Current Research Summaries

of

Workshop Attendees

Current Research Summary

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Research Interests

I am part of a multi-disciplinary team at PNNL working to build and test complementary microscopy methods on biological samples. We have already built a unique instrument that combines magnetic resonance microscopy (MRM) with confocal microscopy (CM), and we now seek to combine MRM with acoustic microscopy (AM). Each of these microscopy modes provides some insights or capabilities not accessible by the other technique, and the primary justification for combining them is to leverage the advantages of each into one instrument that can provide data not readily available to each single instrument. For example, CM imaging is rapid, yet it can not provide chemical or physical data about cells. MRM imaging is slow, yet it provides chemical and physical data. Unlike CM, AM can image opaque samples and it is relatively rapid compared to MRM.

One of our initial cellular systems has been Xenopus oocytes. The unusually large size of these cells, (0.1 - 1.3 mm) enables MRM to accomplish reasonably fast imaging even at sub-cellular resolution. Every two-fold increase in cell size enables a 64-fold reduction in MRM data collection time. Our initial experiments reveal that CM, MRM, and AM can detect differences in heat stressed oocytes. Both MRM and AM detect large changes in the nucleus and cytoplasm of heat shocked oocytes, thereby validating our approach

Current Research Summary

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Research Interests

Viren R. Amin is an Associate Scientist at the Ames Laboratory and Center for Nondestructive Evaluation, and Adjunct Assistant Professor at the Department of Electrical and Computer Engineering at Iowa State University. He received his M.S. and Ph.D. degrees in Biomedical Engineering from Iowa State University in 1989 and 1992, respectively. Prior to that he received M.B.B.S. degree (M.D. equivalent for general medical practice) from Gujarat University, India, in 1987. His research interests include medical and biomedical imaging, ultrasonic imaging, nondestructive evaluation, signal/image processing, pattern recognition, 3D imaging, visualization, and computer based system development for biomedical and agricultural applications. He has co-authored more than 25 articles for journals, conference proceedings, and research reports. He is a member of Institute of Electrical and Electronics Engineers and Biomedical Engineering Society.

Amin, in collaboration with Iowa State University Department of Animal Science colleagues, has successfully developed and transferred technology of ultrasonic live beef quality evaluation that helps improve genetic selection for quality traits. This technology is now used at a national Centralized Ultrasound Processing laboratory for processing ultrasound scans from more than 100,000 live beef cattle per year for all major beef breeder associations. Amin has also worked on ultrasonic evaluation of equine tendon injury and healing, in collaboration with ISU vet clinician. In another project, he is developing a non-invasive ultrasonic technique for evaluation of fatty liver, a major metabolic disorder during peripartal period, in dairy cows.

Amin's recent work under a biomedical initiative at CNDE has established contacts in medical research community for developing new projects for biomedical application of nondestructive evaluation and imaging technology. His major research projects include three-dimensional ultrasound imaging, in collaboration with medical imaging researchers, Milan Sonka, PhD, and Ronald Lauer, MD, of University of Iowa. A three-dimensional ultrasound system that uses existing clinical scanners is developed for potential application to evaluate blood vessel wall parameters and atherosclerosis risk and disease. In a related project, in collaboration with Ron Roberts, PhD, of Ames Laboratory and CNDE, Amin measures ultrasound properties of normal and atherosclerotic rabbit aorta (in vitro). High-resolution measurements using 50 and 100 MHz focused ultrasound probes are being conducted on aorta segments from 24 rabbits to ultrasonically characterize tissue changes in varying degrees of atherosclerosis.

Current Research Summary

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Research Interests

My research interests have traditionally centered on radiopharmaceutical chemistry for both diagnostic and therapeutic applications. In the area of diagnosis, this has related to cancer diagnosis with special emphasis on utilizing biological molecules as targeting vehicles. These studies have utilized molecules such as radiolabeled monoclonal antibodies, peptides and steroids for this purpose.

