Optimal Utilization of Acquired k-space Points for GRAPPA Reconstruction

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Introduction

In GRAPPA [1] the utilization of acquired k-space data to reconstruct each specific miss point is restricted within the phase encoding direction. Since it has been recognized in the generalized approach to parallel MRI [2] that each acquired k-space point can be incorporated in reconstruction, it is necessary to inspect whether the data utilization (within single column) for reconstruction in conventional GRAPPA is optimal. In this report, a reconstruction scheme also incorporating data points in different readout locations is compared with the conventional GRAPPA reconstruction with different coil geometries by simulations and experiments. It is found that the optimal selection of data points for reconstruction should depend on the coil array configuration and the orientation of FOV.

Method

Two reconstruction schemes are compared in this study. One is the conventional GRAPPA method which uses multiple blocks of data points but within single column to estimate each missing point, as shown in Fig. 1a (Recon1-3). The other is an extended GRAPPA reconstruction (called neighbor GRAPPA) which makes use of several neighbor signal points, including the data points in different readout locations, as shown in Fig. 1b (Recon4-5). In both cases the different reconstruction results were combined weighted by the goodness of fits. For simplicity we use four data points in each reconstruction. Incorporating more signals will inevitably increase the time cost for reconstruction.

To simulate the parallel MR acquisitions, the sensitivities of the two typical coil arrays shown in Fig.2 in given FOVs (an axial FOV for Fig.2a and a coronal FOV for Fig. 2b) are simulated using Biot-Savart equation. Then these coil sensitivities were used with a standard Shepp-Logan phantom image to generate full versions of k-space datasets. Simulated raw data with different acceleration factors were then created by extracting partial datasets from the full datasets. To compare the neighbor GRAPPA with the conventional GRAPPA, their reconstruction results at varying acceleration factors were compared in terms of residual aliasing artifact level.

In vivo MRI experiments were performed on a 3T Siemens Trio MRI system. Brain MRI data were acquired with body coil as transmit coil and an 8-element coil array similar with Fig. 2b as receiver. Transverse images were acquired with a spin echo sequence (matrix = 256×256, slice thickness = 5 mm, TE = 6.8ms, TR = 0.7s). In this experiment, a full dataset was acquired and later decimated off-line by a factor of 1.7 (outer reduction factor = 2) to simulate 1.7-fold acceleration. Again, the neighbor GRAPPA was compared with conventional GRAPPA. In both reconstructions 20 ACS lines were used for auto-calibration.

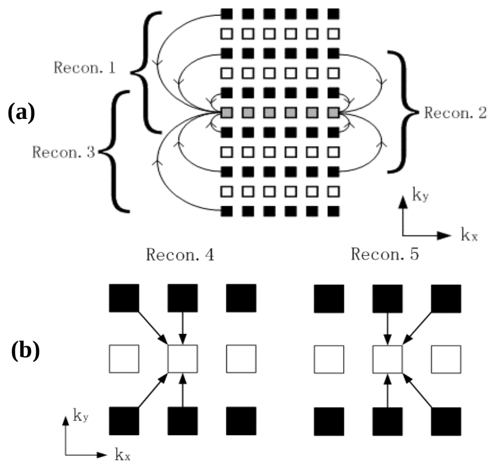

Fig. 1. Two reconstruction schemes for comparison. (a) conventional GRAPPA; (b) the neighbor GRAPPA

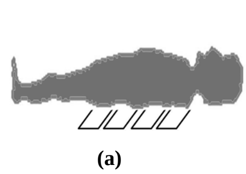

Fig. 2. Sketch of two typical coil arrays. (a) 4-element spine coil; (b) 8-element head coil

Results

The results of artifacts estimation for both reconstructions with the 4-element spine array and the 8-element head array are presented in Fig. 3a and Fig. 3b, respectively. As expected, the artifact level of neighbor GRAPPA reconstruction is notably lower than conventional GRAPPA at all the acceleration factors for the head array, but a little higher than conventional GRAPPA for the spine array.

Reconstruction results from the in vivo MRI data are displayed in Fig. 4. Here Fig. 4a and Fig. 4b are the reconstructed images using the conventional GRAPPA and the neighbor GRAPPA (in both cases, R = 1.7), respectively. It shows that the image produced by conventional GRAPPA suffers from visible aliasing artifacts, while in neighbor GRAPPA these artifacts are significantly reduced.

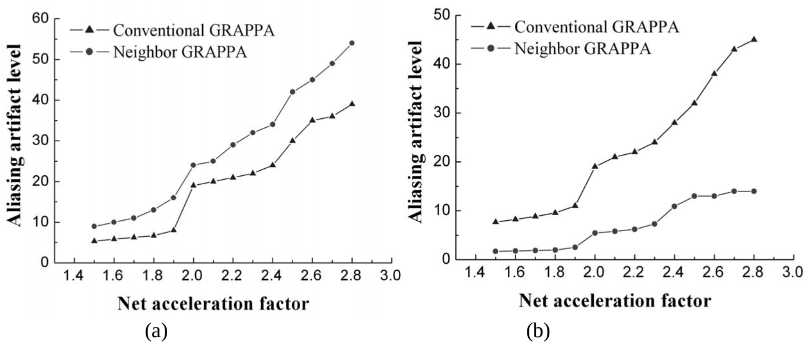

Fig. 3. Residual aliasing artifact vs. net acceleration factor for conventional GRAPPA and neighbor GRAPPA using the 4-element spine coil (a) and the 8-element head coil (b).

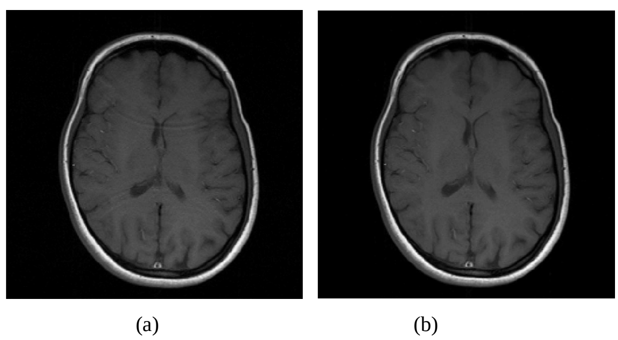

Fig. 4. Comparison of conventional GRAPPA and neighbor GRAPPA reconstruction of a brain image acquired with an 8-element head array. (a) result of conventional GRAPPA; (b) result of neighbor GRAPPA.

Conclusion

The optimal utilization of acquired k-space signals in GRAPPA reconstruction has been investigated for different coil arrays. Computer simulations have shown that the optimal reconstruction scheme should depend on the geometry of the receive coil array and the orientation of FOV. When the elements of the receive coil array have different sensitivity distributions in both directions in the 2-D FOV, such as the case with circularly arranged head coil array, the neighbor GRAPPA which incorporates some neighbor points in reconstruction is more effective than conventional GRAPPA

Acknowledgement

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References

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