Final Report For
DE-FG02-06ER64287

Publications

1. Fenghua Tian, Vikrant Sharma, F. Andrew Kozel, and Hanli Liu, "Functional Near Infrared Spectroscopy to Investigate Hemodynamic Responses to Deception in the Prefrontal Cortex," *Brain Research*, 1303, 120-130 (2009).
2. Fenghua Tian, Britton Chance, and Hanli Liu, "Investigation of the Prefrontal Cortex in Response to Duration-Variable Anagram Tasks Using Functional Near Infrared Spectroscopy," *J. of Biomed. Opt.* 14(5), 054016-1 to -11(2009).
3. F. Andrew Kozel, Fenghua Tian, Sameer C. Dhamne, Paul Croarkin, Shawn M. McClintock, Alan Elliott, Kimberly Mapes, Mustafa M. Husain, and Hanli Liu, "Using Simultaneous Repetitive Transcranial Magnetic Stimulation/Functional Near Infrared Spectroscopy (rTMS/fNIRS) to Measure Brain Activation and Connectivity," *NeuroImage*, 47, 1177–1184, (2009).
4. Fenghua Tian, George Alexandrakis and Hanli Liu, "Optimization of probe geometry for diffuse optical brain imaging based on measurement density and distribution," *Applied Optics*, 48(13), 2496-2504 (2009).
5. Vikrant Sharma, Dheerendra Kashyap, Aditya Mathker, Sweta Narvenkar, Karim Bensalah, Wareef Kabbani, Altug Tuncel, Jeffrey A. Cadeddu, and Hanli Liu, "Optical Reflectance Spectroscopy for Detection of Human Prostate Cancer," *Proc. of IEEE Engineering in Medicine and biology*, 31st Annual International Conference of the IEEE EMBS, 118-121 (2009).
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Conference Proceedings

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2. J. Nyagilo, M. Xiao, X. Sun, and D. P. Davé (invited talk), "Multi-Color Raman Nanotags for Tumor Cell Biomarker Detection", *IEEE-EMBS*, Minneapolis, Sept 2-6, 2009
3. M. Xiao, J. Nyagilo, D. P. Davé, X. Sun "Gold Nanotags for Dual-Modality Imaging of Prostate Cancer", *World Molecular Imaging Conference 2009*, Montreal, Sept 25-30, 2009.
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Patents

1. D. P. Davé, "Fiber-based combined Raman Spectroscopy and optical coherence tomography system", (IP disclosure to UTA).
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3. D. P. Davé, "Label Free Detection and Quantification of Biomolecular Interactions," (provisional patent filed).
4. Hanli Liu, Vikrant Sharma, and Claus G. Roehrborn; "Apparatus and Methods for Guidance of Prostate Needle Biopsy," (Provisional, filed from UT Arlington in July, 2009).

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1. "Development of a Real-Time, Optically Guided Needle Biopsy System for Improved Prostate Cancer Diagnosis"

   PI: Hanli Liu, Ph.D

   Agency and Type: Texas Ignition Fund from the University of Texas System Board of Regents

   Period: 10/01/2009-09/30/2010.

   Total Amount: $50,000.

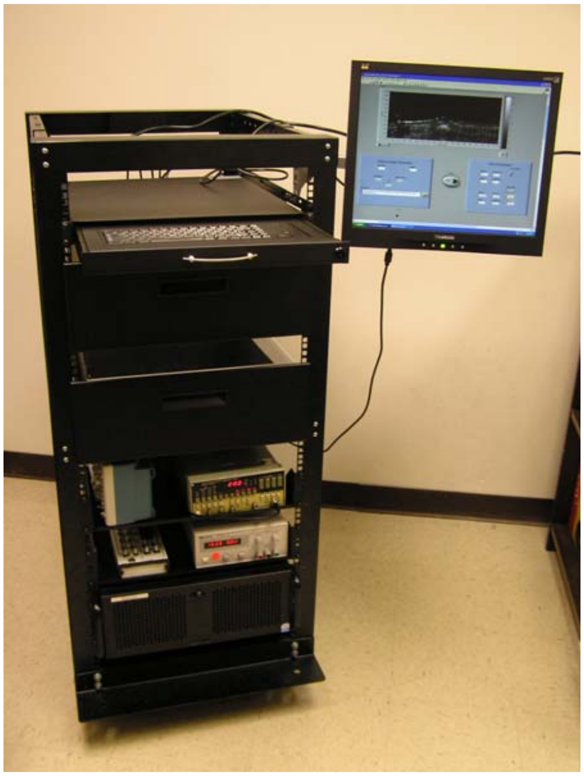
2. "A Breakthrough Probe Technology for Translating Near-Infrared Brain Imaging into a Routine Clinical Tool for Assessing Motor Deficits in Children with Cerebral Palsy "

