Optical imaging of biological tissue using advanced spatial frequency domain techniques

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Determining the structural orientation of biological tissue is a sought-after feature in medical imaging, and is currently being utilized in diffusion tensor magnetic resonance imaging (DT-MRI). We are currently developing an optical analog to DT-MRI by applying advanced techniques to an imaging modality known as spatial frequency domain imaging (SFDI). SFDI is a wide-field, non-contact, near-infrared imaging modality that employs spatially-modulated plane waves to separate light scattering from absorption in its measurements. The interrogation depth of these plane waves can be controlled by varying their modulation frequency. By employing multiple spatial frequencies, we can probe multiple depths, and thus perform SFDI tomography. However, since multiple spatial frequencies are required to process these datasets, the speed at which we are currently capable of performing tomography is limited. We have developed a synthesis technique to process SFDI frames containing multiple spatial frequency components, which allows for custom modulation patterns to generate reconstructions with fewer frames of data. Using this new technique, we show good demodulation quality on a tissue phantom. We also show excellent agreement in optical property calculations between the synthesis technique and conventional SFDI. In addition to spatial frequency synthesis, we can vary the projection angle of custom n patterns to probe tissue orientation. We have used this principle to assess the orientation and anisotropy of tissue structures such as rat tail tendon collagen. This research will be used to assess medical conditions that involve the degradation of ordered tissue structures such as burn wounds and Alzheimer’s disease.