A New Plane Orientation Scheme for Spiral Projection Imaging

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Objective: Spiral Projection Imaging (originally conceived as Spiral-PR hybrid in [1]) is a fast 3D MRI trajectory that has shown promise in applications such as PCMRA and fMRI [2 and 3]. As can be seen in figure 2a, this trajectory samples the k_x axis with every spiral plane, resulting in a self-navigating data set potentially capable of estimating one degree of rotational motion and three degrees of translational motion. By collecting the spiral planes in orthogonal pairs, two degrees of rotational motion could potentially be estimated. The goal of this project was to change the orientation of the spiral planes such that three degrees of rotational motion could be estimated. In order to accomplish this goal, it was desirable for any three consecutive spiral planes to be as orthogonal as possible.

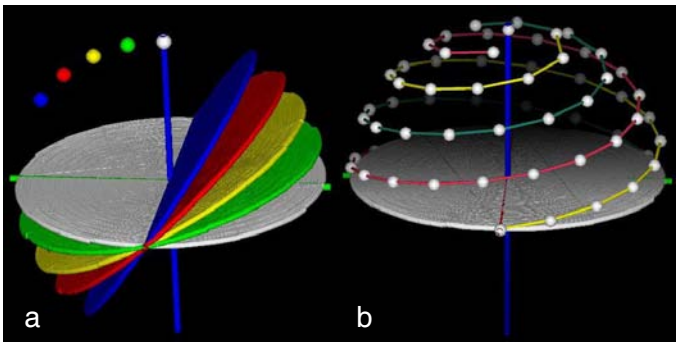

Figure 1: a) In the existing trajectory, the spiral planes are oriented normal to points that lie on a semicircle in the k_y-k_z plane. b) For the proposed trajectory, the spiral planes are oriented normal to points "uniformly" distributed on the surface of a hemisphere.

Methods and Results: The approach taken herein considered the acquisition of spiral planes normal to points uniformly distributed on the surface of a hemisphere The multi-helix placement given in [4] was considered to be a good approximation of uniform point distribution (see figure 1b). For this project, equation 11 in [4] was modified slightly to account for the fact that a hemisphere was being considered instead of a sphere. A color map of sampling density is given in figures 3a and 3b for the existing and proposed spiral projection trajectories respectively using a set of 121 spiral planes. As can be seen in figure 3, the existing trajectory critically samples a larger portion of the center of k-space. This suggests that for the proposed trajectory, it is necessary to acquire a larger number of spiral planes to obtain similar sampling density. However, it can also be seen that the new trajectory more "uniformly" distributes regions of undersampling than the current trajectory. We thus expect the aliasing patterns of the proposed trajectory to be less correlated than those of the existing trajectory.

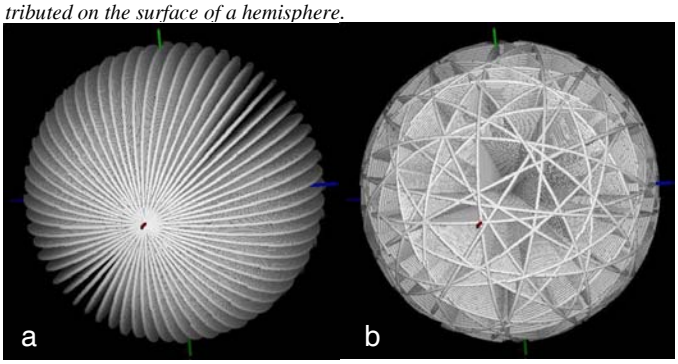

Figure 2: Plane orientation for a) the existing trajectory and b) the proposed trajectory (subset of planes used for typical collection).

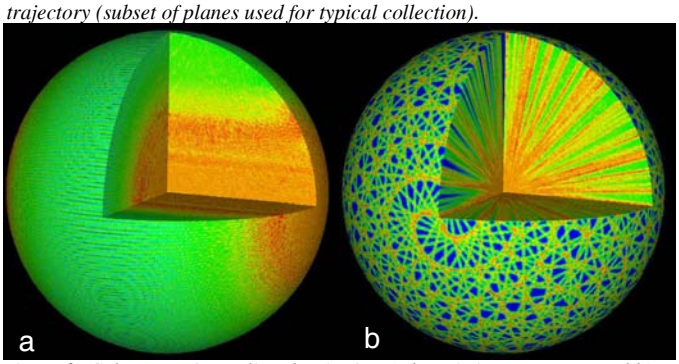

Figure 3: Colormap of sampling density for a) the existing trajectory and b) the proposed trajectory. Red-orange represents regions that are at least critically sampled, and blue represents regions where data are not acquired.

Ordering the spiral planes such that any three consecutive planes are relatively orthogonal will allow for potential estimation of all three degrees of rotational motion as well as the three degrees of translational motion. The proposed trajectory will make such a plane ordering possible. The proposed trajectory was used to obtain a 3D data set on a GE 3T Excite scanner (TE=2.3ms, TR=23ms, FOV=24cm, res=1.5mm, total scan time = 2min) using 240 fully sampled spiral planes (2x azimuthal undersampling). Some sample images from this data set are shown in figure 4.

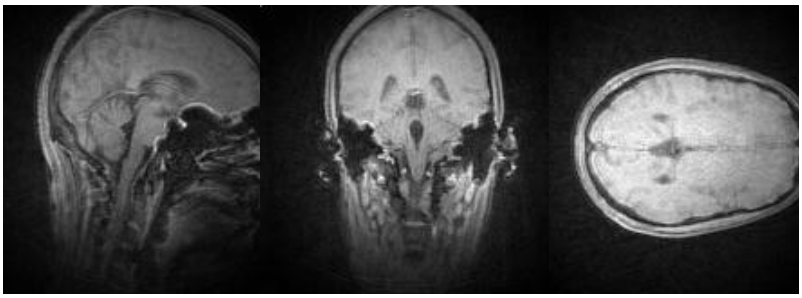

Figure 4: Sample images from data set using proposed trajectory (~2x undersampling)

References: 1. Irarrazabal P, Nishimura DG, *Mag. Res. Med.* 1995 33(5); 656-662. 2. Koladia KV, Pipe JG. Proc. ISMRM 2005, Abstract No. 336. 3. Pipe JG, Koladia KV, Baxter LC. Proc. ISMRM 2006, Abstract No. 1538. 4.Wong STS, Roos MS. *Mag. Res. Med.*1994 32(6); 778-784.