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Design and Performance Validation of Phantoms Used in Conjunction with Optical Measurements of Tissue

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Introduction

This was the first year for this conference on optical phantoms. The 24 presentations were arranged into five sessions covering a wide range of topics in phantom design and use. Presenters were in agreement that the phantoms must accurately mimic absorption and scattering characteristics of tissue within a desired spectral region, but the methods for achieving these tissue characteristics varied. TiO_2 remains a favorite compound for creating scattering in phantoms, and India ink is a useful absorber. However, when more complex tissue qualities such as polarization reflectance or oxy- deoxy-hemoglobin ratio are to be simulated, the phantoms themselves become more complex. This conference attracted speakers with backgrounds in these and other uses of phantoms, making the conference timely and interesting to a broad audience.

The opening session focused on dynamic phantoms needed for optimization of device performance for *in vivo* studies. Two invited presentations demonstrated that there are several ways to approach the need to mimic active properties of tissue such as blood perfusion or biochemical processes. Dr. Randall Barbour presented data showing that liquid crystal devices embedded in geometrically accurate phantoms can simulate the dynamics of hemoglobin in large tissue structures for near infrared measurements. In the second invited presentation of the opening session, Dr. Rohit Bhargava suggested the use of engineered tissue as a suitable phantom with dynamic properties and sufficient lifetime to be useful.

Both the National Institute for Standards and Technology (NIST) and the Food & Drug Administration (FDA) are active stakeholders in the development and use of phantoms for device performance testing. A Hyperspectral Image Projector (HIP) was described by Dr. Steven Brown of NIST. Here, a quantitative image containing the spectral information in each pixel, rather than simply an image color rendition can be projected for testing of spectroscopic devices designed for diagnosis or screening. Dr. Agrawal of the FDA gave a detailed overview of the successes experienced by the use of phantoms in other imaging methodologies, and challenged the optical community to follow these examples.

Optical phantoms designed specifically for use with a particular optical imaging methodology must not only mimic the bulk properties of the tissue, but must also duplicate the finer qualities interrogated by the optical technique. Polarization measurements represent just such a challenge to phantom construction. Not only must these phantoms give faithful representation to the scattering and absorption properties of the tissue, but they must also duplicate polarization and depolarization characteristics of the tissue. These and other specific topics were presented in a special session.

Finally, multimodal devices that combine different imaging methodologies to gain sensitivity and specificity offer unique difficulties when attempting to create accurate phantoms. Not only must the phantom imitate a set of tissue characteristics for one imaging method, it must also imitate the tissue characteristics of the other imaging method as well. Chulhong Kim presented results of his work to create tissue phantoms to mimic the optical and acoustic properties of phantoms for his studies of the optical and ultrasound characteristics of tissue.

The planning committee judged this first presentation of a forum for discussing optical phantom design and use to be a success. It was recommended that the conference be repeated next year.

Robert J. Nordstrom