In addition, I have spent the majority of my time on optimal approaches to treating cancer and other forms of disease. These studies have focused on issues related to maximizing dose to the target tissue while minimizing dose to other tissue. We have employed a variety of strategies for this purpose including intracompartmental administration to physically trap the radiopharmaceutical, biologically targeting the material to the tissue of interest, and generating the cytotoxic radionuclide at the site of choice. In addition to targeting, I have also spent a great deal of effort on maximizing the dose by utilizing appropriate radionuclides. The factors of note include selecting the appropriate half-life of the radionuclide as well as the appropriate emissions. My research has centered on the use of high Linear Energy Transfer (LET) emitters for therapy. They include alpha emitters, Auger and conversion electron emitters, and isotopes that decay by nuclear fission. High LET emitters offer several advantages including cytotoxicity independent of dose rate, the lack of oxygen enhancement, short path length, and a small number of events for lethal consequence.

More recently, I have been working with Robert Kraus at LANL to develop a imaging and therapy system that utilizes magnetic nanoparticles to achieve these aims. His research summary will cover this in more detail. I have also spent time on developing contrast agents for MRI.

Current Research Summary

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Research Interests

We are currently involved in the development of impulse radar technology for medical applications. The core technology is a state of the art low cost ultra wide band (UWB) microwave radar developed at Lawrence Livermore National Laboratory. Specifically, this technology lends itself to devices that are non-invasive, non-contact, portable, compact, and low power. This technology is undergoing investigations for the detection of intracranial hematoma, pneumothorax, vital signs monitoring, and abdominal blood pool detection. As an example, it is envisioned that one device configuration for intracranial hematoma detection will be highly portable and allows for real time assessment of head injuries. This capability will thereby satisfy early detection needs of the field medical technician as well as provide a tool for continuous monitoring of high-risk individuals in emergency departments or intensive care units.

Pilot investigations have been guided by clinical needs. Preliminary results have all demonstrated feasibility. Investigations into the basic science and technology of impulse electromagnetic propagation (tens of picosecond time scale) for medical diagnosis and imaging have yet to be fully addressed including issues such as sensitivity, efficacy of diagnosis, accuracy, robustness, and patient/user interface. Studies have been performed on human subjects, animal subjects, phantoms, and numerical models. There remain large areas for exploration and continual development. It is believed that the unique characteristics of this technology will facilitate new insights into medical diagnosis as well as injury and disease characterization.

Current Research Summary

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Research Interests

The goal of the Unit is to study light-tissue interactions to devise new approaches for non-invasive quantitative optical spectroscopic and tomographic imaging of deep tissue structures for clinical screening and monitoring of physiological parameters and metabolic status. These new approaches for detecting macroscopic scattering and absorption differences intrinsic to normal and pathological tissues, can also benefit from tremendous advances in molecular biology of disease processes, and the development of specific fluorescently-labeled cell markers as specific sources of optical contrast. To achieve this goal, a multifaceted theoretical, computational, experimental, and clinical research program has been undertaken. These include: Time-resolved transillumination of thick tissue applied to quantitative spectroscopy of breast tumors; study the use of specific fluorescent markers(e.g., ligands) for identifying molecular biology of disease processes applied to non-invasive biopsy of Sjogren Syndrome, and lymphatic imaging for sentinel node detection. We are involved in several clinical studies. An NCI study uses our oblique angle reflectometry for non-invasive monitoring of inflammation in oral cavity. Laser Doppler blood flow and thermography are used for monitoring angiogenesis in Kaposi's Sarcoma (NCI) and complex regional pain syndrome, type I (NINDS/NIDCR).

Current Research Summary

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Research Interests

- Intra-operative optical imaging of living tissue in visible, near infrared, and infrared wavelength. Laser Doppler imaging.
- Optical signatures of angiogenesis and cancer genesis.
- Mechanisms of blood flow regulation and thermoregulation of the brain, liver, and kidney.
- Tissue modifications with high intensity focused ultrasound for facilitation of drug delivery and tissue ablation.
- Acousto-thermometric tomography.

Current Research Summary

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Research Summary

The research in my laboratory is currently focused on developing novel new approaches to using magnetic resonance (MR) to estimate in vivo tissue temperature non-invasively. Our goal is to volumetrically image temperature changes in real-time. We have implemented ultra-fast MR imaging techniques to monitor thermal energy delivered by a variety of applicators including external beam pulsed focused ultrasound, multi-segmented interstitial and transurethral ultrasound applicators, lasers, and most recently a novel new tunable gold nanoshell that can be used as a targeted thermal therapy system using near infrared light as an energy source.

