Rapid 3D Parallel Imaging of Non-Cartesian Data

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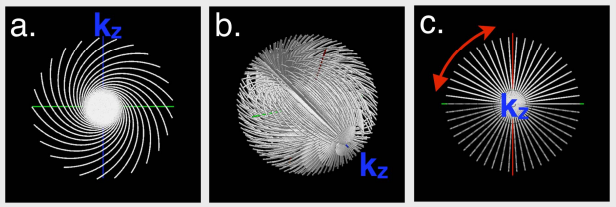
Introduction: The 3D Pretty Easy Parallel Imaging (PEPI) technique, previously presented as a 2D technique [1], is a coil sensitivity based method used for reconstructing arbitrary 3D k-space trajectories. PEPI is an iterative technique that enforces receive b1-field and sampled data consistency in each iteration (eg. [2-4]). The 3D trajectory used is Spiral Projection Imaging (SPI) [3].

Methods: *SPI:* The trajectory described in figure 1 consists of fully sampled spiral planes rotated about the k_z axis. Undersampling in k_x-k_y is caused by omitting planes from the fully sampled sphere in figure 1(b,c). Scan Parameters are: FOV 24cm, $1mm^3$ Res., 384 planes (fully sampled), 75 spiral arms, TE/TR = 0.6/9.9ms, scan time 5min (fully sampled), GE 3T Signa Excite System, 8-channel head coil. Subsampling the full set by factors of 4, 8, and 12 required 96, 48, 32 planes respectively. *PEPI:* Figure 2 shows the iteration loop. Coil combination in image space pushes data out from the SPI trajectory into non-sampled k-space. The new data are kept by masking the skipped k-space locations and recombining with original data in the next iteration. This is performed without the need for degridding and gridding operations at each iteration, improving computation speed.

Results: Figure 3 shows a comparison between fully sampled gridded k-space, undersampled gridded k-space, and PEPI reconstructed data. Total reconstruction time for undersampling by 4 is 56min. The number of PEPI iterations is 18 and takes 10min. Reconstruction was performed on an 8-CPU 3GHz Intel Xeon machine.

Conclusion: PEPI improves image quality at each level of undersampling used with arbitrary 3D SPI trajectories. PEPI provides rapid reconstruction times with less than 20% of the total reconstruction taken by the iteration process.

Figure 1: SPI trajectory. (a) Single spiral plane. (b) Multiple spiral planes rotated around k_z. (c) Side view of sphere, arrow indicates undersampling direction.



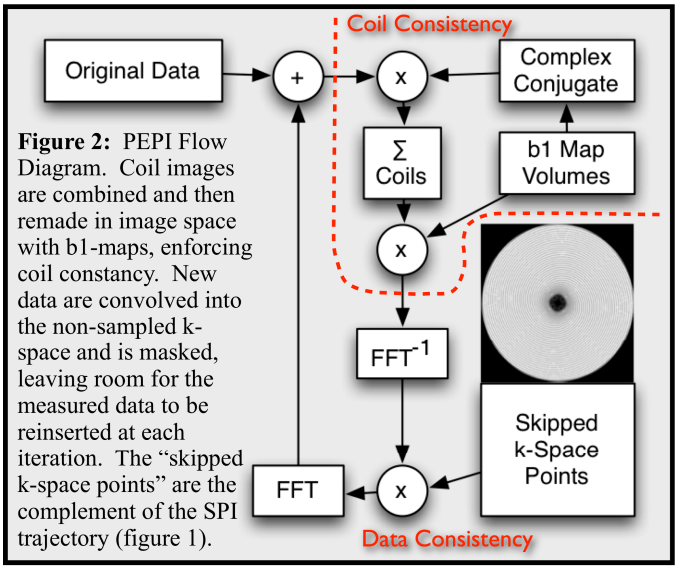


Figure 2: PEPI Flow Diagram. Coil images are combined and then remade in image space with b1-maps, enforcing coil constancy. New data are convolved into the non-sampled k-space and is masked, leaving room for the measured data to be reinserted at each iteration. The "skipped k-space points" are the complement of the SPI trajectory (figure 1).

