

kf ARC Reconstruction for Improving MRI Around Metal using MAVRIC

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Introduction: MRI in vicinity of metallic implants has been difficult due to the severe B0 perturbations caused by the implant. A recently proposed method, MAVRIC¹, was developed to address this challenge by combining spectral images acquired at difference off-resonance frequency bins (FB). However, such an approach necessitates data acquisition for multiple images covering a wide off-resonance frequency range and thus results in a multi-fold increase in scan time. Conventional data-driven parallel imaging methods has proven capable of accelerating MAVRIC² but are limited by coil capability. In this work, we demonstrate a new reconstruction method for improving MAVRIC with high acceleration factors by utilizing not only k-space correlations within individual frequency bins but also spectral correlation between spectral images.

Methods & Materials: MAVRIC collects and combines multiple spectral images, which are acquired using spectral-selective RF pulses with difference center frequency offsets. Overlapping of spectral profile between RF pulses at consecutive frequency offsets is typically used to obtain homogeneous spectral response in the final spectral-combined image. As a result, significant correlations exist in-between spectral images acquired at adjacent frequency bins. A representative example is shown in Fig. 1.

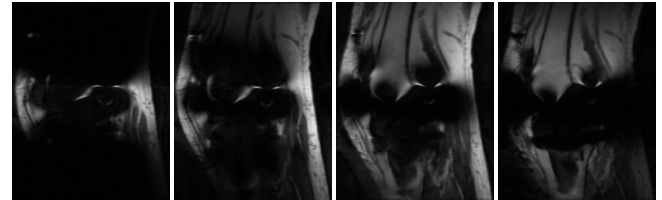


Fig. 1. individual spectral images acquired at 4 adjacent frequency positions showing significant correlation.

kf ARC: Earlier studies have shown that temporal correlation can be utilized to improve reconstruction for highly-accelerated dynamic imaging^{3,4}. Similarly, this work proposes a new method exploiting correlation in both k-space and among frequency bins for MAVRIC (kf ARC) following the reconstruction scheme of kat ARC (k- & adaptive t- ARC) used for cardiac cine imaging⁵. To maximize spectral correlation, undersampling in [ky, kz] was interleaved along the spectral direction, as illustrated by Fig. 2. For image reconstruction, kf ARC was first performed to reconstruct each individual spectral image using a 4D k-space kernel extending along kx, ky, kz and FB. A missing k-space data at FB was synthesized using the 2 nearest k-space neighbors at the same FB and the sampled k-space lines with the closest phase-encoding within the nearest AF (AF: acceleration factor) FB neighbors. Next, spectral images were reconstructed from the synthesized k-space at all FB's and combined as a composite image.

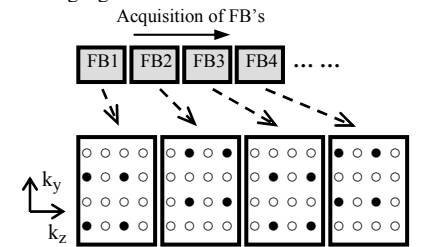


Fig. 2. interleaved ky-kz sampling scheme for kf ARC (2x2). ●: sampled; ○: unsampled.

The proposed method was evaluated in comparison with conventional data-driven parallel imaging. For this purpose, two patients with metal implants on the knee were scanned on a GE 1.5T Signa HDx scanner (GE Healthcare, Waukesha, WI) using an 8-channel knee coil (Invivo Inc., Gainesville, FL). The imaging parameters included: ~16x12cm FOV, matrix size: 256x128 (patient 1) and 320x256 (patient 2), 22 frequency bins, bandwidth +/-125kHz, TR/TE: 3650/39.6ms, 40 slices interpolated into 80 with 1.5mm slice thickness. One dataset was acquired in full k-space and the other was acquired with 2x along ky. Both datasets were offline downsampled to simulate ARC and kf ARC with higher acceleration factors. Images were reconstructed using GE product ARC reconstruction and kf ARC implemented in Matlab.

Results: Fig. 3 compares images obtained from dataset1, reconstructed using full k-space (a), ARC with 5x1 acceleration in [ky, kz] (b) and kf ARC with 5x1 (c). Clearly, ARC exhibits reduced SNR and residual artifacts (white arrow), while kf ARC provides image quality very similar to the full k-space reference. Fig. 4 shows the results from dataset2. ARC with 4x2 (b) produces significant ghosting artifacts (white & black arrows). In comparison, such artifacts are suppressed in the image reconstructed using kf ARC (c). At such a high acceleration factor, kf ARC shows acceptable image quality compared with the reference reconstruction using ARC 2x1 (a). All the images shown here are reconstructed without off-resonance correction. Image quality can be further improved by incorporating this processing prior to spectral combination.

Discussion: This work extended kat ARC for dynamic imaging to imaging around metal using MAVRIC. Our initial results show that kf ARC can improve image reconstruction at high acceleration factors compared to conventional parallel imaging by additionally exploiting the significant correlations between acquisitions at adjacent frequency bins. The proposed method is a promising solution to reducing the long acquisition time needed for MAVRIC. Further investigations are needed to explore the acceleration capability of kf ARC in MAVRIC.

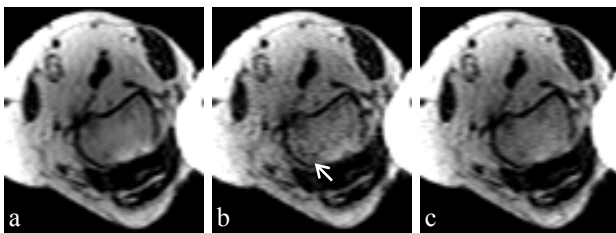


Fig. 3. dataset1: axial reformat images (ky-kz encoded plane) reconstructed using a) full k-space, b) ARC 5x and kf ARC 5x.

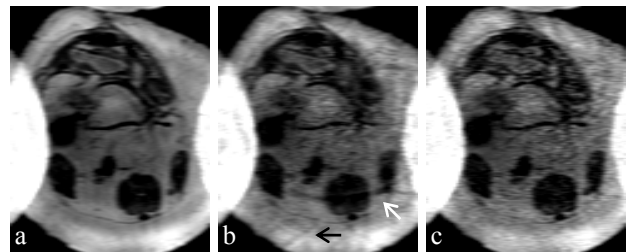


Fig. 4. dataset2: axial reformat images (ky-kz encoded plane) reconstructed using a) ARC 2x1, b) ARC 4x2 and kf ARC 4x2.

References: 1. Koch, MRM 2009 p381; 2. Chen, ISMRM 2009, p2783; 3. Tsao, MRM 2003:1031; 4. Huang, MRM 2005, 54:1172; 5. Lai, ISMRM 2009, p366.