The Johns Hopkins University

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Dynamic MRI Using Internal Detectors

Dissertation Defense By

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Abstract:

With the advent of high speed imaging techniques and higher field strengths, MRI is evolving beyond its initial diagnostic capability to include interventional applications. Up until now, interventional MRI probes have been deployed with external radio frequency (RF) transmit fields at main magnetic field strengths of 1.5Tesla (T) presenting the following technical challenges. Probe tracking, which is essential for imaging and navigation, limits the temporal resolution and signal-to-noise ratio (SNR) by utilizing scan-time that could have otherwise been used for acquiring better quality, or higher resolution images. Existing methods for tracking use localizing RF coils which constrain the probe design. Ultimately, SNR limits the attainable spatial resolution and scan time. In addition, there are safety concerns with using internal probes due to the potential for local heating from currents induced by the RF fields applied during MRI.

To tackle these challenges, methods are investigated herein for internal real-time and high resolution imaging with maximum SNR efficiency and for rendering the devices safe to heating during MRI. An image-based method of tracking is proposed and implemented at 1.5T that determines a probe's orientation without making any additional mechanical design changes to it. The method is demonstrated in an *in viv*o mesocaval puncture procedure performed in a swine model. A novel method of MRI, termed "MRI endoscopy", is then proposed for performing MRI from the viewpoint of an advancing probe, analogous to an optical endoscope. Explicit probe-tracking is not required since the probe images what it "sees". The device, RF pulses and pulse sequence for performing high-resolution and real-time MR endoscopy are developed at 3T, producing resolution as fine as 80μm, *in-vivo* and *in-vitro* and at speeds of up to 2 frames-per-second. Spatial resolution is improved as a result of the increased SNR afforded by the higher field strength. The local RF heating produced in the newly developed method is found to be ≤1ºC, consistent with safe operation.

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