   PI: George Alexandrakis

   Agency: Arlington – UT Dallas & Texas Health Resource Collaborative Research Program

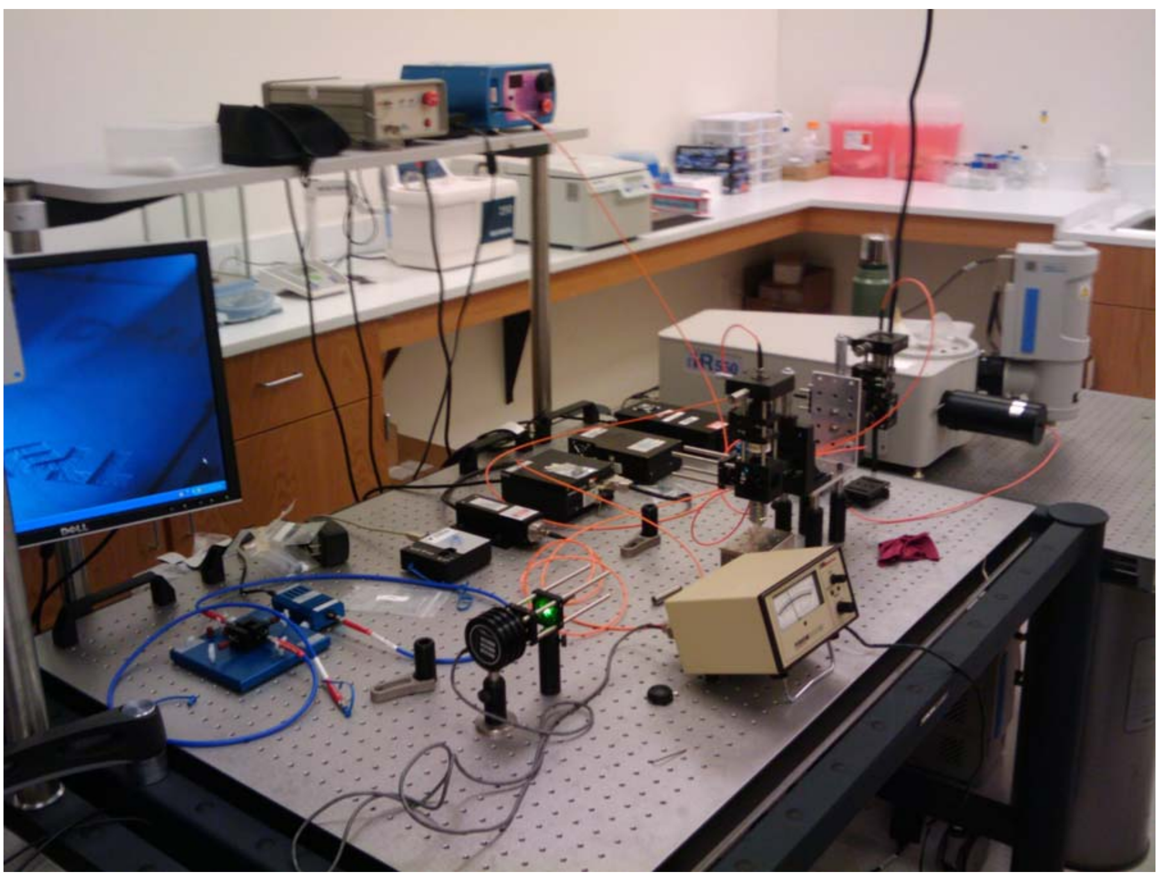
   Duration: January 1, 2010 – December 31, 2010

