3D Through Time GRAPPA For Dynamic Distributed Spirals

Dallas C Turley[1] and Jim Pipe[1]
[1]*Imaging Research, Barrow Neurological Institute, Phoenix, Arizona, United States*

Introduction: There are many applications in MR for increased temporal resolution, including perfusion imaging (DCE and DSC), MR angiography, functional imaging, etc. The goal of this work is to implement GRAPPA parallel imaging [1] in the 3D Distributed Spirals trajectory (DST) [2] to improve temporal resolution for dynamic data acquisition. This work is an extension of the method presented by Seiberlich et al in [3].

Methods: The DST k-space trajectory is shown in **Figure 1**. A cross-section of the volume in the k_z-k_r direction shows a uniform sampling pattern which is used to interpolate missing data using GRAPPA. The fully sampled volume was segmented into 4 bins (A,B,C,D), each bin containing one quarter of the TR's. During dynamic data acquisition, only bin A was acquired. A fully sampled volume was acquired in a separate scan to train GRAPPA weights. The fully sampled volume was segmented into radial planes and GRAPPA weights were calculated for, and applied to, each plane independently.

To measure the temporal resolution of the proposed method, two scans were completed (scan I and scan II) in which a phantom was rotated between scan I and scan II. To fully sample the volume, 4 bins of approximately 120 TR's were required, each bin required 1.1 seconds to acquire. Data from TR's 1-64 from scan I bin D were combined with TR's 65-120 from scan II to simulate a step function in the ROI's shown in Figure 2. A sliding window method reconstructed the step function in the fully sampled data, while the proposed method was used to reconstruct the time course in R=4 undersampled data. The temporal resolution of the sliding window reconstruction was 4.5s, while the temporal resolution of the proposed method was 1.1 s. The reconstructed step-functions are shown in Figure 2H.

Results & Conclusions: Figure 2 shows phantom images acquired using the proposed method. The undersampled image shows substantial aliasing artifacts, which are reduced in the GRAPPA reconstructed image. The proposed method shows substantially higher temporal resolution compared to a sliding window reconstruction of fully sampled data. The proposed method is a promising new approach to improve temporal resolution for dynamic data acquisition.

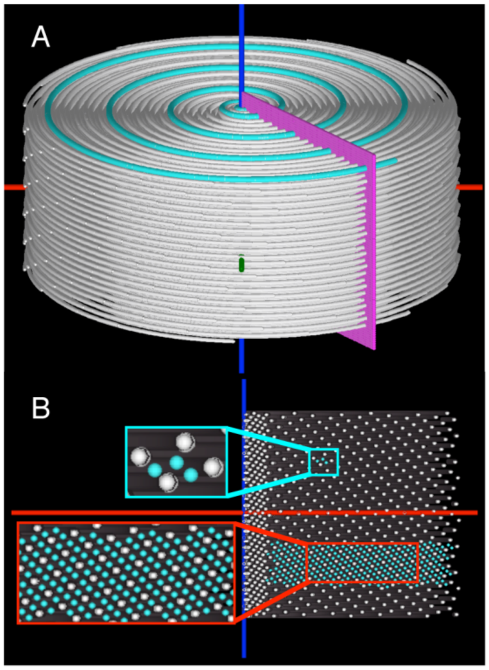

Figure 1. The k-space trajectory is created by distributing spiral arms along the k_z axis and rotating successive arms by the golden angle, sampling a cylinder in k-space (A). The undersampled volume has a uniform sampling pattern in any radial plane (B). A GRAPPA kernel (blue inset) shows the spatial relationship between source (white) and target points (cyan) for undersampling factor R=4. Applying GRAPPA weights supports the fully sampled field of view (red inset).

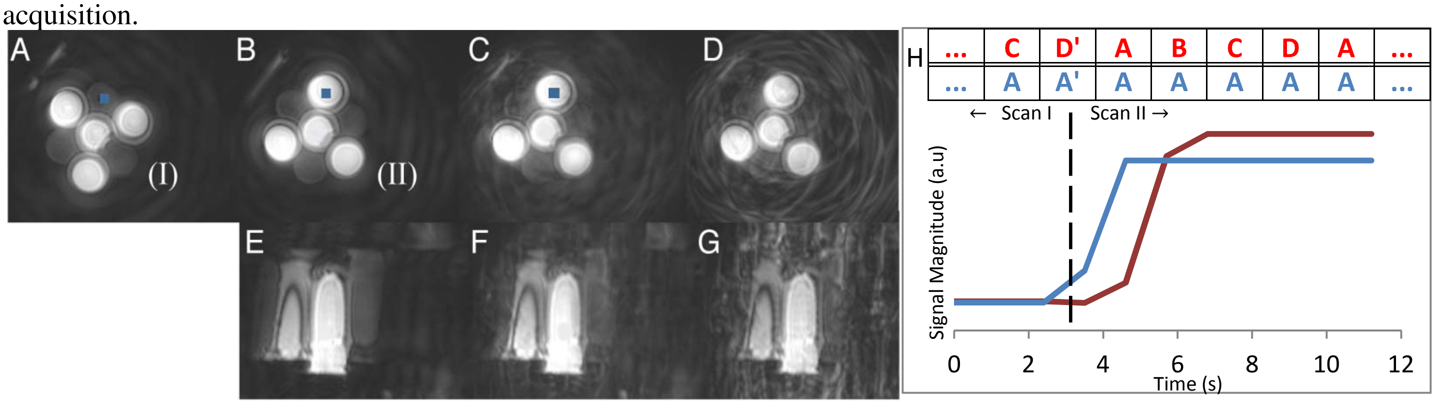

Figure 2. Axial (A-G) and sagittal (E-F) phantom images. Two image volumes (A,B) are acquired, rotating the phantom between scans. R=4 undersampled images (D,G) are obscured by aliasing which is reduced in the proposed method (C,F). Fully sampled volumes were acquired in 4.5 s, undersampled volumes were acquired in 1.1 s. The step-function time-course (H) was reconstructed using sliding window and the proposed method for the ROI shown in A-C.

References: 1. Griswold, MRM 2002. 47(1202-10). 2. Turley, MRM 2013. 70 (413-19). 3. Seiberlich, MRM 2011. 66 (1682-88)

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