3-D Multi-Coil Motion Correction for Spiral Projection Imaging

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Introduction Patient motion is a significant problem for MR imaging. Spiral Projection Imaging (SPI) is a 3-D imaging sequence, which provides enough data to deduce all six degrees of freedom of bulk motion [1]. Motion correction has been successfully demonstrated for quadrature coil data (both real and synthetic), by comparing data from individual planes [2,3] (*Fig. 1*). The extension to multi-coil data is complicated by the introduction of receiver coil sensitivity and phase. This work presents an appropriate approximation by combining multi-coil data in order to facilitate motion correction.

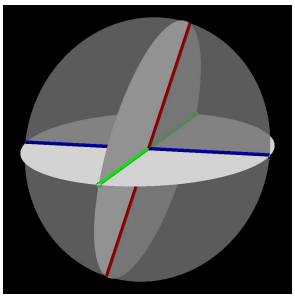

Fig 1: Planes intersect on a line. Planar orientations are solved which best match intersections [2].

Methods The data from a single coil of a multi-coil dataset cannot be used for motion correction, as motion estimates might be biased towards no motion due to the static receiver sensitivity. However, proper coil combination requires motion corrected 3-D data. The multiple coils of each projection are combined in a projected image domain using a root mean squared (RMS) algorithm. This method therefore does not correct for the coil sensitivity that varies through a projection. The effect of this approximation, while apparent (visible in *Fig.* 2), is not detrimental to motion correction. Each planar projection is reconstructed using standard 2-D algorithms. The resulting data from these projections can then be inserted into the previous motion correction algorithms. The raw multi-coil data are used for final image reconstruction.

The motion correction algorithm proposed in [2], matched chords from each pair of planes, and subsequently matched the orientations to be consistent with these measurements of the best matching chords. This technique can be prone to increased error in estimating matching chords for nearly parallel planes. As an enhancement to the algorithm, the orientations are deduced to minimize the error of matching chords. Once the rotational motion is deduced, the translational motion can be deduced trivially using the same coil combined data [2].

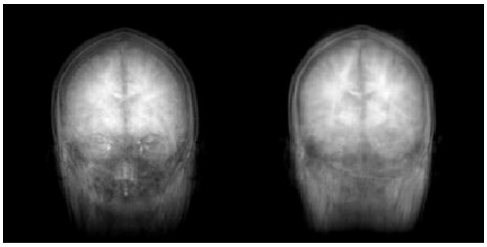

Fig 2: Comparison of 2-D coil combination (left) versus actual projection (right) for in vivo data.

Results Data were synthesized for a 64^3 imaging volume using an 8 channel array. 147 spiral planes were collected to prescribe a critically sampled trajectory. Coil sensitivities were created from previously collected data. Data were reconstructed using standard 3-D imaging techniques, including 3-D coil combination once the motion parameters were deduced. Induced motion was randomly generated with an average of 10.2 degrees and 2.5 pixels off. Estimated rotational motion averaged 5.1 degrees error from absolute orientation parameters. Absolute error in translational motion estimates averaged 0.38 pixels, when applied to the actual orientation parameters. Reconstruction of the data using prescribed, estimated and actual motion parameters are visible in *Fig. 4* along with an illustration of the orientations. Scatter plots of error with respect to motion are shown in *Fig. 4*.

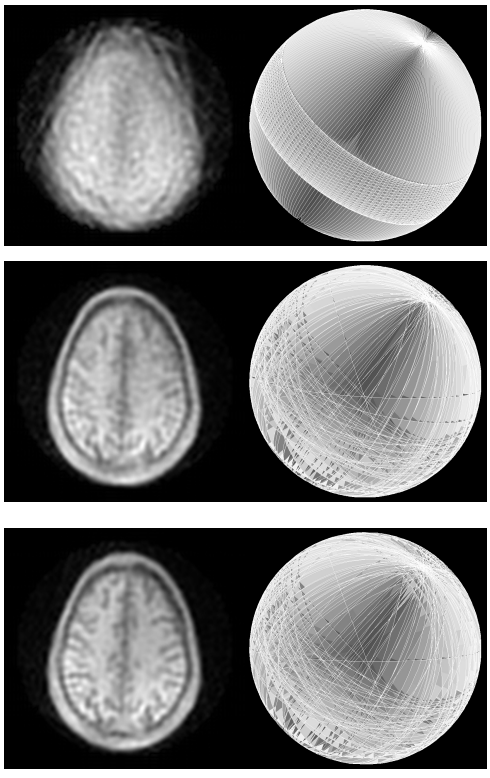

Fig 3: A single slice (left) of the final images, reconstructed using orientations (right) of prescribed orientations (top row), estimated orientations (center row), and actual orientations (bottom row).

Discussion This work demonstrates the feasibility of motion correction of multi-coil data, with relatively high accuracy on synthesized data using fast and simple algorithms. The implemented simulation is expected to model real data accurately. A small reduction in actual resolution is expected due only to the motion, which affects the prescribed critically sampled trajectory.

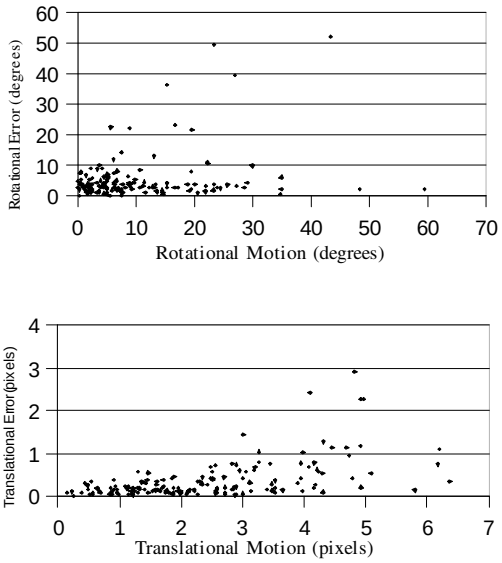

Fig 4: (Top) Absolute error of estimated rotational motion versus actual motion. (Bottom) Error of translational motion when applied to the actual planar orientations

References [1] Robison RK, Pipe JG. *Proc ISMRM 2007*. #1664. [2] Johnson KO, Pipe JG *Proc. ISMRM 2008*.#1469. [3] Robison RK, Pipe JG. *Proc. ISMRM 2008*. #1470.