References: [1] Pipe, ISMRM 2009, abstract 2722; [2] Pruessmann et al., MRM, 46:638, 2001; [3] Lustig et al., ISMRM 2007, abstract 333; [4] Wajer et al., ISMRM 2001, abstract 767; [5] Irarrazabal, P., MRM, 33:656, 1995

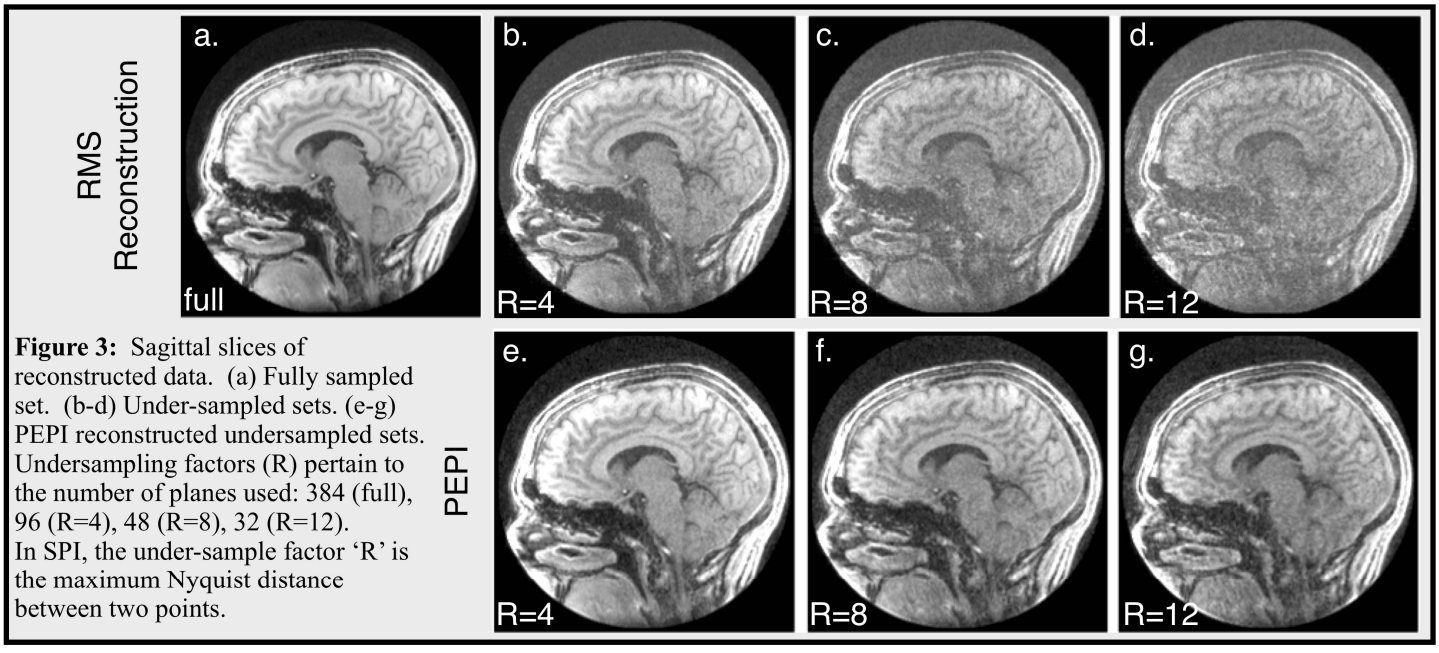


Figure 3: Sagittal slices of reconstructed data. (a) Fully sampled set. (b-d) Under-sampled sets. (e-g) PEPI reconstructed undersampled sets. Undersampling factors (R) pertain to the number of planes used: 384 (full), 96 (R=4), 48 (R=8), 32 (R=12). In SPI, the under-sample factor 'R' is the maximum Nyquist distance between two points.