Comparing Gridding and Masking in 3D Parallel Reconstruction

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Introduction: Parallel image reconstruction methods synthesize data to replace undersampled or non-sampled gaps in k-space. The SENSE parallel imaging algorithm presented in [1] is generalized for the reconstruction of non-cartesian k-space trajectories through the use of a grid/de-grid step within the iteration loop. In an effort to reduce the number of computations in each iteration, a method of masking k-space [2] was introduced as a replacement for the grid/de-grid step. The proposed method of generating this mask builds upon the work previously presented as PEPI [3]. The relative quality and computation time are compared between masking and grid/degrid using an implementation of the CG-SENSE setup described in [1], for the reconstruction of a uniformly undersampled 3D trajectory, FLORET [4], at two levels of undersampling.

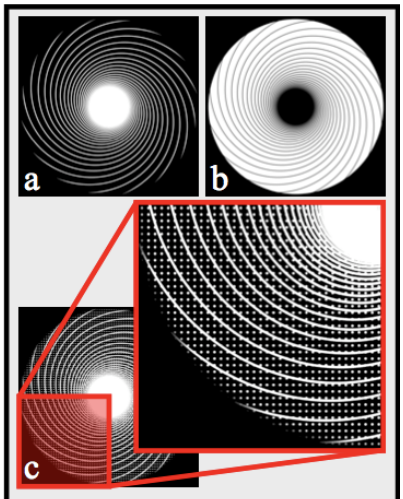

Figure 1: Example trajectory (a) and trajectory complement (b). The complement is density corrected by considering sampled points on the trajectory as well as points that will be synthesized during iterative parallel reconstruction, which lie off of the trajectory (c).

Methods: The iterative SENSE algorithm enforces data consistency (along the sampled trajectory) and coil consistency (using b1 maps) in each iteration. Data consistency is maintained by identifying and storing the synthesized data in each iteration by either gridding and degridding along the sampled trajectory or via multiplying gridded k-space by a mask (figure 1b). *Mask Generation:* The mask is created by adding nyquist spaced sample points to the sample trajectory and estimating sample density of the combined set using the algorithm proposed in [5]. The nyquist spaced points are then gridded separately to make a mask that is conditioned for both sampled points and synthesized points. Benchmarks were performed on a 12-CPU platform. *Trajectory:* Figure 2e shows variable density spiral-cone FLORET trajectory with parameters: 24cm FOV, 14.2msec ADC and 240 matrix at isotropic reduction factors of R=4 and 9. Scans were performed on a GE Signa Excite 3T system using an 8 channel head coil.

Results: The masking method produces less reduction in aliasing versus the grid/de-grid method (figure 2f, g). The time per iteration for masking is 10sec for both R=4 and R=9 (each requiring 5 iterations); the time for a grid/de-grid step is 50sec for R=4 and 10sec for R=9 (each requiring 15 iterations). The prep time for masking is about 10min for R=4 versus 2min for the grid/de-grid method.

Conclusion: The proposed masking method is less effective than the grid/degrid method but provides short, trajectory independent, iteration time which is advantageous when the total iteration time offsets the prep time (eg. dynamic imaging).

References: [1] Pruessmann et al., MRM, 46:638, 2001; [2] Wajer et al., 2001 ISMRM Proc., #767; [3] Zwart et al., 2010 ISMRM Proc., #2894; [4] Pipe et al., 2010 ISMRM Proc., #4974; [5] Johnson, MRM, 61:439, 2009.

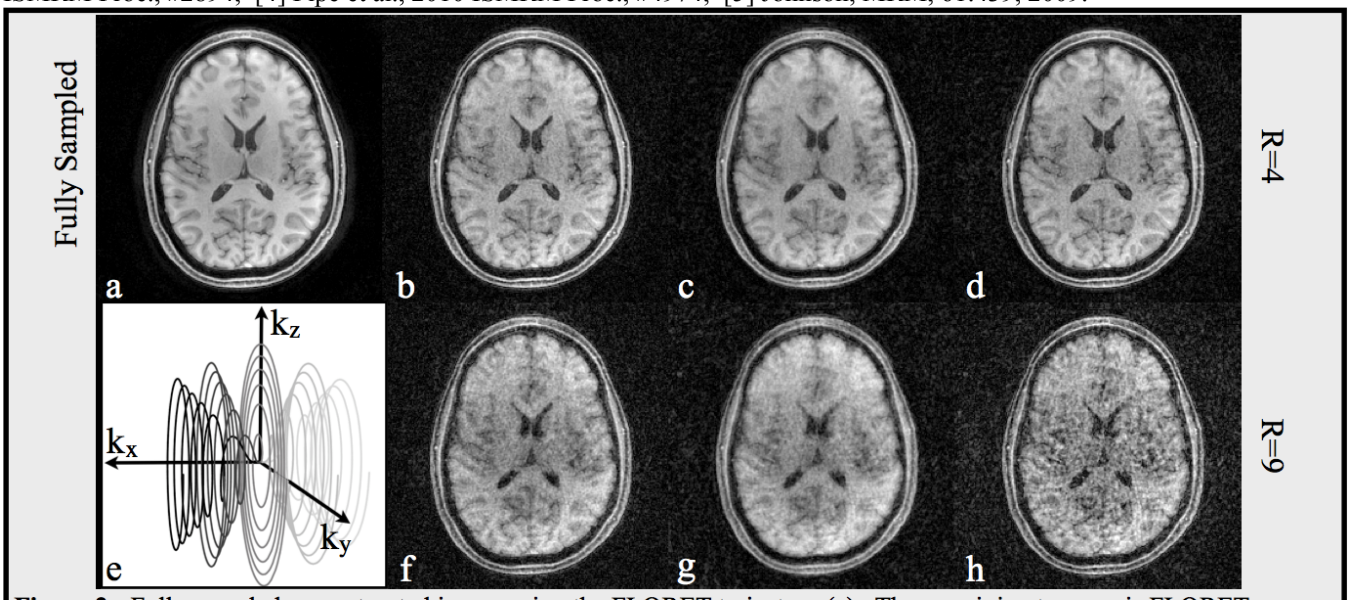

Figure 2: Fully sampled reconstructed image using the FLORET trajectory (a). The remaining top row is FLORET undersampled with R=4; the bottom row is undersampled with R=9. Images (b) and (f) were reconstructed using a grid/degrid step, (c) and (g) with masking, and (d) and (h) without parallel imaging. A sample FLORET is shown in (e).