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Bridging the gap between optics and life science using Photoacoustic and nonlinear optical microscopy

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SESSION SPEAKER

Although near-IR light can reach several centimeters into tissue, it will likely have undergone hundreds of scattering events. A scrambled photon path inhibits effective optical focusing. Fortunately, ultrasonic waves induced by photons in tissue are scattered much less. By combination of optical excitation with ultrasonic detection, Photoacoustic imaging (PAI) technique, a hybrid imaging modality, acoustically detects optical absorption contrast via the photoacoustic (PA) effect. PAI has a deep penetration depth that is comparable with ultrasound imaging and can monitor multiple independent optical reporters simultaneously in vivo based upon wavelength. PAI is sensitive to optical absorption contrasts by pumping the characteristic peaks of the key molecules in biological tissue and is able to penetrate deep tissue comparable with ultrasound. Combining with nanosecond (ns) pulse laser excitation at different wavelengths, this technique can monitor multiple independent optical reporters simultaneously in vivo based upon characteristic wavelength of molecules of our interest. These advantages make PAI unmatched in comparison with any other in vivo optical-based imaging techniques. Photoacoustic technology is available to help advance life science research in neuroscience, cell biology, and in vivo imaging. In this presentation, we will review PAI techniques, from PA effect to photoacoustic microscopy (PAM), the development of optical-resolution photoacoustic microscopy (OR-PAM), functional brain imaging, and therapeutic efficiency of anticancer drug monitoring glioma treatment in small animal models. Solid-state nanosecond (ns) lasers are the optimal excitation source widely used in PAI to induce PA effect. This type of laser outperforms other types of lasers in PA applications. Therefore, the concept and design of solid-state lasers will be illustrated to emphasize their application in PAI technique. The results demonstrated that high spatial resolution OR-PAM systems with ns pulse lasers at selective wavelengths are promising approaches for future brain imaging, label-free tumor imaging, drug therapeutic effect and delivery monitoring, and other important biological and biomedical applications. For the future outlook, we will address two bottlenecks that impede the wide-spread implementation of PAI: 1) high energy laser; and 2) corresponding multichannel data acquisition (DAQ) electronics, which cause unaffordable high cost for the PAI system. Combination of ORPAM and nonlinear optical microscopy technologies is another promising direction since it allows pathologists to gain the molecular information as well as enough information for traditional pathology which they were trained since their career. If success, it will cause the revolutionary advancement of the regulations of current pathology in cancer detection and cancer grading system.

Biography

Dr. Yang Pu is current a CTO of Davinci Applied Technologies (DAT) Inc., NY 11790, USA. The missions of DAT to develop and manufacture industry and scientific laser, as well new laserbased imaging technologies and products. Dr. Pu obtained his Ph.D. degree in Electrical Engineering at the City College of City University of New York (CCNY of CUNY). He is a skilled multi-disciplinary experienced biomedical optics researcher. He has published 39 journal papers, 1 book, 6 book chapters, over 60 conference papers, and delivered over 60 presentations in conferences. His research is trying to breakthrough two limits of optics: 1. Enhancing the resolution of microscope to break the limitation of diffraction; and 2. Imaging deep organ of large animal and human using Photoacoustic technology. He was a Principal Investigator (PI) of Prostate Cancer Research Program (PCRP) from U. S. Army Medical Research and Material Command (USAMRMC). His research is currently focused on photoacoustic tomography and spectral near infrared (NIR) imaging using native contrast or contrast agent for early cancer detection using cancer targeting contrast agents (mainly on prostate and breast cancer), ultrafast time-resolved spectroscopy in biological environment, inverse model for 3D imaging location, and super-resolution microscopy of cancer cell. In application, his is trying to break through the bottlenecks of photoacoustic tomography screening for clinical use – high performance and low-cost multiple channels DAQ device and high energy laser system.