Multiple MR parameters are sensitive to changes in temperature, including the molecular diffusion of water, spin-lattice or T1 relaxation time, and proton resonance frequency (PRF) shift. Each of these parameters has advantages and limitations. Work in our lab has been to device new acquisition strategies using echo-planar and non-rectilinear k-space trajectories, and the development of methods for comparing one strategy against another in terms of temperature sensitivity, temporal and spatial resolution. While most work to date has focused on techniques sensitive to the PRF shift, new approaches using ultra-fast chemical shift imaging (CSI) techniques may be of significant value in the monitoring of heating in tissues that are susceptible to motion.

Animal models have included small animals for pilot studies (various tumors in mice and rats), intermediate size animals for demonstration purposes (VX2 tumors in rabbits), and large animal models for final pre-clinical evaluation (transmissible venereal tumor, TVT, in dogs). With excellent veterinary support, we have been able to show excellent correlation between ablation volumes predicted by thermal dose calculations, post-therapy imaging of changes in tissue perfusion, gross sections, and histopathology.

The goal of my talk will be to review our work in MR thermography and to consider where the science needs to go to meet clinical demands.

Current Research Summary

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Research Interests

The SQUID Sensor Team that I lead is involved in a broad array of projects applying SQUID sensor technology and techniques to basic and applied research topics. These include magnetoencephalograpy (MEG, functional brain imaging), micro MEG (high-resolution functional brain imaging), measurement of action potentials in axons (including spinal cords in an effort to understand damage and repair in terms of signal propagation), magnetocardiography (MCG, functional cardiac imaging), nondestructive testing and evaluation of materials (detection and localization of deeply buried defects and features in conducting materials), measurement of basic nuclear properties (in search of the neutron electric dipole moment), and the project of specific interest to this workshop: magnetocarcinotherapy (MCT).

Thermal energy deposition and the measurement of local and global heating are critical components of MCT. Magnetocarcinotherapy is a rather unimaginative name we attached to our concept of localization and treatment of tumors. Simplistically, MCT utilizes recent advances in magnetic sensor technology combined with biological contrast agent chemistry to detect and localize tumors. As in many imaging techniques (MEG, PET, scintigraphy, etc.), a receptor specific contrast agent is introduced into the subject and concentrated with some relative specificity in tumors. The contrast agent used in MCT consists of strongly magnetic nanoparticles bound to a targeting agent (or group of targeting agents). Tumors are identified by virtue of localized concentrations of magnetic particles that are readily detected and 'imaged' by an array of SQUID sensors (similar to those used in MEG). If a tumor (or tumors) is identified, the localized concentration of magnetic particles enables rapid and significant deposition of RF magnetic energy through a variety of mechanisms, resulting in necrosis of the tumor cells with minimal collateral damage. For example, 106 500nm particles located around a 1mm3 tumor will raise the local temperature by 15^{o}C within a matter of seconds. This technique is envisioned to be directly therapeutic (e.g. not adjunctive) and does not use any form of ionizing radiation or chemotherapy. This approach is unique and readily differentiated from numerous approaches published in the last decade to induce hyperthermia. Features unique to the MCT approach include the magnetic materials and shape and temporal evolution of the RF magnetic field.

Current work at Los Alamos on MCT is being supported by internal management-directed research and program development funds.

Current Research Summary

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Research Interests

I direct the Medical Technologies Program at Lawrence Livermore National Laboratory. This program develops and partners in the commercialization of technologies and devices that can be used to diagnose or treat diseases. Our expertise includes biomedical engineering, biochemistry, biophysics, computations, polymer chemistry, physics and electrical/mechanical engineering, imaging science and signal processing. Some of our current projects include the development of catheter-based devices to treat ischemic and hemorrhagic stroke, the development of a 3D ultrasound mammography system, the development of hand-held pathogen monitors, the development of a compact Compton light source for mammography and radiotherapy, the development of artificial retina for sight restoration, the development of adaptive optics microscopes for diagnosing retinal disorders, the development of micropower impulse radar diagnostics for vital signs monitoring and hematoma detection, the development of transdermal glucose monitors, the development of an optical needle biopsy system for breast and prostate cancer detection, the development of optical biopsy systems for imaging tumors in vivo, the development x-ray laser and linear coherent light source systems for imaging biomolecules and subcellular organelles in vivo. I currently also direct the Biomedical Technology Program at the UC Davis Cancer Center and I am the principal investigator on a proposed NSF Science and Technology Center for Biophotonics. My role in the Cancer Center is to develop new technologies for both research instrumentation and clinical translation. We are currently working on single molecule detection systems for observing cancer biomarkers in blood and urine. For the NSF Center, we will be applying the power of photonics to the biosciences and medicine. Example projects in the Center will include development of Surface Enhanced Raman Spectroscopy for Sequencing single DNA molecules, portable pathogen monitors, light microscopy beyond the limits of conventional resolution and biomedical applications of light.