   Total Amount $100,000

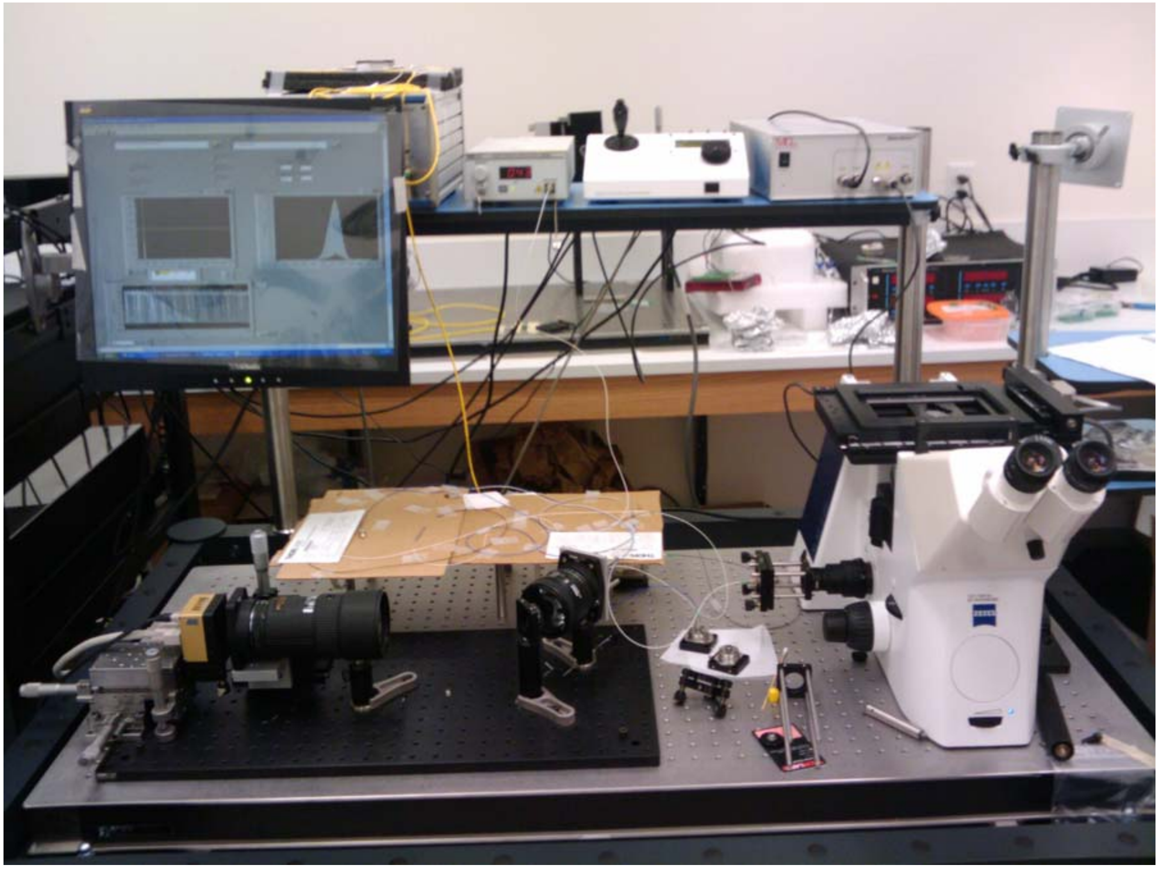


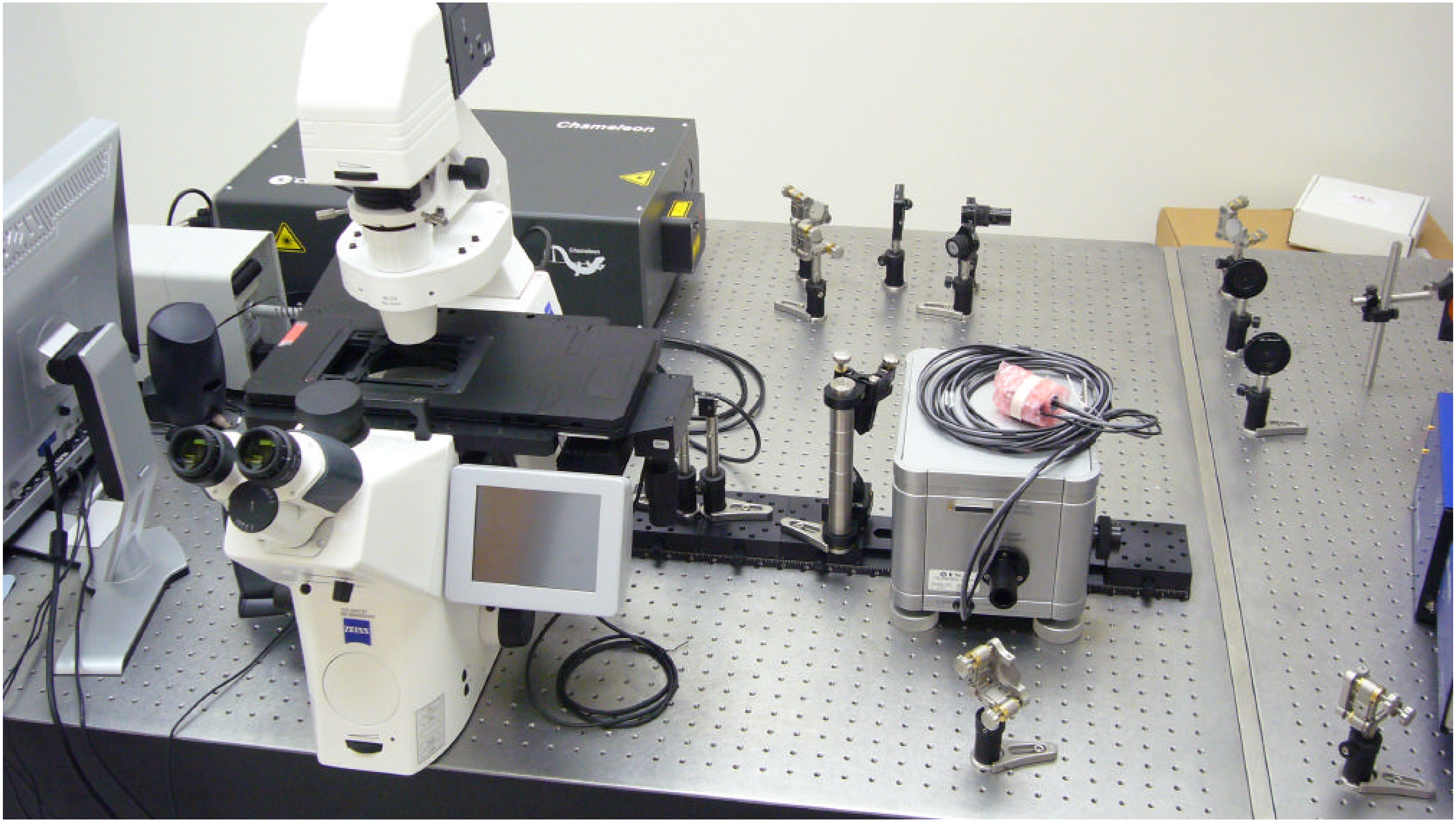
Portable OCT Imager for Tissue Imaging

Dual Color Raman Spectroscopy System for SERS

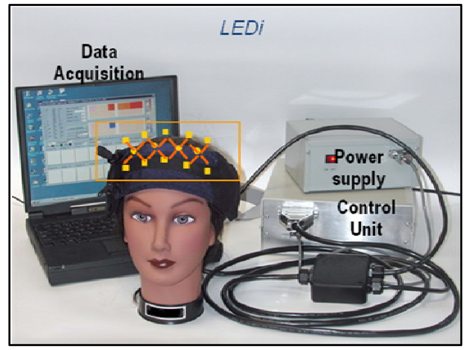


Interferometric System for Label Free Detection of Biomolecules



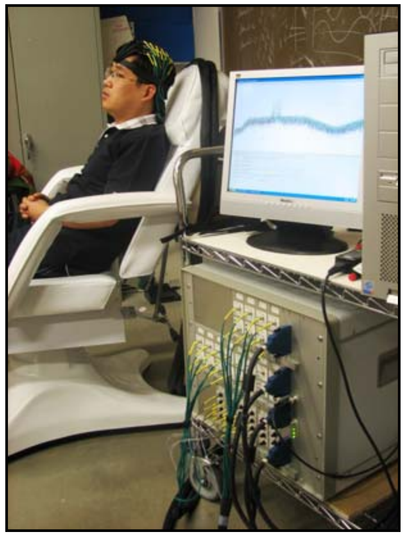

Chameleon

(1) <u>10-detector, 4-source, three-wavelength, DC NIR imager:</u> it allows us to measure 16 amplitudes of NIR light simultaneously at three wavelengths so that vascular oxygenated hemoglobin and deoxygneated hemoglobin concentrations of measured sample can be calculated. With 16 channel readings, we can obtain 2D images of Hb and HbO and other hemodynamic parameters of brain tumors d uring therapeutic interventions.

