In-Plane Estimation Based Motion Correction for Spiral Projection Imaging

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Objective: SPI (Spiral Projection Imaging) acquires data in sets of 2D spiral planes that are rotated to fill a sphere in 3D k-space[1]. Prior studies [2] have asserted the potential of SPI to accomplish 3D self-navigated motion estimation and correction. The goal of this study was to verify the capability of SPI to correct for three degrees of rotational motion.

Methods and Results: It has previously been shown [2] that the SPI trajectory is flexible with respect to the orientation of the spiral planes. For the purposes of rotational motion correction it is desirable to have a high degree of orthogonality between temporally adjacent planes. For this reason, this study utilized the tri-axial orientation illustrated in figure 1. The tri-axial oriented SPI data were simulated from an SPGR data set using the DFT. Rotational motion was introduced into the simulation process. Sample slices from the simulated data are shown with introduced motion in the left column of figure 2. The degree of introduced motion can be seen in figure 3.

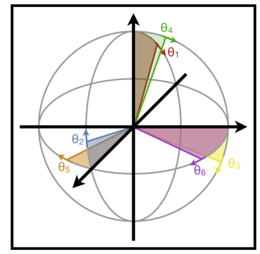

Fig. 1 Planes are rotated about three axes in six directions to maximize the orthogonality of any three consecutive spiral planes.

The motion correction algorithms utilized in this study were based heavily on the algorithms used for PROPELLER motion correction [3]. Translational motion correction in SPI is a direct extension of PROPELLER translational motion correction. The rotational motion correction algorithm used in SPI estimates the rotational motion seen by a given plane. This is similar to PROPELLER which estimates the rotational motion seen by a blade. The SPI rotation correction algorithm differs from the PROPELLER algorithm as follows:

1) A unique reference is computed for each individual plane in SPI. In PROPELLER there is one reference for all blades.
2) The data used to form a given reference plane in SPI will have contributions from two or more spiral planes. In PROPELLER every reference data point is contributed to from all blades.
3) Rotational motion estimates from temporally adjacent planes are used in conjunction with the rotation estimate from the plane of interest to infer both the through-plane and the in-plane rotation present when the plane was acquired. In this manner all three degrees of rotational motion affecting a given plane can be estimated. It is this step that benefits from the high degree of orthogonality between temporally adjacent planes.

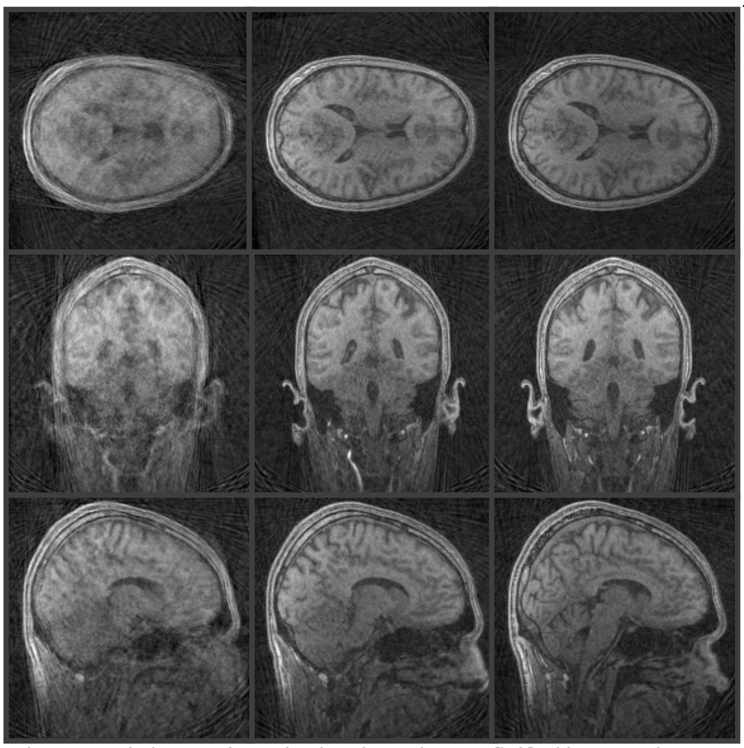
Fig. 2 Sample images from simulated SPI data set [left] without rotation correction [center] corrected using estimates from algorithm, and [right] corrected using known rotational motion values.

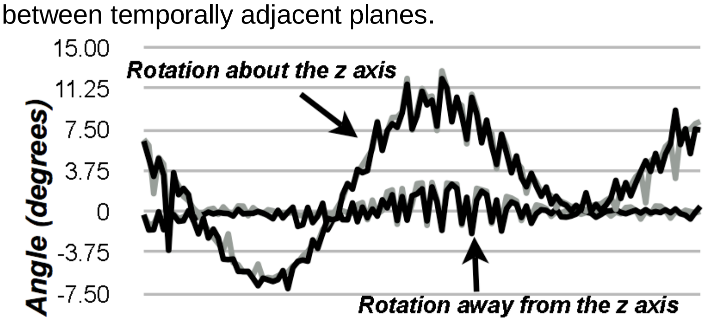

Fig 3. Applied [black] and estimated [grey] rotations for data shown in figure 2 in terms of rotation away from the z axis and about the z axis.

The rotational motion correction algorithm was applied to the simulated data. Current processing time for this algorithm on an 8-core 2.66GHz processor is on the order of 6-8 hours. The results are shown in figures 2 and 3. Figure 3 suggests that the estimated motion closely tracks the applied motion. These results argue in favor of the validity of estimating and correcting for patient motion in an SPI acquisition. Alternative methods of correcting for patient motion in SPI are simultaneously being studied.

References: 1) Irarrazabal P, Nishimura DG, Mag. Res. Med. 1995 33(5); 656-662. 2) Robison RK, Aboussouan A, Pipe JG. Proc. ISMRM 2007, Abstract No. 1664. 3) Pipe JG, Mag. Res. Med. 1999 42(5); 963-9.