The Department of Electrical and Computer Engineering Presents

A DISTINGUISHED SEMINAR

PROFESSOR LIHONG V. WANG

WORLD'S DEEPEST-PENETRATION AND FASTEST OPTICAL CAMERAS: PHOTOACOUSTIC TOMOGRAPHY AND COMPRESSED ULTRAFAST PHOTOGRAPHY

ABSTRACT

We developed photoacoustic tomography to peer deep into biological tissue. Photoacoustic tomography (PAT) provides in vivo omniscale functional, metabolic, molecular, and histologic imaging across the scales of organelles through organisms. We also developed compressed ultrafast photography (CUP) to record 10 trillion frames per second, 10 orders of magnitude faster than commercially available camera technologies. CUP can tape the fastest phenomenon in the universe, namely, light propagation, and can be slowed down for slower phenomena such as combustion.

PAT physically combines optical and ultrasonic waves. Conventional high-resolution optical imaging of scattering tissue is restricted to depths within the optical diffusion limit (~1 mm in the skin). Taking advantage of the fact that ultrasonic scattering is orders of magnitude weaker than optical scattering per unit path length, PAT beats this limit and provides deep penetration at high ultrasonic resolution and high optical contrast by sensing molecules. Broad applications include early-cancer detection and brain imaging. The annual conference on PAT has become the largest in SPIE's 20,000-attendee Photonics West since 2010.

CUP can image in 2D non-repeatable time-evolving events. CUP has a prominent advantage of measuring an x, y, t (x, y, spatial coordinates; t, time) scene with a single exposure, thereby allowing observation of transient events occurring on a time scale down to 100 femtoseconds, such as propagation of a light pulse. Further, akin to traditional photography, CUP is receive-only—avoiding specialized active illumination required by other single-shot ultrafast imagers. CUP can be coupled with front optics ranging from microscopes to telescopes for widespread applications in both fundamental and applied sciences.

BIOGRAPHY

Lihong Wang earned his Ph.D. degree at Rice University, Houston, Texas under the tutelage of Robert Curl, Richard Smalley, and Frank Tittel. He is Bren Professor of Medical Engineering and Electrical Engineering at California Institute of Technology. His book entitled "Biomedical Optics: Principles and Imaging," one of the first textbooks in the field, won the 2010 Joseph W. Goodman Book Writing Award. He also edited the first book on photoacoustic tomography and coauthored a book on polarization. He has published 495 peer-reviewed articles in journals, including Nature (Cover story), Science, PNAS, and PRL, and has delivered 500 keynote, plenary, or invited talks. His Google Scholar h-index and citations have reached 122 and 61,000, respectively. His laboratory was the first to report functional photoacoustic tomography, 3D photoacoustic microscopy, photoacoustic endoscopy, photoacoustic reporter gene imaging, the photoacoustic Doppler effect, the universal photoacoustic reconstruction algorithm, microwave-induced thermoacoustic tomography, ultrasound-modulated optical tomography, time-reversed ultrasonically encoded optical focusing, nonlinear photoacoustic wavefront shaping, compressed ultrafast photography (10 trillion frames/s, world's fastest real-time camera), Mueller-matrix optical coherence tomography, and optical coherence computed tomography. In particular, photoacoustic imaging broke through the long-standing diffusion limit on the penetration of optical imaging and reached new depths for noninvasive biochemical, functional, and molecular imaging in living tissue at high resolution. He chairs the annual conference on Photons plus Ultrasound, the largest conference at Photonics West. He was the Editor-in-Chief of the Journal of Biomedical Optics. He received the NIH's FIRST, NSF's CAREER, NIH Director's Pioneer, and NIH Director's Transformative Research awards. He also received the OSA C.E.K. Mees Medal, IEEE Technical Achievement Award, IEEE Biomedical Engineering Award, SPIE Britton Chance Biomedical Optics Award, Senior Prize of the International Photoacoustic and Photothermal Association, and OSA Michael S. Feld Biophotonics Award. He is a Fellow of the AIMBE, Electromagnetics Academy, IEEE, OSA, and SPIE. An honorary doctorate was conferred on him by Lund University, Sweden. He was inducted into the National Academy of Engineering.

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11:10 a.m. - 12:00 p.m.