media that form an intensity peak in the retro-reflection direction of the incident light. The method is an extension of Enhanced BackScattering (EBS) that employs a small yet finite spatially coherent beam. This low-coherence beam provides advantages over EBS by eliminating laser speckle, broadening the peak to a more easily resolved angular scale, and limiting the depth of penetration to a superficial layer of the medium. LEBS also has the advantage of using broad band illumination or white light. This illumination mode enables the spectroscopic study of LEBS.

By measuring and characterizing the peak shape and spectral dependence, slight differences in the scattering medium which are visually indistinguishable can be differentiated. Relating the characteristics of the peak to changes in optical properties of the medium allows for a better understanding of the roll of LEBS in discriminating healthy and disease states. This paper describes an analytical model and corresponding numerical simulations that relate the LEBS peak shape to the optical properties chosen to model a scattering medium. The analytical model, which must make use of some approximations, provides insight into the dependence of LEBS peak shape to the scattering phase function and mean free path. Monte Carlo simulations provide additional support by treating higher order scattering events for a range of optical properties.

7187-05, Session 2

Turbidity suppression through optical phase conjugation in living tissues

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Elastic light scattering is the dominant process through which light is attenuated as it travels through biological tissue. This sets a limit for optical imaging techniques in terms of penetration depth, and information is lost due to multiple scattering. We have shown that information passing through a scattering media can be recovered using a technique termed turbidity suppression through optical phase conjugation (TSOPC). Taking advantage of the fact that elastic light scattering is deterministic, holographic methods