Improved Spatial and Temporal Resolution using Parallel Imaging and SOS Trajectory for HYPR Reconstruction

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Purpose: HighlY contstrained BackProjection (HYPR) [1] has been utilized as a post processing reconstruction method for a variety of imaging applications, including contrast enhanced MR angiography (CEMRA). In the lower extremities, it has been shown that HYPR reconstruction allows for improved spatial and temporal resolution compared to view sharing reconstructions like TRICKS [2]. Both Stack-of-Stars (SOS) [3] and Vastly undersampled Isotropic Projection Reconstruction (VIPR) [4] have been studied as possible k-space trajectories for CEMRA exams of the lower extremities [5]. Each trajectory has its own advantages and limitations. A previously presented advantage of the VIPR acquisition is the high, naturally isotropic spatial resolution, whereas one limitation of the SOS trajectory has been decreased through plane resolution in order to maintain high temporal resolution. In this work, we apply a k-space based parallel imaging algorithm to the slice encoding direction of a SOS acquisition to achieve high, isotropic resolution while also improving temporal resolution.

Methods: Coronal slices of the anatomy were acquired, while an axial excitation slab is utilized to reduce artifact [6]. Increased spatial resolution resulting from the addition of parallel imaging will manifest in the anterior/posterior direction. In our implementation, all slices for a given projection angle are acquired before advancing to the next projection angle. Angle acquisition ordering is determined by the Golden Angle scheme [7]. Parallel imaging is performed with an acceleration factor of approximately two (R≈2), due to the fact that every other slice of our prescription is left un-acquired – except for the central 16 slices, which are fully acquired. The central 16 slices serve as the auto-calibration lines necessary to determine the reconstruction weights in the parallel imaging reconstruction algorithm.

Four volunteers were imaged on a 3T MR750 scanner (GE Healthcare) with a 32 channel torso coil (Neo Coil). Gadolinium based contrast (Multihance, Bracco Diagnostics) was administered intravenously at a rate of 3 ml/s. The contrast volume per injection did not exceed 0.1 mmol/kg. Prior to injection, an accelerated mask image was obtained. Mask subtraction of k-space data was performed prior to parallel imaging calibration and reconstruction.

Parallel imaging reconstruction was performed using a coil-by-coil data-driven calibration technique, similar to the GRAPPA method [8]. The specific method utilized here is Autocalibrated Reconstruction with Cartesian sampling – or ARC [9]. A 2D kernel of 5 points along the projection readout x 7 points along the slice encoding direction was used for the ARC algorithm, which was performed for every accelerated projection readout x slice plane. An acceleration factor of R ≈ 2 in the A/P direction was achieved for the stack of coronal slices, leading to a spatial resolution of 1.0 x 1.0 x 1.0 mm (FOV: 480mm x 480 mm x 120 mm Matrix Size:480 x 480 x 120). HYPR reconstruction of this data was performed using 20 projections per slice per frame, yielding a temporal resolution of 6.5 seconds. This corresponds to a total acceleration factor of ≈80 (40x radial undersampling factor and R≈2 parallel imaging acceleration factor).

Results and Discussion: Figure 1 shows both coronal and sagittal-oblique MIPs of four consecutive time frames from a healthy volunteer. The exam was performed with the HYPR-ARC combination described above. From the oblique reformats, it is clear that ARC successfully unwraps the coherent aliasing due to undersampling in the phase encoding direction. The high, isotropic spatial resolution and high temporal resolution can also be appreciated by examining these consecutive time frames. Note that while data was acquired bilaterally, only one leg is show here due to space considerations.

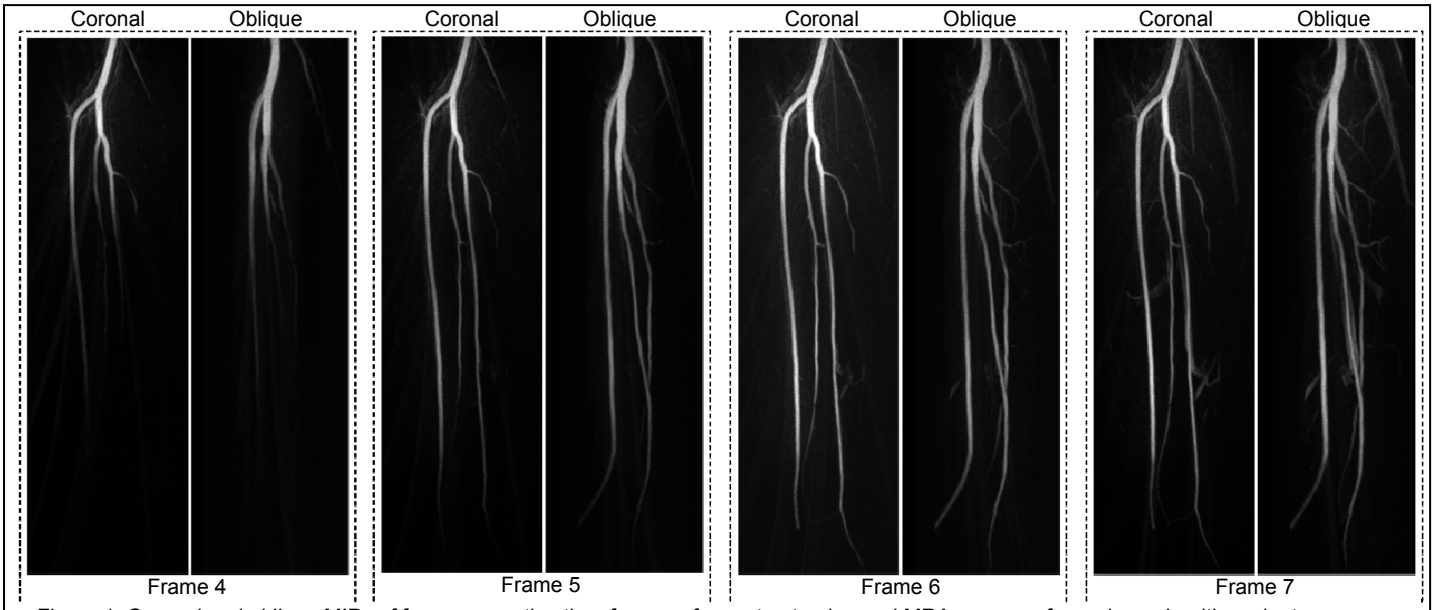

Figure 1: Coronal and oblique MIPs of four consecutive time frames of a contrast enhanced MRA exam performed on a healthy volunteer. Spatial resolution: 1.0 mm isotropic. Temporal resolution: 6.5 seconds

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Acknowledgments: We gratefully acknowledge GE Healthcare for contributing research support to this project. This project is funded by NIH grant R01EB006882.