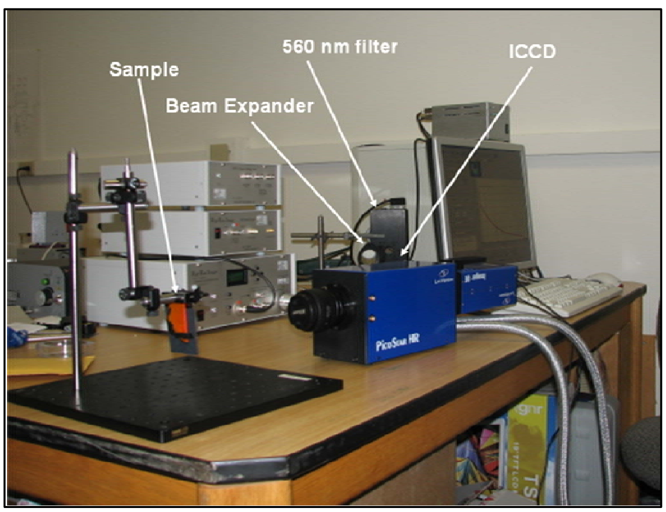


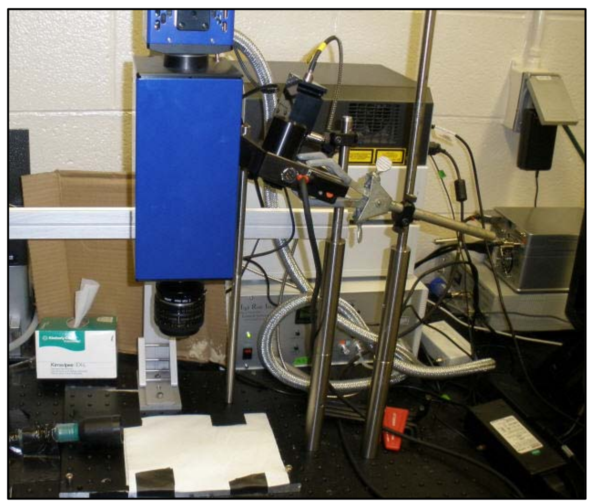
(2) <u>Fast-speed CCD camera</u>: this is a fast-speed, multi-wavelength, CCD camera to be used for *in vivo* light scattering imaging. The imaging system is based on a 12 bit CCD array and can be focused on the animal's spinal cord or cortex. There is a mechanical wheel positioned in front of the CCD camera to hold 6 filters at the NIR wavelengths between 650 nm and 850 nm for multi-spectral measurements. The illumination light can be delivered through a broadband light source from the top, including the NIR region. A pair of linear light polarizers can be added in front of the light source and the CCD camera to improve the light penetration depth into the spinal cord and cortex.

(3) <u>Multi-channel, fMRI-compatible, functional NIR brain imager</u> (CW-5, TechEn, Inc., Milford, MA): This state-of-the-art system is fMRI compatible and consists of 24 laser source transmitters and 24 detector receivers. It has 24 sine-wave modulated laser diodes. The lasers are at two wavelengths of 690 nm and 830 nm. Each laser is modulated to a single frequency starting from 6.4 kHz and with an interval of 0.2 kHz between two adjacent frequencies. The 24 laser diodes consist of 12 pairs of two wavelengths and combined into 12 source bundles. These source bundles can be symmetrically placed on left/right hemispheres along middle coronal section. The distance between two adjacent sources can be designed according to our needs. Meanwhile 24 detector bundles can be placed into multiple lines parallel to the source bundles. Overall, this non-invasive fNIR brain imaging system will allow us to map he modynamic activities at different cortical areas of the human brain in response to a variety of neural stimulations, as well as to record such hemocynamic responses simultaneously with fMRI stidies within the magnet for necessary validation and comparison of the spatio-temporal properties of HbO and HbR signals.

