ovel Acquisition Strategies for Time-Resolved 3D Magnetic Resonance Angiography

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Magnetic Resonance Imaging (MRI) with the use of contrast agents has recently begun to play a major role in the visualization of blood vessels in the human body. Current Magnetic Resonance Angiography techniques use all available imaging time to acquire a single volume aimed at depicting the arterial system. On the other hand, most physicians are accustomed to X-ray DSA, which provides projection images with the high frame rates to visualize complex flow patterns. The work in this thesis investigates methods to acquire image sets with dynamic information in addition to the three-dimensional spatial information from standard MR techniques. In particular, time-resolved imaging of the vasculature in the abdomen and the heart was addressed, where the scan efficiency is further reduced by breathing and cardiac motion.

A real-time system was developed on standard hardware for time-resolved 3D abdominal MRA. Dynamic monitoring of the arrival of the contrast agent in the abdomen allows for optimal coordination of the start of the breath-hold and data acquisition. A previously described time-resolved 3D acquisition was modified to fit the specific needs of abdominal imaging and evaluated in volunteer and patient examinations with the real-time system.

In standard cardiac cine imaging, a single 2D slice or a stack of them are acquired over multiple breath-holds to visualize a portion of the beating heart. A novel acquisition for 3D cardiac cine imaging in a single breath-hold was developed and evaluated in volunteers. VIPR, a radically undersampled 3D projection imaging technique, provides higher spatial resolution than obtainable with traditional Cartesian MR imaging. VIPR was modified and a retrospective electrocardiogram (ECG) gating algorithm was developed to visualize the entire heart with isotropic resolution during different states of the cardiac cycle.

Motion correction with 3D projection reconstruction was investigated to explore the inherent advantages of radial acquisitions. The correction of translational motion in all three dimensions was demonstrated in phantom scans and in vivo. Future combination of the cardiac acquisition with motion correction may allow for free breathing acquisitions. In addition, a method for the correction of rotational motion was demonstrated in 2D simulations.