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Research Group

Biomedical Imaging and Neuroengineering

- B.S., Electrical Engineering, Zhejiang University, 1982
- M.S., Electrical Engineering, Tokyo Institute of Technology, 1985
- Ph.D., Bioelectrical Engineering, Tokyo Institute of Technology, 1988
- Postdoctoral Fellowship in Biomedical Engineering, Harvard University - M.I.T., 1991

Functional Neuroimaging

Brain activation is a spatio-temporally-distributed process. Recent advances in medical imaging technology, especially functional MRI, have greatly increased our ability to image brain functions with high spatial resolution but with limited temporal resolution. Electrophysiological recordings such as EEG, on the other hand, offer millisecond temporal resolution in detecting and characterizing brain activity. Our approach is to achieve high resolution spatio-temporal functional neuroimaging by solving the “inverse” problem of the brain from scalp recorded EEG with the aid of MR images. Innovation in engineering methods has led to greatly enhanced spatial resolution of brain electrical imaging, which has been applied to aid presurgical planning in epilepsy patients. Furthermore, we are developing multimodal neuroimaging methods integrating EEG with BOLD functional MRI based on quantitative neurovascular coupling models. Experimental investigations are being carried out to study brain functions with sensory, motor and cognitive paradigms.

Brain-Computer Interface

There are currently over two million people in the United States suffering from various degrees of paralysis. A means to rehabilitate these individuals would thus have tremendous economic and social impact. The brain-computer interface has been developed as a means to “read” the minds of the individuals and translate these thoughts into actions performed via a computer, which aims at restoring function in paralytics by providing the brain with new output pathways. Our approach is to develop non-invasive brain-computer interface systems, which can perform complex tasks reliably and efficiently. These include development of practical BCI systems and to elucidate basic mechanisms underlying BCI applications. Of particular interest is the motor imagination based BCI applications and its fundamental research.

Cardiac Electrical Tomography

Another major area of research activity in our laboratory is in the investigation of advanced imaging technologies for assessing dynamic cardiac electrical activity. Research in this area is aimed at improving the understanding of the mechanisms of cardiac functions and dysfunctions and aiding clinical diagnosis and management of cardiac diseases. Our approach is to image cardiac activation and repolarization from noninvasive or minimally invasive recordings. We have proposed and developed 3-dimensional cardiac electrical imaging methods and been pursuing experimental validation of these novel methods in animal models. Clinical investigation is also under its way to assess the clinical applicability of our developed cardiac electrical tomography techniques. The ultimate goal is to establish high resolution cardiac functional electrical imaging methodology which can image and localize sites of arrhythmogenesis and its mechanisms in a clinical setting.

Electrical Impedance Imaging

In addition to imaging electrical sources, we are also pursuing imaging of electrical properties of tissues, such as electrical impedance. Such impedance imaging has important applications in cancer detection, functional brain imaging, and functional cardiac imaging. Our approach includes magnetoacoustic imaging with magnetic induction (MAT-MI), magnetic resonance electrical impedance imaging (MREIT), and magnetic resonance electrical property imaging (MREPT). We have proposed and developed a novel MAT-MI technique, integrating biomagnetism and ultrasound, to achieve high resolution imaging electrical impedance. Also under investigation is the use of MRI to image electrical properties of brain and other tissues.

Selected Publications

- Wilke C, van Drongelen W, Kohrman M, He B: “Identification of epileptogenic foci from causal analysis of ECoG interictal spike activity,” Clinical Neurophysiology, 2009 Jul 16. [Epub ahead of print].
- Xia R, Li X, He B: “Reconstruction of Vectorial Acoustic Sources in Time Reversal Tomography,” IEEE Transactions on Medical Imaging, 28(5): 669-675, 2009.
- Royer AS, He B: “Goal Selection vs. Process Control in a Brain-Computer Interface based on Sensorimotor Rhythms,” Journal of Neural Engineering, 6(1): 016005, 2009.
- He B, Liu Z: “Multimodal Functional Neuroimaging: Integrating Functional MRI and EEG/MEG,” IEEE Reviews in Biomedical Engineering, 1: 23-40, 2008.
- Yuan H, Doud AJ, Gururajan A, He B: "Cortical Imaging of Event-related (de)Synchronization during Online Control of Brain-computer Interface Using Minimum-norm Estimates in the Frequency Domain," IEEE Transactions on Neural Systems and Rehabilitation Engineering, 16: 425-431, 2008 (cover article).
- Ding L & He B: “Sparse Source Imaging in EEG with Accurate Field Modeling,” Human Brain Mapping, 29(9): 1053-1067, 2008 (cover article).
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- Zhang X, Ramachandra I, Liu Z, Muneer B, Pogwizd SM, He B: Noninvasive Three-Dimensional Electrocardiographic Imaging of Ventricular Activation Sequence, American Journal of Physiology - Heart and Circulatory Physiology, 289(6):H2724-32, 2005.
- Lai Y, van Drongelen W, Ding L, Hecox KE, Towle VL, Frim DM, He B: “In vivo human skull conductivity estimation from simultaneous extra- and intra-cranial electrical potential recordings,”

Clinical Neurophysiology, 116(2):456-465, 2005.

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- Qin L, Ding L, He B: "Motor Imagery Classification by Means of Source Analysis for Brain Computer Interface Applications", *J of Neural Engineering*, 1:135-141, 2004.