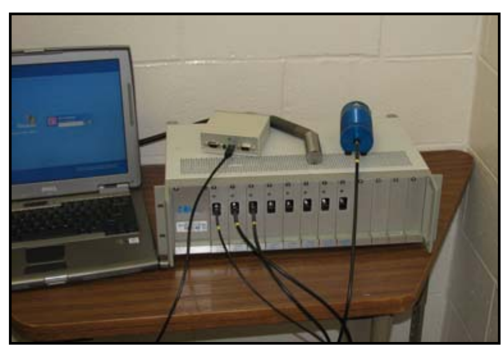


(4) Ultra-fast gated, intensified CCD Camera System (PicoStar HR 12) with (a) a filter wheel holding 6 standard filters and (b) a pico-second, broad-band laser. This system allows us to perform measurements of both time-resolved reflectance and fluorescence life-times and can be available to many projects.

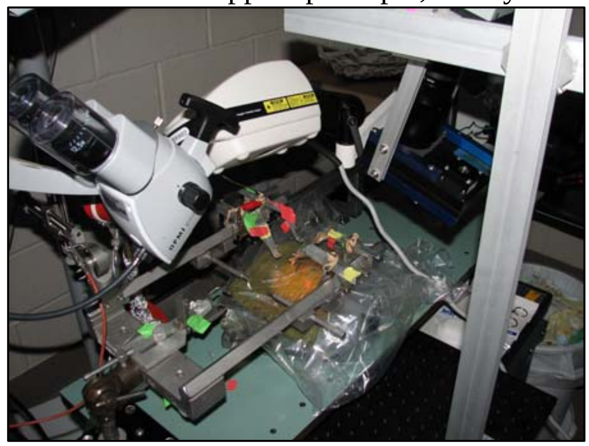




(5) Several of minaturized, multi-wavelength spectrometers with micro-fiber probes: these systems provide a means to measure either transmittance or reflectance of optical signal through a small piece of tissue. The measured spectra can be converted to absorbance within wavelengths of 450 nm-800 nm, and such spectral absorbance can be used as an independent method to quantify hemoglobin concentration and saturation, i.e. SO_2, as well as to determine the concentration of cytochrome oxidase.



(6) Laser Doppler Perfusion Imager (Periscan PIM II, Perimed Inc., Sweden): it offers the PI a non-contact means to measure blood perfusion from a variety of tissues *in vivo.* The system uses a laser beam at 670 nm. Based on the laser Doppler principle, the system collects backscattered light from the tissue and generates color coded images of the spatial distribution of the tissue perfusion. Images can be collected from multiple sites using the Repeated Mode or from a single site using the Duplex Mode. The blood perfusion is represented in Volts; intensity of light that gets back scattered. Higher perfusion rates are given by higher voltages and vice versa. For our study, we want to measure the blood perfusion in the spinal cord due to peripheral nerve stimulation.



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Photos of the Official Opening of the Optical Medical Imaging Laboratories

August 29, 2008

Figure 1: Ribbon-cutting ceremony of the Optical Medical Imaging Laboratories. From left to right, Dr. Keith McDowell Vice Chancellor of the University of Texas System; Mr. Ron Wright Senior Staff with Congressman Barton office; Dr. Kern Wildenthal President of UT Southwestern Medical Center at Dallas; Mr. Jim Spaniolo, President of UT Arlington; Dr. Kambiz Alavi (back row) Professor of Electrical Engineering at UT Arlington and a co-principal investigator on this project; Dr. Ronald Elsenbaumer, Vice President for Research and Federal Relations; Dr. Karel Zuzak (back row), Assistant Professor of Bioengineering and a co-principal investigator on this project; Dr. Bill Carroll Dean of the College of Engineering; and Khosrow Behbehani, Chair of Bioengineering and principal investigator on this project.

Figure 2: Audience during the opening ceremonies. Dr. Donald Bobbit, Provost and Vice President for Academic Affairs of UT Arlington is shown in the far right (in the foreground).

