21COE Programme: Mechanical Systems Innovation Open Seminar

21 COE Programme: Mechanical System Innovation Fifth Open Seminar 2005 will be held as follows.
Any participants will be welcome.

Invited Speaker: Professor Lihong V. Wang, Ph.D. (Biomedical Engineering & Electrical Engineering, Texas A&M University)

Title: High-resolution Biophotonic Imaging

Date & Time: 7th September 2005, 17:00~18:30

Place: The University of Tokyo, Engineering Building No.8, 2nd Floor, Meeting Room (8-226)

Abstract: We develop novel biophotonic tomography for early-cancer detection and functional imaging using physically combined non-ionizing electromagnetic and ultrasonic waves. Unlike ionizing x-ray radiation, non-ionizing electromagnetic waves, such as optical and radio waves, pose no health hazard and, at the same time, reveal new contrast mechanisms. For example, our spectroscopic oblique-incidence reflectometry can detect skin cancers accurately based on functional hemoglobin parameters and cell nuclear size. Unfortunately, electromagnetic waves in the non-ionizing spectral region do not penetrate biological tissue in straight paths as x-rays do. Consequently, high-resolution tomography based on non-ionizing electromagnetic waves alone, as demonstrated by confocal microscopy and two-photon microscopy as well as optical coherence tomography, is limited to superficial imaging within about one transport mean free path (~1mm) into biological tissues. Ultrasonic imaging, on the contrary, furnishes good image resolution but has strong speckle ultrasound-mediated imaging modalities by combining electromagnetic and ultrasonic waves synergistically to overcome the above problems. The hybrid modalities yield speckle-free images of high electromagnetic contrast at high ultrasonic resolution in relatively large volumes of biological tissues. The specific technologies to be reviewed in the talk are summarized below.

Mueller optical coherence tomography provides microscopic-scale depth-resolved tomographic images of the complete polarization properties in scattering biological tissues. Polarization properties are related to the orientation and density of fibril structures (such as collagen) in skin, retina, cartilage, muscle, and other anisotropic biological tissues. Potential applications include the imaging of burns, detection of glaucoma, study of osteoporosis, and detection of cancer.

In ultrasound-modulated optical tomography, a focused ultrasonic wave tags diffuse laser light in scattering biological tissue, which is analogous to the encoding concept in MRI. Because the tagged photons that carry the ultrasonic frequency originate from the localized ultrasonic wave, they can be extracted from the observed optical speckles to achieve high-resolution tomographic imaging.

In photo-acoustic tomography, an expanded pulsed laser beam diffuses into the biological tissue and generates a small but rapid temperature rise, which causes the emission of ultrasonic waves as a result of thermoelastic expansion. The short-wavelength ultrasonic waves are then detected to form diffraction -limited high-resolution tomographic images.

Thermo-acoustic tomography is similar to photo-acoustic tomography except that low-energy radio-frequency pulses, instead of laser pulses, are used. Although the long-wavelength radio-frequency waves diffract rapidly in the tissue, the short-wavelength ultrasonic waves provide high spatial resolution.

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