Towards Motion-Insensitive Magnetic Resonance Imaging Using Dynamic Field Measurements. - DTU Orbit (08/11/2017)

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Magnetic resonance imaging (MRI) of the brain is frequently used for both clinical diagnosis and brain research. This is due to the great versatility of the technique and the excellent ability to distinguish different types of soft tissue. The image quality is, however, heavily degraded when the subject being scanned moves, which in many cases is impossible to avoid. Subject motion during scanning is therefore one of the big challenges for the method. Techniques to correct for image quality degradation due to subject motion are under rapid development. A promising approach is to monitor the head motion during scanning and update the MRI scanner in real-time such that the imaging volume follows the head motion (prospective motion correction). In this thesis, prospective motion correction is presented where head motion is determined from signals measured with an electroencephalography (EEG) cap with inter-connected electrodes that the subject wears during
scanning. The signals measured with the EEG system are induced voltages due to temporal changes of the gradient fields. The signals contain information about the head position because these magnetic field changes are spatially depending, and because the induced voltages also depend on the orientation of the wire-loops relative to the direction of field changes. Some of the advantages with the developed technique are that it can be used in closed head coils where camera based tracking is facing problems, and that it does not require additional hardware for the many hospitals and research institutions that already have an EEG-system for use in an MRI environment. In the thesis, the technique is considered in detail and proof of concept is demonstrated with phantom experiments. The experiments show that the newly developed technique has potential, but further optimization is required to improve accuracy and precision, and to improve the practical usability.
During MR examinations, a radio frequency (RF) field is transmitted into the subject to tip the magnetization of the hydrogen nuclei in the body away from equilibrium, and measurable signal is emitted. Changes in the transmitted RF field due to subject motion has up to now largely been left undescribed in the literature. This effect of subject motion is considered in the second study of the thesis, which focuses on single voxel spectroscopy where the effects are believed to have significant impact. A linear model is proposed to estimate tip angle changes during the scan from motion parameters, e.g. obtained from an external tracking system. The technique requires a previously performed calibration scan where the tip angle changes are measured for different head positions. A method for measuring actual tip angle changes was therefore implemented and pilot experiments were performed in a phantom and a healthy volunteer. The simple model seems promising based on these preliminary results. In MRI of the brain, not only head motion, but also motion of other parts of the body can lead to image degradation. This is because tissue is magnetized by the very strong, static background field (B0) such that the tissue contributes slightly to the background field.
Motion of the body is thus felt in the brain as small fluctuations in the background field, and e.g. breathing motion can lead to substantial image quality degradation for certain brain imaging sequences through this effect. It has previously been shown that magnetic field sensors (field probes) can be applied to stabilize the B0 field during scanning. However, the field probes are placed around the head, while it is the B0-fluctuations inside the head that are of interest. This interpolation problem is the subject of the last study inthe thesis. Experiments were performed with healthy volunteers to test how field estimates in the brain based on outside field probe measurements compare to field measurements performed in the brain, in cases with breathing and shoulder motion. Simulations were performed to elucidate where the field probes should be placed in order to optimize the correspondence.

General information

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