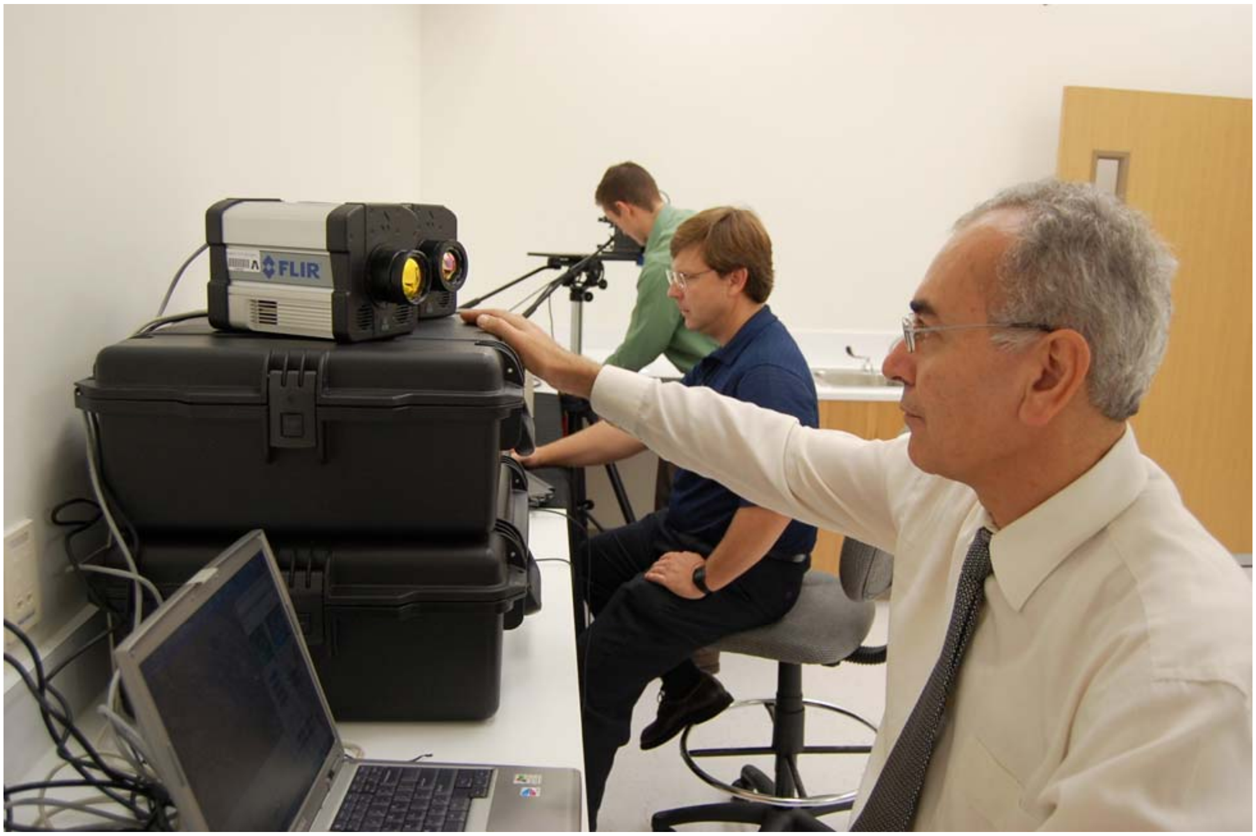

Figure 3: Dr. Alavi (foreground) Professor of Electrical Engineering at UT Arlington and a co-principal investigator on this project is shown in the newly opened laboratory working with the super sensitive infra-red cameras. These cameras can be useful in detecting very small temperature differentials due to increase blood perfusion, a hallmark of cancer tumors. Dr. Karel Zuzak (in the background) and Dr. Alavi share one of the labs at the Optical medical Imaging Labs. Mr. Robert Francis (his back is to the camera), a graduate student working with Dr. Zuzak is seen in the background.

Figure 4: Dr. George Alexandrakis, Assistant Professor of Bioengineering at UT Arlington and a co-principal investigator on this project (left) is describing the function of his experimental setup to Dr. Keith MacDowell (second from left foreground) Vice Chancellor of the University of Texas System and Dr. Philip Cohen (right) Dean of the Graduate School and Vice Provost for Academic Affairs of the University of Texas at Arlington. Several students and visitors can be seen in the background.

