Non-Cartesian parallel reconstruction based on BOSCO with simultaneous off-resonance correction

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Introduction: Various parallel imaging reconstruction methods for data acquisition using non-Cartesian trajectories have been reported (1-4). For non-Cartesian data acquisition, off-resonance can cause image blurring. This blurring effect is more pronounced for long readout trajectories, e.g. spirals. Blurring is also a problem for non-Cartesian parallel imaging. Barmet et al (5) reported an iterative reconstruction method to correct B0-inhomogeneity-induced image artifacts in parallel imaging using SENSE reconstruction. In this abstract, we propose a non-iterative method based on BOSCO (parallel image reconstruction based on successive convolutions) (4) for off-resonance correction in non-Cartesian parallel imaging.

Theory: In our algorithm, we adapted multifrequency interpolation (6) for off-resonance correction, which approximates conjugate phase reconstruction by linearly combining images reconstructed at a set of demodulation frequencies. We investigated two different strategies to combine mutlifrequency interpolation with BOSCO to achieve simultaneous parallel reconstruction and off-resonance correction. For both strategies, we calculate the unaliased and deblurred image for each coil. The final image is then formed by the square root of the sum of squares of the images from all coils.

<u>Strategy A:</u> We perform demodulation on the raw time signal from each coil. Each demodulated data set is then convolved onto the Cartesian grid using gridding reconstruction. Among these gridded datasets, those from different coils but demodulated by the same constant frequency are used to form unaliased Cartesian k-space data by performing a BOSCO convolution. Unaliased channel images are then formed by Fourier transform. Multifrequency interpolation (6) is used to linearly combine these images to obtain a deblurred image.

<u>Strategy B:</u> We first perform BOSCO reconstruction to obtain unaliased k-space data on the Cartesian grids. We generate a set of phase masks on the Cartesian grids using constant demodulation frequencies. The unaliased k-space data is then multiplied with these phase masks and Fourier transformed to form a set of base images. These base images are linearly combined to form a deblurred image using multifrequency interpolation.

Theoretically, strategy A is more accurate than strategy B since the demodulation process is performed accurately on the time signal in strategy A, whereas it is approximated as a multiplication with a Cartesian phase mask in strategy B. However, we did not observe obvious differences between the final reconstructed images from two strategies. Strategy B requires significantly less computation than strategy A. In the strategy A, the BOSCO kernel needs to be recalculated when the dataset is from a different demodulation frequency or the target coil is different, whereas in the strategy B, the BOSCO kernel only needs to be recalculated when the target coil is changed. For example, if we have N coils and M demodulated datasets, we need to estimate M*N BOSCO kernels in strategy A whereas only N BOSCO kernels in strategy B.

Methods and Results: We tested our algorithm on both phantom and in-vivo datasets. The datasets were acquired on a 1.5T Siemens Avanto scanner using a variable density spiral sequence. The center of k-space is fully sampled and used for BOSCO kernel estimation. The outer k-space is under-sampled with acceleration factor 2. The readout length is 16.4ms with 16 interleaves in total. Two single shot spirals were used to acquire a low resolution field map to support pixelwise deblurring. A head coil with 12 elements was used for the phantom data acquisition and a surface coil with 9 elements was used for in-vivo coronary artery imaging. Figures 1 and 2 show the phantom and in-vivo coronary artery imaging examples, respectively. For the phantom data acquisition, we adjusted the shim intentionally to make the field more inhomogeneous. The algorithm has reduced the blurring artifacts in both examples.

Discussion: Our experiments were conducted at 1.5T. The improved SNR at 3T can enable higher parallel acceleration. However, field inhomogeneity is also more pronounced at high field, which makes off-resonance correction for non-Cartesian imaging more important. A potential difficulty in implementing the proposed method at 3T is how to acquire an accurate field map to support pixelwise deblurring. Further study should be investigated for simultaneous off-resonance correction and non-Cartesian parallel imaging at 3T.

Conclusion: We demonstrated that the BOSCO reconstruction can be combined with multifrequency interpolation for simultaneous off-resonance correction and non-Cartesian parallel imaging.

References: 1. Pruessmann et al, MRM 46: 638 (2001) 2. Heidemann et al, MRM 56, 317 (2006) 3. Heberlein et al, MRM 55: 619 (2006) 4. Hu et al, Proceedings 14th ISMRM, 10 (2006) 5. Barmet et a proceeding 13th ISMRM, 682 (2005) 6. Man et al, MRM 37, 785 (1997)

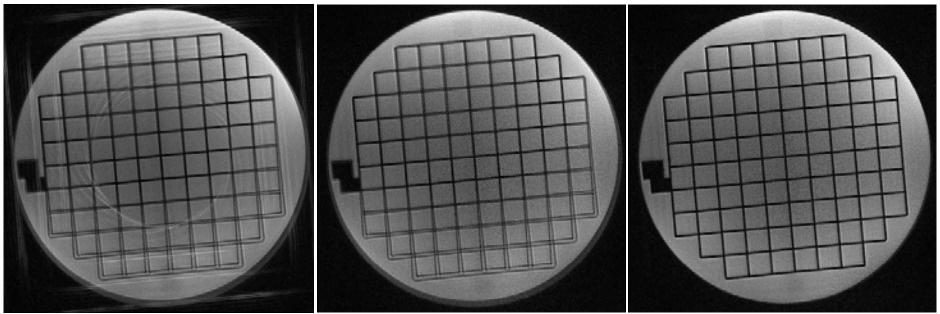

Figure 1: Phantom example. Left: Image with direct gridding reconstruction; Center: Image with BOSCO reconstruction; Right: image reconstructed using the proposed algorithm.

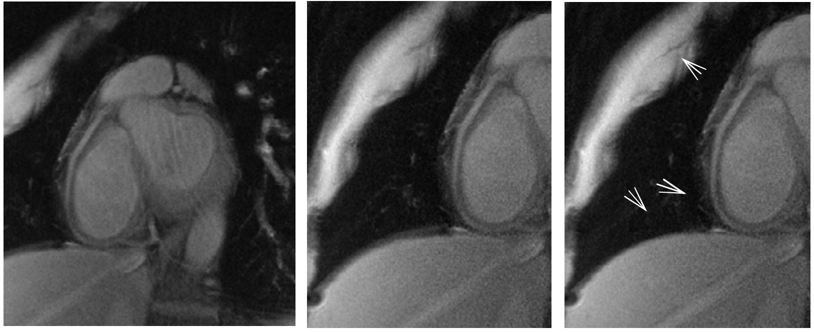

Figure 2: In-vivo coronary artery imaging example. Left: Image with direct gridding reconstruction; Center: Zoomed in image with BOSCO reconstruction; Right: Zoomed in image that was reconstructed using the proposed algorithm. The white arrows depict the areas with reduced blurring artifacts after the off-resonance correction.