TECHNICAL PRESENTATIONS: SESSION III

Standards for Quantitative CT and PET Imaging

Lisa Karam, Ionizing Radiation Division, NIST

Historically, medical imaging has been mostly *qualitative*, but many health care applications, such as treatment planning, drug development, and clinical studies, demand a more *quantitative* approach for assessing efficacy and for patient safety. Working closely with colleagues in government, academia, and industry, NIST has been developing measurement standards for more accurate calibration of PET instrumentation. In addition, x-ray measurements of our recently developed small, resilient, and inexpensive phantom (a device, calibrated for length, which mimics distances in the body) have shown the potential usefulness of such a “pocket” phantom for patient-based calibration of CT (alone or with PET) systems. The ability to calibrate diagnostic imaging tools in a way that is traceable to national standards will lead to a more quantitative approach, increasing accuracy in treatment planning and increased safety for the patient.

Assessing the Performance of Software in Measuring Tumor Change

Charles Fenimore, Biomedical Imaging Project, Information Access Division, NIST

NIST is conducting the Biochange challenge problems for assessing the accuracy of software and algorithms that measure change in the size of lung tumors. There are two key goals in the Biochange project. The first is to encourage the development of algorithms for measuring change in tumors. The second is the concurrent development of methods for performance assessment of these algorithms. For a set of tumors, Biochange provides algorithm developers with two CT scans. Participants in Biochange run their algorithm(s) on the set of CT scan pairs and report their change measurements to NIST for analysis. From the results of multiple participants, NIST is uniquely able to assess the state-of-the-art and identify future directions of research. The impact of improved accuracy in change measurement should be felt in the clinical treatment of disease and the development of new pharmaceuticals.

Passive Terahertz Heterodyne Imager for Biomedical Applications

Eyal Gerecht, Biomagnetics Program, Electromagnetics Division, NIST

We are developing a new family of detectors, known as hot electron bolometers (HEB), that already demonstrated superior sensitivity and spectral resolution at terahertz frequencies when compared with other detector technologies. Terahertz imaging based on HEB technology promises to be a potent new tool for *in vivo* diagnosis of biological tissues; in particular, for the identification of diseased tissues and the classification of disease states. Because MRI and THz images result from different physical processes, they provide qualitatively different and complementary information. Furthermore, the ability of terahertz radiation to penetrate the sub-surface of a biological tissue also provides access to additional and different information than is obtained with optical images.

X-ray Microcomputed Tomography to Measure Cell Adhesion and Proliferation in Polymer Scaffolds

Carl Simon, Biomaterials Group, Polymers Division, NIST

We have explored the use of X-ray microcomputed tomography (µCT) for assessing tissue generation in polymer scaffolds. µCT is able to image through opaque scaffolds to yield quantitative 3-D spatial information regarding cell distribution, adhesion and proliferation.

Instrumentation for Fast Functional in Vivo Imaging of Small Animals Employing Free Radical Spin Probes

Sankaran Subramanian, Radiation Biology Branch, NCI

Time-domain (Fourier transform, FT) and Continuous wave (CW) instrumentations for performing three-dimensional imaging of small animals perfused with non-toxic stable free radicals. Methodology for imaging spin distribution and mapping of in vivo partial pressure of oxygen, pO2 [non-invasive in vivo oximetry] both in CW and FT modalities. In vivo tumor oximetry, tissue oxygenation, spin perfusion and tissue redox status can be quantitatively monitored non-invasively with very good temporal resolution. Methods for coregistration with anatomy via MRI (and or CT) have also been developed. Applications include investigating tumor angiogenesis, prognosis of cancer treatment and treatment-outcome in radiation oncology and chemotherapy, wound-healing, transplant organ viability, tissue redox status, peripheral vascular insufficiency (in diabetes mellitus patients), and possibly in radiation dosimetry.

Development of RF Preamplifiers and RF Coils for High Field MRI

Afonso C. Silva, Stephen J. Dodd, Hellmut Merkle, George C. Nascimento, Alan P. Koretsky, Joseph Murphy-Boesch, Laboratory of Functional & Molecular Imaging, NINDS

There continues to be a push to higher magnetic fields for both animal and human imaging. Due to the specific challenges of these high fields and the need for high performance receivers, we are currently developing the building blocks for coil development for these high field systems. In particular, we are working on the design of low input impedance, low-noise RF preamplifiers and RF coils to optimize the sensitivity and image quality of MRI at high field strengths. We have designed a modular RF preamplifier that has < 1 Ohm input impedance, gain of 28-30 dB and output impedance of 50 Ohms that is fully compatible with the architecture of all major MRI vendors. The design has been fully tested and approved for operations at 7T and 11.7T. In addition, we are working on new RF coil designs and coupling schemes that improve on power transfer and noise rejection characteristics. We are looking for a partner to take our designs from the prototype level to a commercial package.

Susceptibility-Matched Multi-well Plates for High-Throughput Screening by Magnetic Resonance Imaging and Spectroscopy

Kenneth W. Fishbein, Gerontology Research Center, NIA

NMR spectroscopy has numerous established and emerging applications in clinical, agricultural and industrial chemistry. Traditional NMR technology requires clean samples to be transferred to special tubes or flow capillaries, limiting throughput and risking contamination and sample loss. An attractive alternative to this practice would be to directly scan samples in multiwell plates, the containers in which samples are conventionally placed for optical scanning and/or storage. Unfortunately, conventional multi-well plates typically give poor performance for MRI-based assays since they provide inadequate matching of magnetic susceptibility between the plate, the samples and their surroundings. This results in distortion of the magnetic field within the scanner and thus reduces the resolution of NMR spectra. Here, we present novel, NMR-compatible multi-well plates that permit high-throughput screening of samples with minimal handling and that may be used with existing robotic equipment. This design can easily be extended to non-aqueous samples by the selection of an appropriate, commercially-available plastic resin or resin blend. Finally, by reducing background magnetic field inhomogeneities, these plates also offer enhanced sensitivity and throughput for the detection of functionalized magnetic nanoparticles in novel immunoassays and other molecular imaging applications.

Metrology Tools for Quantitative Medical Optical Imaging

Maritoni Litorja, Optical Thermometry and Spectral Methods Group, Optical Technology Division, NIST

The thrust towards quantitative clinical imaging necessitates the use of calibrated instruments and standardization of measurements. Some of the new clinical imaging measurement methods are optical in nature, based on standard biochemical assays. One example is reflectance hyperspectral imaging, a technique commonly used in environmental remote sensing. Our is working on applying lessons learned from measurement issues encountered in the global standardization efforts in climate remote sensing to those in clinical imaging. We are also working on methods and tools to calibrate and validate these instruments. One of them is the hyperspectral imaging projector (HIP) image as a digital tissue imaging reference/calibration sample (phantom (imaging reference)) for calibrating hyperspectral imagers used in the biomedical field.