Figure 5: Dr. Digant Dave’ (far left in the background), Assistant Professor of Bioengineering at UT Arlington and a co-principal investigator on this project, is describing his research and equipment in the new lab to a faculty member from UT Southwestern Medical Center at Dallas. Two Bioengineering students who are doing research with Dr. Dave’ are in the foreground.

Grant No. DE-FG02-05CH11280

Figure 6: Dr. Hanli Liu, Professor of Bioengineering at UT Arlington and a co-principal investigator on this project (left), is demonstrating the multi-channel near infrared imager that she has acquired as part of this project and can be used to scan brain for brain blood flow oxygenation.

Figure 7: Dr. Karel Zuzak, Assistant Professor of Bioengineering at UT Arlington and a co-principal investigator on this project (left), is demonstrating his hypespectral imaging system that is being used by Mr. Van Jackson from the Surgery Department at UT Southwestern Medical Center at Dallas to collect images during surgery. Hyperspectral imaging system is capable of detecting blood oxygenation in peripheral vasculature, an imaging mode useful for assessing blood perfusion.

Publications

1. Natee Pantong, Jianzhong Su, Hua Shan, Michael V. Klibanov, and Hanli Liu, "A globally accelerated reconstruction algorithm for diffusion tomography with continuous-wave source in an arbitrary convex shape domain," *JOSA A* 26(3), 456–472 (2009).
2. Cole A Giller, Hanli Liu, Dwight C German, Dheerendra Kashyap, Richard B Dewey, "A Stereotactic Near-Infrared Probe for Localization During Functional Neurosurgical Procedures: Further Experience," *J. of Neurosurgery* 110, 263–273 (2009).
3. Edward H. Livingston, Praveen Gulaka, Sarita Kommera, Boping Wang, and Hanli Liu, "In-vivo spectroscopic characterization of porcine biliary tract tissues: first step in the development of new biliary tract imaging devices," *Annals of Biomedical Engineering*, 37(1), 201-209 (2009).
4. Karim Bensalah, Disha Peswani, Altug Tuncel, Jay D. Raman, Ilia Zeltser, Hanli Liu and Jeffrey Cadeddu, "Optical Reflectance Spectroscopy to Differentiate Benign and from Malignant Renal Tumors at Surgery," *Urology* 73(1), 178-181 (2009).

Conference Proceedings

1. Vikrant Sharma, Jiwei He, Sweta narvenkar, Dheerendra Kashyap, Yuan Bo Peng, and Hanli Liu, "Quantification of Optical Properties of Tissue and Its Application to Study of Pain Mechanism in Rats," oral presentation given in *SPIE, Photonics West*, BiOS Biomedical Optics Symposium, January 24-29, 2009, San Jose, California.
2. George Alexandrakis, Khosrow Behbehani, Fenghua Tian, Bilal Khan, Nayan Asanani, Mauricio Delgado, and Hanli Liu, "Translation of Near Infrared Brain Imaging to Assess Children with Cerebral Palsy," oral presentation given in *SPIE, Photonics West*, BiOS Biomedical Optics Symposium, January 24-29, 2009, San Jose, California.
3. R. Parlapalli, V. Sharma, K.S. Gopinath, R.W. Briggs, and H. Liu, "Comparison of hemodynamic response non-linearity using simultaneous near infrared spectroscopy and magnetic resonance imaging modalities," Proceedings of the SPIE, 7171, 71710P-71710P-12 (2009).
4. Aditya V. Mathker, Karim Bensalah, Wareef Kabbani, Altug Tuncel, Jeffrey Cadeddu, and Hanli Liu, "Optical Reflectance Spectroscopy for Detection of Human Prostate and Kidney Cancer," paper 7161B-208, oral presentation given in *SPIE, Photonics West*, BiOS Biomedical Optics Symposium, January 24-29, 2009, San Jose, California.

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7. George Alexandrakis, Nimit Patel, Pavan Rajamahendravarapu, Zi-Jing Lin, Hanli Liu, "Relative capacities of time-gated versus CW imaging to localize tissue embedded vessels with increasing depth," oral presentation given in *SPIE, Photonics West*, BiOS Biomedical Optics Symposium, January 24-29, 2009, San Jose, California.
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