A GRAPPA Reconstruction for Simultaneous Multi-Slice Radial Acquisition

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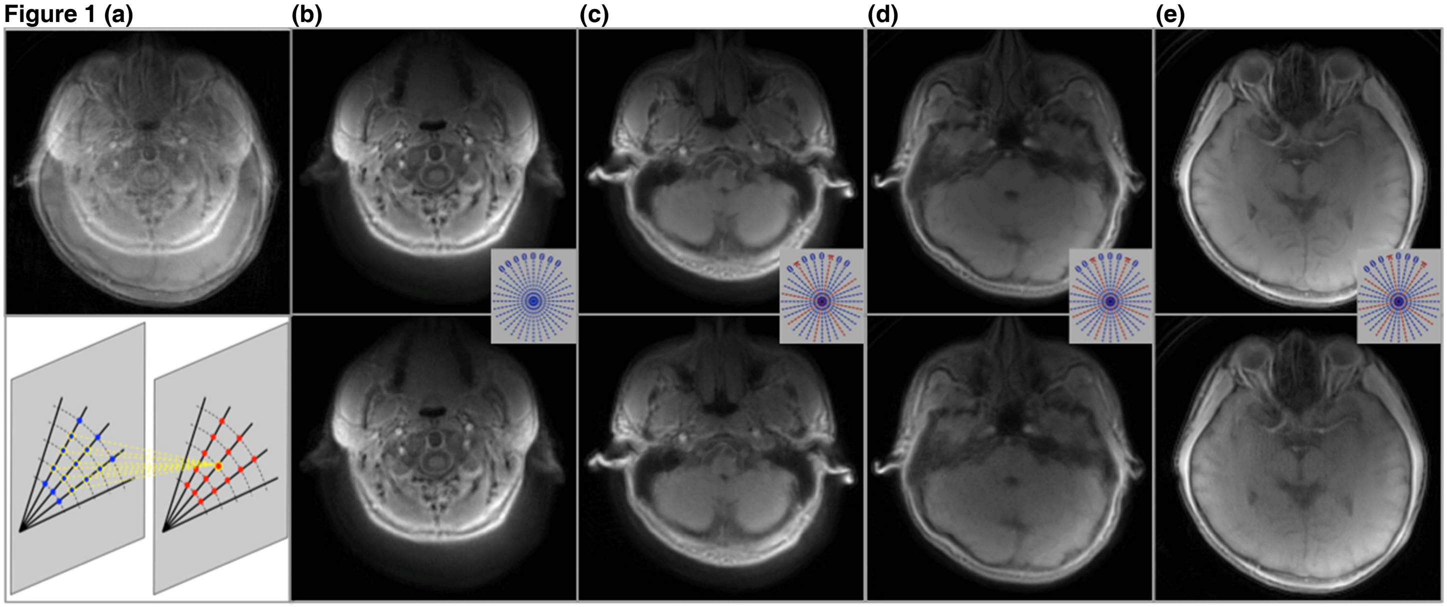
Target Audience: MRI physicists and engineers.

Purpose: A reconstruction method based on the framework of GRAPPA [1] for Simultaneous Multi-Slice (SMS) radial acquisition is proposed. Radial acquisition is useful for ultra-short echo (UTE) imaging and is robust against motion artifacts [2]. Recent progress in CAIPIRINHA [3-5] allows for optimizing SMS acquisitions for radial trajectories and can reduce the scan time by up to eight fold without significant SNR loss. However, reconstruction of radial CAIPIRINHA data relies on SENSE [6], which formulates the reconstruction as a linear inverse problem solved using a computationally intensive iterative numerical method.

Methods: Fully sampled *in vivo* brain images were acquired on a Siemens (Erlangen, Germany) TimTrio 3T scanner using a 32-channel head coil and a 2D UTE radial sequence (half-sinc excitation, TE=0.02ms, FOV=2cm, 32 5mm slices). Figures 1b to 1e show four fully sampled slices. These four slices were phase cycled in a CAIPIRINHA style: Fig. 1b 0-0-0-0, 1c 0-π-0-0, 1d 0-0-π-0, and 1e 0-0-0-π. The phase cycling patterns are shown in the lower right corner of Fig. 1b to 1e. The phase-cycled four slices were summed to simulate a collapsed SMS slice shown in Fig. 1a. The schematic of the SMS radial GRAPPA reconstruction is shown in Fig. 1f. The blue dots represent SMS data, and the red dots represent calibration data and the separate slice data. The radial plane was divided into 64 pie-shaped partitions, and the calibration and reconstruction were performed separately for each partition. The GRAPPA coefficients were estimated using nine surrounding SMS calibration data points during calibration. The slices were then separated using the estimated coefficients and the SMS data. The calibration and reconstruction were performed for each slice. After the slice separation, radial data were gridded onto a Cartesian grid [7] with an over-sampling factor of two. Images of individual coils were obtained using FFT and combined as the square root of the sum of squares.

Figure 1 (a) **(b)** **(c)** **(d)** **(e)**



(f) **(g)** **(h)** **(i)** **(j)**

Results: The images in the lower row of Fig. 1g to 1j are magnitude images reconstructed using the proposed SMS radial GRAPPA method. The corresponding fully sampled images are shown in the upper row. No visible aliasing artifact is observed comparing the slices reconstructed using the radial SMS GRAPA method to the fully sampled slices.

Discussion & Conclusion: The results show that SMS radial images can be successfully separated using a GRAPPA-based reconstruction. This method is computationally fast and therefore suitable for online implementation on a scanner. This is useful for simplifying the reconstruction of UTE imaging that uses the SMS method to reduce the prolonged scan time. Further study will include investigation of different phase-cycling schemes for SMS acquisition and g-factor calculations for SNR quantification.

References: [1] Griswold, MRM 47:1202-1210 (2002). [2] Glover, MRM 28:275-289 (1992). [3] Breuer, MRM 53:684-691 (2005). [4] Yutzy, MRM 65:1630-1637 (2011). [5] Breuer, ISMRM 21 (2013). [6] Pruessmann, MRM 42:952-962 (1999). [7] Rasche, IEEE Trans Med Imaging 18:385-392 (1999).

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