Current Research Summary

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Research Interests

In order to manage thermal coagulation therapy as a means of cancer treatment, it is generally necessary to unambiguously visualize the spatial extent of cell killing. Not only to ensure the death of cancer cells inside treated tumors but also the preservation of healthy counterparts in surrounding tissue.

At Pacific Northwest National Laboratory, we have developed a novel microscope for identifying the magnetic resonance (MR) signatures of cell death. The microscope itself allows cultured cells to be studied simultaneously with both confocal scanning laser fluorescence optical microscopy and MR methods. Magnetic resonance parameters measured in both time and space can therefore be correlated with cell viability using widely employed fluorescent labeling schemes. In preliminary studies of cell death resulting from either UV exposure or starvation in nutrient deficient culture media, MR measurements show that the mobility of diffusing water inside dead cells is significantly lower than in live cells. In diffusion-weighted MR images, this leads to their selective enhancement. While further studies would be needed to test whether a similar behavior is observed as a result of heat treatment, preliminary data suggests that the changing mobility of intracellular water may be a generic marker of cell death that can be accurately measured with MR techniques.

Presently, experiments are underway that are aimed at developing a more mechanistic understanding of why the mobility of intracellular water is sensitive to cell death. As part of this effort, we are currently examining how water motion is slowed by interactions with intracellular proteins, reductions in membrane permeability, and cell shrinkage. A logical extension of this work would be to exploit the microscope's optics for delivering high intensity light to focally heat cultured cells. The spatial extent of cellular damage observed in optical images could then be compared directly with lesion boundaries observed in MR images sensitized to intracellular water mobility. If a high degree of correlation is indeed observed with a good contrast-to-noise ratio, measurements could then be extended to excised tissues and results tested in vivo using animal models. If successful, such work might lead to simple MR methods useful for managing thermal therapy. Methods not specifically designed for measuring tissue temperature, but rather the effects of elevated temperature on cell viability.

Current Research Summary

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Research Interests

Microsystems technology (microelectromechanical systems - MEMS) has been under development at Sandia for over a decade, one of the current development thrusts is aimed at leveraging this technology into the biological and medical sciences.

Some of the potential applications include integrated sample handling, research tools (such as cellular manipulation systems - micromachined patch clamp array, neural probes, micro-reaction chambers), therapeutic devices (drug delivery, sample collection) and a large array of sensor-based applications.

This technology development has mainly focused on BioMEMS and microfluidics, however, the same technology base has applications in many other areas, such as chemical systems, microelectronics (chip cooling, novel optical switching/routing mechanisms) and sensors (microbolometers, chemical sensors).

Current projects:

- Micromachined Patch Clamp Array: devices for localizing cells, delivery/extraction of fluids, electrical-mechanical-optical coupling and manipulation/measurements on single or multiple cells in a controlled microenvironment, aimed at high throughput characterization of cellular response/signaling.
- Cell manipulation/sample preparation system: integrated microsystem for automating cellular sample preparation (collection, purification, processing of DNA/RNA/proteins; transfection)
- Retinal Implant (joint project with Oak Ridge, Lawrence Livermore, USC): micromachined electrode arrays for enhancing the retinal tissue/electrode coupling. Overall project goal is the development of fully functional retinal implants for restoring vision.
- Neural Probes (with Jit Muthuswamy at ASU): neural probes integrated with micromachined components for mechanical control and measurements.
- Polymer based microsystem integration: polymer structures for hybrid assembly of micro and meso-machined components.

