

Abstract

Diffusion-Weighted MRI (DW-MRI) has a unique ability to non-invasively probe tissue microstructure without the need for ionizing radiation or contrast agent administration. This ability makes DW-MRI a powerful tool for the detection, staging, and treatment monitoring of cancer. However, DWI remains limited by multiple imaging challenges, especially in extracranial organs such as liver and prostate. The major challenges include: 1) relatively long acquisition time in multi-parametric mapping, 2), T2-shinethrough effect 3) artifacts caused by tissue motion and 4) image distortions arising from local magnetic field heterogeneities. In this thesis, technical developments are introduced to address these challenges in prostate and liver DWI. A Stimulated-Echo based mapping (STEM) approach is developed and optimized to achieve simultaneous T1, T2 and ADC mapping within five minutes. The STE-DWI sequence is also evaluated in patients with prostate cancer, in order to achieve high contrast-to-noise ratio (CNR) with moderate b-values. To address the motion artifacts in liver DWI caused by cardiac motion, a M1-Optimized Diffusion Imaging (MODI) method is proposed to compensate the motion sensitivity while maintaining the blood-suppression effect using optimized diffusion encoding gradient waveforms. Additionally, reduced Field-of-View and multi-shot EPI acquisitions are assessed in prostate DWI to reduce the geometric distortion artifacts. Finally, a synergistic combination of MODI and multi-shot EPI acquisitions are proposed for motion-robust, reduced-distortion liver DWI. In this work, the feasibility, quantitative accuracy and reproducibility of the proposed techniques are evaluated in simulations, quantitative diffusion phantoms, healthy volunteers and a small number of patients with known or suspected cancer.