Rapid Parallel Imaging Reconstruction of NonCartesian Data

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Introduction: There are many parallel imaging methods for reconstructing non-Cartesian data, but they typically exhibit modest performance, restricted applicability, or significant computational time even for 2D applications. This work presents a simple method for parallel imaging that makes few assumptions, is robust, and computationally fast.

Method: As illustrated in Fig. 1, this method iteratively (I) enforces coil consistency in image space and (II) reinserts the collected data. Coil consistency is enforced by combining coil images (using conjugate coil sensitivity maps to minimize noise sensitivity) (1,2), then multiplying the combined image by coil sensitivity maps to produce new coil images $f_{n,i}$. Data consistency is enforced by effectively gridding together the original spiral data d_s and the previous iteration's Cartesian data $f_{n,i}$, i.e. $G_{n+1,i} = W_S D_S + W_C F_{n,i}$. The sampling density weights W_C and W_S are calculated together using the method of Pipe (3,4), with the input relative weighting for spiral data (W_S) 10x higher than that for the Cartesian data (W_S). This effectively replaces the Cartesian data with collected data. These two data ($d_1 = W_S D_S$ after gridding, FFT, and rolloff-correction, and the transform of $W_c{*}F_{n,i}$) can then be added together in image space, since gridding and the FFT are linear operations. The Cartesian data forgo gridding and rolloff correction, and the collected spiral data (d_1) are processed just once. Thus this parallel imaging method requires only 2N two-dimensional FFT's per iteration (N coils), and little other significant calculation (e.g. no additional gridding/degridding per iteration).

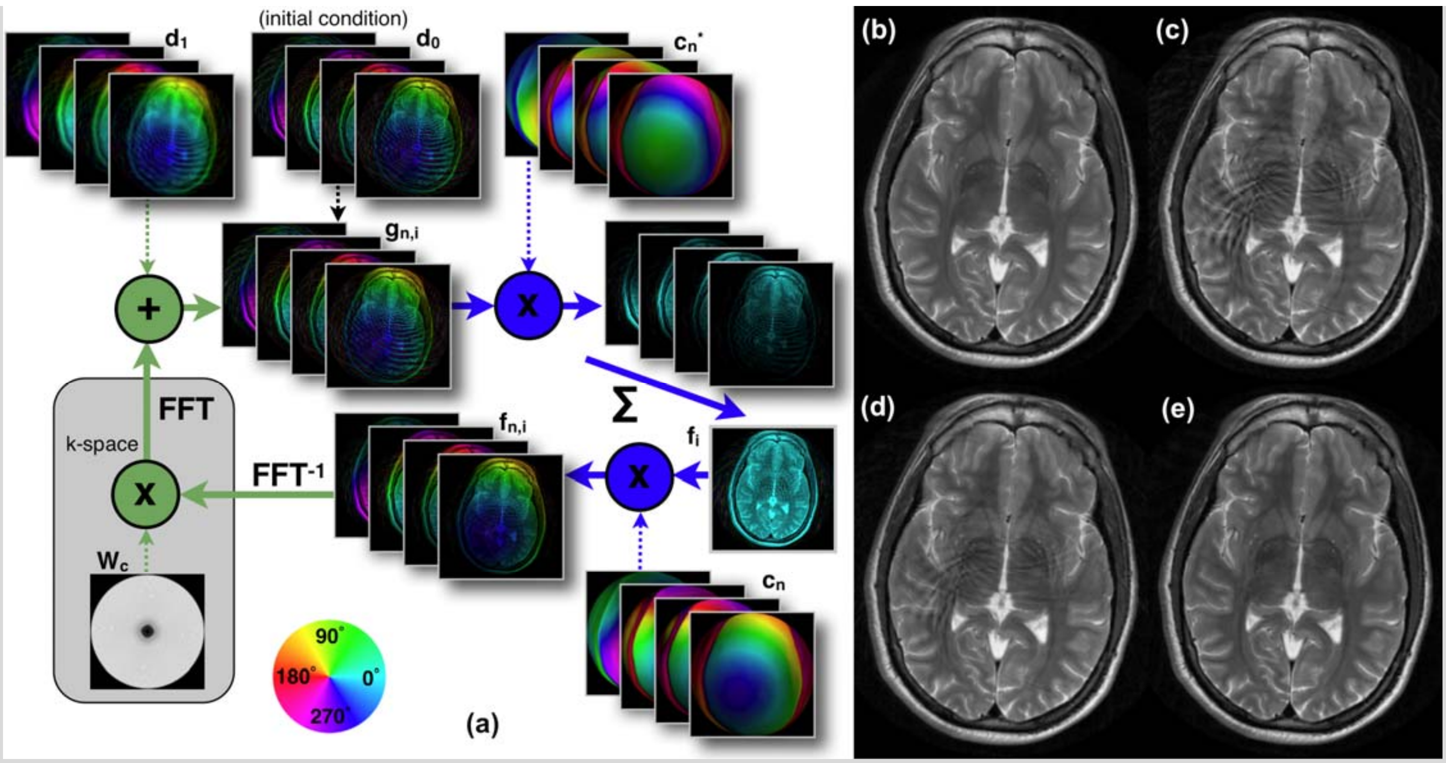

Fig. 1. (a) Flowchart for proposed iterative parallel imaging method. Images are color-coded based on phase, using the colorwheel at the bottom. In the first stage, images $g_{n,i}$ are multiplied by the conjugate c_n of coil sensitivity maps, summed across coils, then multiplied by the same (not conjugated) coil sensitivity maps c_n. This enforces consistency with the coils. In the second stage, data $f_{n,i}$ are transformed to k-space, multiplied by a weighting function W_c to remove data where it was collected, transformed back to image space, and added to the (appropriately weighted) collected data d_1. This enforces consistency with the collected data. Results are shown on the right for data synthesized on a linearly undersampled 2D spiral trajectory (1/2 Nyquist interleafs, same ADC) from (b) original image reconstructed using (c) simple rms weighting and the proposed algorithm after (d) 2 and (e) 8 iterations.*

Conclusions: This is a robust, fast method, and is extendible to 3D NonCartesian imaging methods with reasonable computational time (2Nx3D FFT's per iteration). It is general, only requiring B_1 maps and sampling coordinates. This work resembles other iterative methods that re-insert data (e.g. 5,6); one of the significant contributions of this work is the illustration that Non-Cartesian data can be reinserted each iteration without the need for degridding/gridding operations.

References: 1. Roemer et.al., *Mag Res Med* 16, 192. 2. Deveraj et.al., ISMRM 2008, abstract 1262. 3. Pipe, *Mag Res Med* 41, 179. 4. Johnson et.al., ISMRM 2006, abstract 2951. 5. Pruessmann et.al., *Mag Res Med* 46, 638. 6. Lustig et al., ISMRM 2007, abstract 333.

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