Current Research Summary

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Research Interests

For accurate deposition of acoustic energy for imaging or stressing tissues an understanding of the distortion caused by inhomogeneous tissues is critical. Paul Panetta has been developing a fundamental understanding of wave propagation in inhomogeneous media through experimental and theoretical efforts. His work has been designed to improve the focusing and characterization abilities of acoustics. Interests also include experimental advancements in high frequency acoustic microscopy for imaging and property determination

Paul Panetta has served as a session chair at the 10th International Symposium on Nondestructive Characterization of Materials in Karuizawa, Japan in 2000. He has also served as an adjunct professor at the University of Denver in Colorado.

Current Research Summary

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Research Interests

My formal background is primarily in applied physics and electrical engineering, with most recent work (past six years) focused on leading projects in high-power wideband and microwave electromagnetic systems RD&T, directed energy applications development, and related enabling technology development. I am currently affiliated with the Advanced Concepts Group at Sandia National Laboratories, which is chartered with broad-based laboratory-wide emphasis on addressing future national needs, including the identification of, and recommendations for, emerging directions for innovative enabling technology development, systems applications, and strategic partnering.

Specific interests pertaining to this workshop include electromagnetic field coupling, interaction mechanisms and related bio-effects, and associated measurement and/or diagnostic techniques in biological systems. I am particularly interested in helping expand the broader application of state-of-the-art 3-D electromagnetic, thermal, elasto-mechanical, and other (e.g., ion channel) modeling and simulation computational capabilities at Sandia National Laboratories as a complement to experimental investigations to address practical issues and promote technical advancements in computational biophysics, biotechnology, and biomedical applications development.

Current research interests in bioelectromagnetics include macroscopic EM-field coupling with high-resolution (anatomically-correct configuration of heterogeneous, dispersive, and anisotropic biomaterial) modeling, energy deposition, and active tissue excitation; microscopic-level coupling and modulation of cell membrane level ion channel signaling and other membrane transport processes; cellular and systems-level effects; and non-invasive neuro-stimulation and modulation, imaging, information transfer, and/or command/control associated with man/machine interfacing, medical diagnostics, and therapeutic treatments.

Current Research Summary

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Research Interests

Our laboratory is interested in the development of electromagnetic imaging methods for both diagnostic and interventional clinical decision-making. We have focused on emerging technologies that are in developmental stages of investigation. At present our group is studying methods which require nonlinear image reconstruction approaches resulting from the diffusely-distributed or highly-scattered nature of the probing signal. We use parameter estimation strategies that invoke advanced computational modeling to extract images of the physical properties of intervening tissues. These properties carry information intrinsic to the structural, physiological and pathophysiological status of the imaged region. Efforts involve hardware and software developments for imaging systems spanning the electromagnetic spectrum from near DC to near-infrared wavelengths. Specifically, we are investigating electrical impedance spectroscopy (EIS), magnetic resonance elastography (MRE), microwave tomography (MT) and near-infrared diffusion tomography (NIR). Prototypes have reached the stage of being deployed in pilot studies in animals and human subjects. Target organ systems currently include the breast and brain.

Current Research Summary

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Research Interests

I am currently working on thermal management of electronics, MEMS and photonic micro-systems. To obtain my data, I frequently use an IR thermographic imaging system to resolve temperatures at the 10-micrometer scale. I'm quite interested in developing and evaluating methods to obtain three-dimensional temperature data of micro-systems. This work involves designing, fabricating and testing active micro-channel one- and two-phase cooling systems similar to those involved in and around the human brain.

I am also involved in passive cooling of micro-systems, including micro-channel heat pipes. The heat pipe is a heat transfer enhancement product in which the thermal conductivity of the device exceeds that of it's substrate material by a significant amount (currently 8X for copper/methanol systems) but at a much lower overall device weight.

Current Research Summary

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Research Interests

Dr. Roberts specializes in theoretical and experimental wave propagation in acoustic and elastic media and methods for data inversion. His theoretical work addresses development of efficient computational methods for forward-modeling of wave propagation and scattering phenomena, and the use of computational methods for the inversion of scattering data. This latter area also includes work in limited data X-ray computed tomography. He has experimental expertise in ultrasonics as applied to nondestructive evaluation and biomedical applications. Recently, he has worked on a rigorous examination of the mathematical connection between biological tissue strain and ultrasonic backscatter response, for the purpose of identifying new algorithms for high-resolution strain imaging. His work on modeling ultrasonic field intensity distributions in random inhomogeneous media is also applicable to biological tissues.

