OPTICAL TOMOGRAPHY SYSTEM USING SHORT PULSE LASER FOR EARLY LUNG CANCER DETECTION

Kunal Mitra, Ph.D.
Associate Professor
Mechanical and Aerospace Engineering Dept.
Director- Laser, Optics, and Instrumentation Laboratory
Florida Institute of Technology
150 W. University Blvd., Melbourne, FL 32901
Phone: (321) 674 7131
Fax: (321) 674 8813
email: kmitra@fit.edu

Research/Technology Overview:

Lung cancer, which accounts for 25% of all cancer deaths, is currently the most common cause of cancer death among men and women in the United States. It is projected that in 4 years, there will be twice as many women who will die of lung cancer as breast cancer. Currently lung cancerous tumors are usually located by using conventional x-rays, bronchoscopy, sputum assays, random biopsies, etc. Excisional biopsy followed by histology, the most common techniques used for early neoplastic changes and carcinoma detection, can have unacceptable false negative rates, often arising from sampling errors. Considerable savings and less patient discomfort might be gained if tumors could be detected earliest, presumably the most curable stage, using a minimally invasive technique and hence treated early. Long-term survival of patients with lung cancer has not changed significantly in 20 years. The majority of patients are diagnosed at an advanced stage and most of the research has been aimed at treating the advanced disease. However, treatments at this advanced stage have been not shown to make a significant difference in improving the survival rate over the last two decades. The non-invasive nature of time-resolved optical tomography system using short pulse laser proposed in this research makes it most attractive for early detection of lung cancer and tumor. Optical tomography is expected to yield physiological information with a safer, simpler and less expensive system than the other types of methods. Optical tomography using short pulse laser will provide information about lung cancer and tumor properties, location, and size with high resolution, which is critical before performing tumor necrosis.

Target Industry Overview:

The development of time-resolved optical tomography system proposed in this research will break new ground in detection and treatment of lung cancer and tumor, one of the

leading causes of mortality in US and other parts of the world. The technology for time-resolved optical tomography is not yet at a stage of commercial viability.

Commercial Applications:

Through this research the related state of the art in time-resolved optical tomography will be advanced, and thus assist in paving the way for transporting the technology from present exploration and feasibility demonstration stages to the arena of commercial viability.

Stage of Technology Development and Commercialization:

From the standpoint of detecting lung cancer and tumors, a primary technological challenge arises from the fact that laser light is highly scattered in all directions by tissues. The nascent but rapidly developing technology of optical tomography using short pulse laser holds the promise of providing non-invasively detailed information about the tissue interior by measuring the temporal profile of the time-varying transmitted and reflected optical signals. To achieve these goals, detailed experimental study of delivery of laser energy with high efficiency in tissue samples, phantoms, biochemical species, and animals such as rabbits, mice will be performed. Delivery of pulsed laser light to the cancerous cells and tumor is done using hollow waveguides having different coatings for high transmission efficiency. The problem of determining the optical properties of tissues and tumors and hence the state of the tissues from experimentally measured time-dependant optical signals then requires the development of software using sophisticated inverse algorithm. Transient radiative transport models used for analyzing short pulse laser propagation through tissue media will be used for developing such algorithm. The scattered, reflected, and transmitted signals measured when short pulse lasers interact with scattering-absorbing media like tissues possess a unique feature compared to the conventional cw laser measurements. The distinct feature is the multiple scattering induced temporal signature that persists for time periods greater than the duration of the source pulse and is a function of the source pulse width, the scattering and absorbing properties of the medium, and the location in the medium where the properties undergo changes. If the detection is carried out at the same short time scale (comparable to the order of the pulse width), the signal continues to be observed even at large times after the pulse has been off due to the time taken for the photons to migrate to the detector after multiple scattering in the tissue media. Once the whole system is optimized for optimal performance, commercialization activities will begin.

Kunal Mitra, Ph.D.
Associate Professor

Institution and Contact Information

- Mechanical and Aerospace Engineering Dept.
  Director- Laser, Optics, and Instrumentation Laboratory
  Florida Institute of Technology
  150 W. University Blvd., Melbourne, FL 32901
- Phone: (321) 674 7131
- Fax: (321) 674 8813
- Email: kmitra@fit.edu

Education

- Ph.D. Mechanical Engineering (Thermal-Fluid Science)
  Polytechnic University, Brooklyn, N.Y. 6/93 - 5/96
- M.S. Mechanical Engineering (Thermal-Fluid Science)
  Polytechnic University, Brooklyn, N.Y. 8/91 - 5/93
- B.S. Mechanical Engineering
  Jadavpur University, Calcutta, India. 7/87 - 5/91

Professional Experience

- 8/02 - present **Associate Professor** Mechanical and Aerospace Engineering Department, Florida Institute of Technology, Melbourne, FL.
- 8/97 - 7/02 **Assistant Professor** Mechanical and Aerospace Engineering Department, Florida Institute of Technology, Melbourne, FL.
- 10/96 - 7/97 **Research Associate**- Environmental Technology Laboratory, National Oceanic and Atmospheric Administration, Boulder, CO.
- 6/96 - 9/96 **Research Staff**- Department of Mechanical Engineering, Polytechnic University, Brooklyn, N.Y.

- 8/91 - 5/96 **Teaching Fellow**- Polytechnic University, Brooklyn, N.Y.
- Summer 1993 **Research Fellow**- Energy System Laboratories, Polytechnic University, Brooklyn, N.Y.
- Summer 1990 **Trainee Engineer**- Tata Iron & Steel Company, India.

Professional Awards and Honors

- Best Faculty Award by Pi Tau Sigma (Honorary Mechanical Engineering Fraternity), 2004.
- Invited speaker for Light Activated Tissue Regeneration and Therapy at Kona, Hawaii, August 22-27, 2004.
- Invited and supported by National Science Foundation to attend "Fifth ISHMT/ASME Heat and Mass Transfer Conference," Calcutta (India), January 3-5, 2002.
- Invited to contribute a review article for publication on Advances in Heat Transfer, 1999 (authors receive royalty).
- Member, American Society of Laser Medicine and Surgery (invitation only membership).
- Member, Tau Beta Pi (The Engineering Honor Society).
- National Research Council Fellowship for Research Associateship at National Oceanic and Atmospheric Administration, Boulder, 1996-1997.
- Invited and supported delegate to "The International Symposium on Molecular and Microscale Transport Phenomena," Yokohama (Japan), December 1-4, 1996.
- Graduate Fellowship, Department of Mechanical Engineering, Polytechnic University, 1991-1996.
- Best Teaching Assistant Certificate, Polytechnic University, 1994.
- Gold Medal, Jadavpur University, 1990.
- Special Merit Award covering tuition and fees for undergraduate studies from Govt. of India, 1987-1991.