# Parallel Imaging Techniques for Contrast-enhanced MR Angiography using 3D Non-Cartesian Trajectories


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**INTRODUCTION:** Undersampled projection (PR) or radial trajectories have been used to reduce the tradeoff between spatial and temporal resolution in contrast-enhanced MR angiography (CE-MRA) [1,2]. However, radial sampling in two k-space dimensions produces streak artifacts while 3D PR sampling creates a structured noise-like artifact. Both artifacts can reduce the available CNR. Here we implement two parallel imaging techniques to reduce these artifacts.

**METHODS:** A time-resolved, peripheral vasculature exam of the calf station was implemented with PR in-plane encoding and Cartesian-encoding the through-plane dimension to study the calf station. 60 projections were acquired with 256 readout resolution for a scan time acceleration factor of 4 with four receiver coils. The method, known as PR Hyper-Tricks [3], produced 21 time-frames in a 3 minute scan time that included the mask acquisition. A post-processing technique with similarities to PILS [4] was used to suppress the propagation of artifacts from a region imaged by one coil element into regions imaged primarily by other coils. Each coil was weighted by a spatial Fermi filter, described by the equation:

$W_j(r) = \frac{1}{1+e^{\beta(r-r_0(j))}}$ where $W_j(r)$ refers to the weighting factor assigned to the voxel located a distance *r* from the center of coil *j* and $r_0(j)$ refers to the radius of the sensitive region of coil *j* where the signal should be well-maintained. The actual radius $r_0(j)$ was chosen empirically, however methods to automatically determine this parameter are provided in [4].

The conjugate gradient SENSE (CG SENSE) method [5] was used to reconstruct data from the Vastly undersampled Isotropic PRojection (VIPR) sequence in the second technique. An acceleration factor of four was achieved using four receiver coils. The method proposed by Walsh et al [6] was used to generate 3D receiver sensitivity maps. All data was acquired on GE Signa 1.5T magnets ( GE Healthcare, Milwaukee, WI).

**Results:** Severe streaks originating from a region superior to the coronal 3D CE-MRA exam are seen in Fig. 1a. Application of the spatial Fermi filter in Fig. 1b significantly reduces this artifact. The CG SENSE method was implemented with four iterations, requiring approximately eight times the reconstruction time of a standard VIPR exam. In Fig. 2 a, much of the center of the slice should be a signal void but aliased signal provides a strong background signal. The VIPR SENSE image, shown in Fig. 2b, improves the ratio of signal to the mean background by a factor of 2.

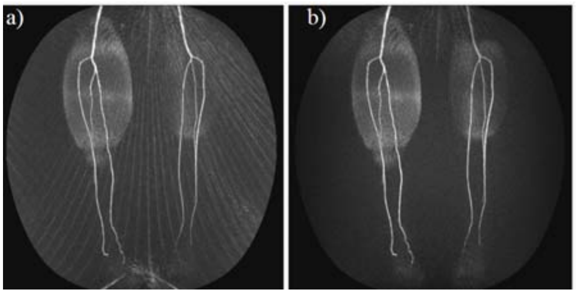


**Figure 1:** a) Original image produced by combining unfiltered data from all four coils. b) Artifacts significantly reduced by applying spatial Fermi filter to each coil's image volume.

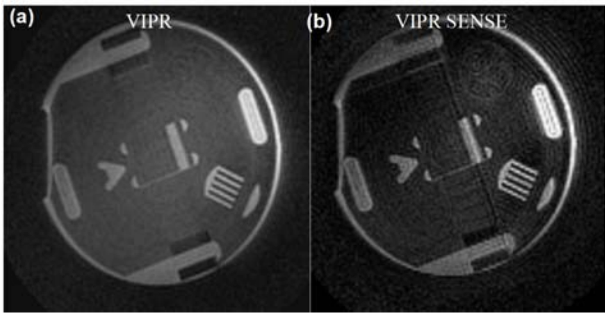


**Figure 2:** (a) A slice from an image volume after conventional VIPR reconstruction. (b) The same slice after VIPR SENSE reconstruction shows an improvement in signal to background contrast by a factor of 2. This image was obtained after the fourth CG iteration

**DISCUSSION:** As the number of available coils increases**,** the attraction of the simplicity of the PILS processing will grow**,** especially if different demodulation frequencies were available for each coil. An effort to compare the power of the CG SENSE and Radial GRAPPA [7] techniques is underway. While processing is reduced for Radial GRAPPA, the validity of acquiring all the necessary ACS lines prior to contrast administration must be verified.

**REFERENCES:**


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