Current Research Summary

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Research Interests

Current biomedical research involves the use of thermal therapy in combination with traditional cancer therapies including radiation and chemotherapy. The research aims focus on three specific areas:

1. Development of radiofrequency and ultrasound technology for inducing local elevation of temperatures in the pelvis, lower extremities and breast.

2. Development of numerical techniques to calculate distributions of non-ionizing radiation in the above anatomic sites.

3. Development of non-invasive MRI techniques for measuring temperature distribution in the above anatomic sites.

Current Research Summary

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Research Interests

My current research involves the development of sensors and techniques for noninvasive characterization of fluids (liquids, gases, emulsions, suspensions, solids, etc.,) inside sealed containers. This characterization is based on the Swept Frequency Acoustic Interferometry (SFAI) technique that allows the determination of sound speed, sound attenuation, and density of a fluid without being affected by the container wall. In another approach, we use sound projection based derived from acoustic nonlinearity of the medium to excite resonance in a target and characterize the target based on its resonance characteristics. The SFAI technique can also be used to characterize a small amount of liquid, less than a single drop. A particular implementation of the SFAI technique uses a cylindrical resonator that is particularly well suited for characterizing suspensions. Various physical properties of suspended particles can be determined by this method in a matter of seconds. It has shown promise in monitoring bacteria in aqueous solution. The cylindrical resonator can also be used as a very efficient acoustic concentrator of suspended particles both in air and in liquids. Although these techniques were developed specifically for the Department of Defense, these can be adapted for various biomedical applications. Interferometrics, a Houston based company, has recently licensed these techniques specifically for biomedical applications.

Current Research Summary

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Research Interests

RAD peer-reviews many of the thermography grant applications. A good fraction of workshop participants have sat on this study section.

Current Research Summary

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Research Interests

- Ultrasonic arrays
- Acoustic Time Reversal
- Sonic IR
- Acoustic Tomography

Current Research Summary

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Research Interests

My current research and development activities center on the building a computational framework for performing numerical simulations of biological systems and responses that take into account the detailed geometry of the systems. My specific research projects fit into the four following areas: 1) Reconstruction of three-dimensional geometry and feature extraction from 3-D stacks of 2-D image data, such as NMR, confocal microscopy, transmission electron microscopy. 2) Transforming complex geometry descriptions into discrete, computational meshes. 3) Solving coupled sets of time-dependent partial differential equations (PDEs) using discrete meshes as the basis for the finite-volume integration technique. The sets of PDEs that are solved include: Computational Fluid Dynamics, Tissue Mechanics, Computational Electro-magnetics, reaction-diffusion, discrete particle transport. 4) Using the results of the calculations to interpret and predict biological phenomena from everything from cells to organs.

Here is a brief description of the projects that I work on day-to-day:

1) "**Development of a Virtual Respiratory System Model for Quantitative Dosimetry, Clearance and Biological Response to Particulate Matter (PM) in the Mammalian Lung**", LDRD project:
The long term goals of this project are to develop 3-D grid structure for the upper and lower respiratory tract of rats, mice and humans coupled with a computation fluid dynamics model for airflow during inhalation and exhalation; develop MRI techniques for visualization of the respiratory tract and particulates in culture and in vivo, linkage of virtual respiratory tract model to physiologically based pharmokinetic models for complete description of PM disposition in the body and conduct in vivo and in vitro kinetic studies with particulates for model parameterization and validation.

2) "**Computational Cell Simulation Framework for Eukaryotic & Prokaryotic Cells**", LDRD project:
The primary objective is to build a computational cell simulation framework to be used as a quantitative modeling tool for simulating the kinetics related to metabolic networks and biochemical pathways as well as more gross cell phenomena. The algorithmic basis for this simulation framework will be to combine high-fidelity geometry and topological definitions with spatially and temporally integrated discrete kinetic models that integrate multi-dimensional, time-dependent fluid dynamics, continuum mechanics, reaction/diffusion, and discrete stochastic particle dynamics. The systems that we will be modeling, using the Computational Cell Simulator, include both eukaryotic and prokaryotic systems. For eukaryotic cells we will concentrate on calcium dynamics, calcium waves, calcium sensor response.

