Lights, Sound, and Action: Multimodal Ultrasound and Photoacoustic Imaging Strategies for Pre-clinical and Clinical Applications

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Abstract

Advanced multimodal imaging techniques offer a powerful means to study complex disease mechanisms in pre-clinical models and significantly enhance diagnostic and therapeutic outcomes in clinical settings. While conventional multimodal imaging modalities such as Magnetic Resonance Imaging, Positron Emission Tomography, and X-Ray Computer Tomography have garnered substantial clinical relevance, their bulky nature and high cost render them impractical for point-of-care applications. Moreover, these modalities often lack the necessary spatiotemporal resolutions to effectively capture dynamic events within living subjects. To address these limitations, we have developed novel multimodal optical, ultrasound and photoacoustic imaging systems and integrated them with model-based machine learning tools for providing complementary contrasts, scalable resolution and enhanced image quality. In this talk, I will present our multimodal imaging results for pre-clinical and clinical applications covering cancer, neurological and vascular diseases. This includes **(i)** first-in-human prostate cancer molecular imaging using a transrectal endoscope; **(ii)** the development of a portable system for diagnosing peripheral arterial disease in resource poor settings; **(iii)** studying brain cancer mechanisms in pre-clinical rodent models; and **(iv)** studying mechanisms of ultrasound neuromodulation using multimodal microscopy. These biomedical innovations at the interface of multimodal learning and instrumentation enable us to pioneer a new era of precision imaging for improved disease understanding and patient care.

Biography: Dr. Raj Kothapalli is an associate professor in the Department of Biomedical Engineering and Penn State Cancer Institute, at the Pennsylvania State University. He earned his Ph.D. in Biomedical Engineering from Washington University in St. Louis in 2009 under the guidance of Dr. Lihong Wang. From 2009 to 2013, he received postdoctoral training from Dr. Sam Gambhir in the Molecular Imaging Program at Stanford University. Dr. Kothapalli served as an instructor in the Department of Radiology at Stanford University from 2014 to 2016, during which time he conducted the first-in-human photoacoustic prostate imaging studies. Since 2017, he has led the BioPhotonics and Ultrasound Imaging lab at Penn State, which focuses on developing novel multimodal imaging strategies combining optical, ultrasound and photoacoustic technologies. Dr. Kothapalli was awarded the Hamalainen Peter Michael Postdoctoral Fellowship from the Sir Peter Michael Foundation (2009 to 2012), the K99-R00 NIH Pathway to Independence award in 2014, and the NSF CAREER award in 2023.

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