Technical University of Denmark

DTU

Popular science summary of the PhD thesis

PhD student	Cihan Göksu
Title of the PhD thesis	A Novel Magnetic Resonance Imaging (MRI) Approach for Measuring Weak Electric Currents Inside the Human Brain
PhD school/Department	DTU Elektro

Science summary

* Please give a short popular abstract in either Danish or English (approximately half a page) suited for the publication of the title, main content, results and innovations of the PhD thesis also including prospective utilizations hereof:

Knowing the electrical conductivity and current density distribution inside the human brain will be useful in various biomedical applications, i.e. for improving the efficiency of non-invasive brain stimulation (NIBS) techniques, the accuracy of electroencephalography (EEG) and magnetoencephalography (MEG) source localization, or localization of pathological tissues. For example, the accuracy of electric field simulations for NIBS techniques is currently reduced by assigning inaccurate ohmic conductivity values taken from literature to different brain tissues. Therefore, the knowledge of individual ohmic conductivity values may open up the possibility of creating more realistic and accurate head models, which may ameliorate the simulations and practical use of NIBS techniques.

Magnetic resonance current density imaging (MRCDI) and magnetic resonance electrical impedance tomography (MREIT) are two emerging methods for calculating the current flow and for reconstructing the ohmic conductivity distribution inside the human brain. Both methods use measurements of the magnetic field $\Delta B_{Z,C}$ that are induced by weak currents applied via surface electrodes. The sensitivity of the measurements directly affects the accuracy of the current flow estimations and the quality of the reconstructed conductivity images. It increases with increasing strength of the injected currents that are limited to 1-2 mA for in-vivo human brain applications. Therefore, sensitivity improvements of the underlying MRI methods are crucial for implementing MRCDI and MREIT in neuroscience and clinical applications.

In this thesis, systematic sensitivity and efficiency analyses of two different MRI pulse sequences, multi-echo spin echo (MESE) and steady-state free pre- cession free induction decay (SSFP-FID), are performed in order to optimize these sequences for in-vivo application in the human brain. The simulations are validated by comprehensive phantom experiments. Secondly, the optimized sequences are tested for in-vivo human brain applications, and adapted to increase their robustness to physiological noise. The current-induced magnetic field $\Delta B_{Z,C}$ inside the brain is measured in different individuals, revealing inter-individual $\Delta B_{Z,C}$ differences due to anatomical variability. Finally, a volume conductor model of an exemplary participant is created and used to simulate the current-induced $\Delta B_{Z,C}$. The comparison of the $\Delta B_{Z,C}$ simulations and measurements demonstrates a good correspondence. In summary, the results presented in this thesis pave the way for employing the optimized MRI sequences in future studies to reveal current flow distributions due to external stimulation non-invasively in-vivo in the human brain.

Please email the abstract to the PhD secretary at the department