3) "**The Terascale Simulation Tools and Technologies (TSTT) Center**", DOE SciDAC Project:
The primary objective of the TSTT center is to develop technologies that enable application scientists to easily use multiple mesh and discretization strategies within a single simulation on terascale computers. We will focus our efforts in the areas of high-quality, hybrid mesh generation for representing complex and possibly evolving domains, high-order discretization techniques for improved numerical solutions, and adaptive strategies for automatically optimizing the mesh to follow moving fronts or to capture important solutions features. The development of this set of general purpose computer modeling tools, NWGrid and NWPhys, involve simulating problems in computational physics, computational biology, computational physiology, engineering, atmospheric science, and subsurface modeling. NWGrid, http:www.emsl.pnl.gov:2080/nwgrid, is the mesh generation and problem setup tool for unstructured, hybrid meshes. NWPhys, http:www.emsl.pnl.gov:2080/nwphys, is the parallel, time-dependent, dynamic/adaptive mesh, computational physics/biophysics simulation tool.

Current Research Summary

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Research Interests

We explored novel ultrasound-mediated medical imaging using non-ionizing electromagnetic and ultrasonic waves. Non-ionizing electromagnetic waves are safe for biomedical applications unlike ionizing x-ray radiation and reveal new contrast mechanisms, even functional information. Unfortunately, electromagnetic waves in the non-ionizing spectral region do not penetrate biological tissue in straight paths as x-rays do. Consequently, it is difficult to obtain good imaging resolution in thick biological tissue using non-ionizing electromagnetic waves alone. Ultrasonic imaging, on the contrary, furnishes good imaging resolution but limited contrasts in many clinical problems. We developed ultrasound-mediated imaging modalities by combining electromagnetic and ultrasonic waves synergistically. The hybrid modalities yield electromagnetic-contrast information at ultrasonic resolution in relatively thick biological tissue.

In acousto-optical tomography, a focused ultrasonic wave tags some diffuse laser light in scattering biological tissue. Because the tagged light originates from the localized ultrasonic wave and carries the ultrasonic frequency, it can be extracted from the emitted optical speckles for tomographic imaging.

In thermo-acoustic tomography, low-energy laser or microwave pulses induce acoustic waves in biological tissue due to thermoelastic expansion. Although laser light diffuses rapidly and microwave diffracts rapidly in the tissue, the short-wavelength low-scattering acoustic waves are detected using an ultrasonic transducer to form high-resolution tomographic images of the tissue.

More information can be found at http://oilab.tamu.edu.

Current Research Summary

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Research Interests

See www.cc.nih.gov/drd/rfa

I am an interventional radiologist, which is minimally-invasive image-guided therapy, or image-gi Thermal ablation of cancer throughout the body, mainly using radiofrequency (also microwave, cryotherapy, or high-intensity focused ultrasound). This is a local method of tissue destruction which is needle-based, relying on dielectric analysis of tissue and thermometry to optimize tissue destruction and minimize collateral damage. Optimization of the bio-heat equation, and any treatment modeling are dependent upon thermal feedback. Heat activated, liposome-based, drug and gene therapy delivery is also being studies in animals, with intent to move into clinical trials in 2002-2003.

Current Research Summary

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Research Interests

1) Imaging of Flow and Motion by Phase Contrast MRA Techniques

Development and application of novel phase contrast imaging techniques and data processing methods to reduce venous contamination in MR angiography, to improve accuracy of flow/motion measurement, and to reduce acquisition time.

2) MR Physics and Technical Development

Analyses of phase encode ordering schemes for suppressing and/or relocating motion artifacts to improve image quality in applications of abdominal MRI.

Development and evaluation of projection reconstruction MRI and its application in interventional and fMRI applications.

Exploration of techniques to reduce macroscopic off-resonance effects and eddy current effects in fast MR imaging (e.g., gradient echo EPI and spiral techniques) at high field strength (3T and above) and using fast gradient switching.

3) MR Application Research

Application of proton-resonance frequency shift MR thermometry in image-guided thermal-coagulation therapy.

Application of MRI techniques to study contrast physiochemical characteristics in the tumor. Analysis of pharmacokinetic model parameters (derived from contrast enhancement curves) and their correlation with histological and DNA array analyses of extracted tumor specimens to study tumor development and physiology.