

## Prospective motion correction using NMR probes.

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### INTRODUCTION

Motion is one of the primary sources of artifacts in MRI. With sub-millimeter voxel dimensions attainable at ultra high fields, even a small amount of motion can degrade image quality. Improved motion correction is therefore especially useful in high-resolution imaging. Nuclear magnetic resonance (NMR) probes have recently been employed successfully in rigid body motion correction at 1.5 Tesla [1,2]. In this work, real time prospective head motion correction based on NMR probes at ultra high field (7T) is presented.

### METHODS

Three receive only <sup>1</sup>H probes were built for use on a whole-body 7 Tesla MR scanner (Philips Healthcare, Cleveland, OH, USA). Each probe (Figure 1) contained a 1 mm diameter glass capillary tube, filled with 2.5mM gadolinium-doped tap water. The tube fit inside a solenoid of enameled copper wire. Tuning and matching capacitors constituted the remainder of the resonant circuit. The circuit was placed in a fiberglass box with copper shielding to reduce the signal received from the imaged object. The top of the box was un-shielded to allow probe excitation by the volume transmit coil. The probes were mounted on a CuSO<sub>4</sub>/NaCl phantom bottle and connected to unused scanner receive channels.

**Probe Interrogation and Geometry Update:** An 18 ms long probe data acquisition module was performed every TR for position encoding of the individual probes (Figure 2). The module consisted of non-selective low flip angle (5°) excitations and projections in each of the X, Y and Z directions. Probe position data were extracted in real time and motion parameters including rotation and translation were calculated as reported in [1]. Following this, the geometry of the imaging module was updated prospectively to compensate for the estimated motion.



Figure 2: Probe data gathering module

frequency to simulate translation. Two gradient recalled echo (GRE) experiments were performed with rotations about the foot head axis in one and translation applied along the same axis for the second (64×64 matrix, 1 axial slice, FOV 300 mm, TR/TE = 20/5 ms).

**Motion Correction Scans:** For testing of real time prospective motion correction, 2 GRE experiments with the same scan parameters (64 x 64 matrix) as above were performed in which an artificial translation of 30 mm along the anterior posterior (readout) axis was applied for phase encodes 20-28 and 37-44, without and with real time motion estimation and compensation.

### RESULTS

Figure 3 shows image space projection data of the probes in three directions. Probe data reflected the real time rotations and translations applied and matched expected probe positions based on input motion values. Mean squared error (MSE) values calculated over the 128 time points showed high accuracy. Figure 4 shows the phantom images without and with prospective motion correction demonstrating effective real time motion compensation.

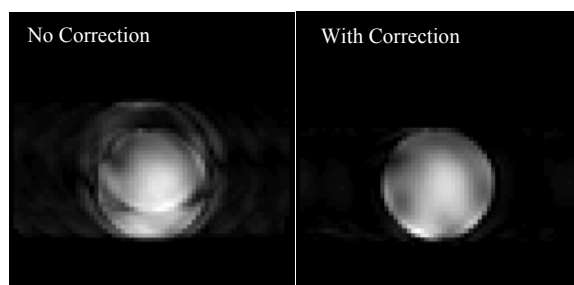


Figure 4: Phantom image without and with real time motion correction.

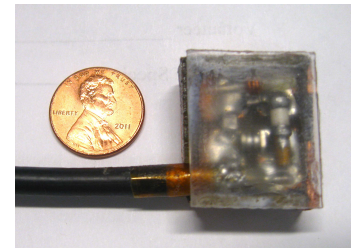


Figure 1: NMR Probe

**Probe Validation by Motion Simulation:** To validate the real time measurements of marker positions, known motion was synthetically applied on a stationary setup by updating dynamically in every TR the gradient orientation matrix to simulate rotation and the receiver demodulation

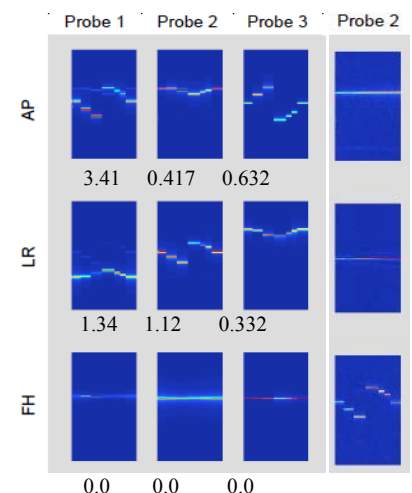


Figure 3: Image space probe data with simulated rotation (left) and translation (right) with MSE values in mm.

### DISCUSSION

Future work will focus on performance characterization and improvement of the system accuracy, precision, size and time requirements. Validation of marker accuracy by using synthetic motion is significant as it circumvents the complexity involved in performing validation using unwieldy motion phantoms. Even though motion simulation does not fully replicate the effects of real motion, it may serve as a valuable tool for development of NMR probe systems for correction of motion and other dynamic instabilities that confound ultra high field (7T) systems.

### REFERENCES

- [1] Ooi MB, et al. MRM, (2009) 62: 943. [2] Ooi MB, et al. MRM, (2011) 66: 73.