Chemistry of Contrast Media

Basic Considerations about Suitable Modalities and Probes

Physical limits of optical, photoacoustic and ultrasound imaging: sensitivity, specificity and quantitation

Stanislav Y. Emelianov
Biomedical Engineering, University of Texas at Austin, Austin, TX, USA

Learning Objectives:

- Understand the fundamental principles of optical, ultrasound and hybrid (i.e., photoacoustic) imaging techniques
- Know how optical/ultrasound/photoacoustic images are formed
- Understand how imaging contrast agents can enhance contrast, signal-to-noise ratio and penetration depth in optical/ultrasound/photoacoustic imaging
- Understand the ability of optical/ultrasound/photoacoustic imaging system to visualize desired properties of imaged tissue using imaging contrast agents or probes
- Identify the role of contrast agents in basic science and clinical applications

This primary purpose of this presentation is to provide a broad overview of optical, ultrasound and hybrid (i.e., photoacoustics, IVUS/OCT) imaging techniques and to discuss the strengths and weaknesses of these technologies. Basic physics of each imaging modality will be introduced, and contrast mechanisms, imaging contrast agents or imaging probes, and sources of noise and artifacts will be discussed. Finally, examples of biomedical and clinical applications of each imaging technology will be given. To archive these objectives, we will start with foundations of optical and ultrasound imaging, including brief discussion of governing equations. We will also review relevant optical/acoustic properties of the tissues. The experimental aspects of optical, ultrasound and hybrid imaging will be then discussed with emphasis on instrumentation, i.e., system hardware and signal/image processing algorithms. Specifically, penetration depth and spatial/temporal resolution of each imaging modality will be analyzed in relationship to an energy source, a sensor and other components of the imaging system. Techniques to increase contrast and to differentiate various tissues will be presented. Main emphasis, however, will be placed on design, synthesis and optimization of imaging contrast agents and probes to enable quantitative and/or molecular/cellular imaging. We will discuss design of system and contrast agents capable of multiplexed imaging, multi-modal imaging and image-guided therapy including drug delivery and release. The presentation will continue with an analysis of sensitivity and specificity of optical, ultrasound and hybrid imaging. Regulatory aspects of imaging contrast agents or probes will be presented. Finally, examples of biomedical and clinical applications of optical, ultrasound and photoacoustic imaging will be provided to stress fundamental similarities between the imaging modalities and to highlight vital differences between different imaging techniques. The presentation will conclude with discussion of future directions in optical, ultrasound and hybrid imaging.

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