Reconstruction methods for exploiting non-Cartesian steady-state MR imaging

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Non-Cartesian acquisitions have several benefits in accelerating MRI for capturing time-resolved or physiological information. This thesis presents a method to quickly measure the timing error in the MR receiver hardware for off-axis imaging and separate its effect from errors caused by anisotropic gradient delays. Using the timing error and measured k-space deviations from the actual k-space trajectory, a retrospective phase correction was applied to each k-space sample during reconstruction which dramatically improved image quality.

The popularity of radial acquisitions has increased substantially over the last ten years due to their benign behavior when undersampling. Acquiring multiple echoes per excitation in gradient echo sequences can further accelerate imaging. This thesis develops a method to acquire multiple echoes per excitation and remove artifacts due to off-resonance by posing the reconstruction as a matrix equation. The conjugate gradient method is used to iteratively approach the solution. This thesis expands the method to handle multi-channels of MRI coil data. In this case, further improvement of image quality is possible when the scan is undersampled.

Diffusion tensor imaging (DTI) with MR is a promising method for mapping microstructural properties in the brain. Steady-State 3D projection (SS 3DPR) MRI with multiple echoes can image a large volume quickly with 3D isotropic spatial resolution with minimal spatial distortions and reduced motion sensitivity. SS 3DPR acquisition for DTI was synchronized to the cardiac cycle, linear phase errors were corrected and each projection was weighted based on its measures of consistency with other data. The iterative parallel imaging reconstruction method in this thesis was also adopted for removing off-resonance artifact and undersampling artifacts due to the rejection of data required to avoid motion artifacts.

Finally, non-contrast-enhanced MRA has achieved renewed interest due to concerns with possible MR contrast reactions. This thesis presents methods for carotid and peripheral artery imaging with a steady-state free precession implementation of 3D radial imaging. A magnetization-prepared inversion recovery technique was implemented to attenuate the undesired fluid signals. A density compensation technique was applied to emphasize the oversampled central spatial frequencies acquired when undesired fluids were nulled.