SENSITIVITY ENCODED ISOTROPIC PROJECTION RECONSTRUCTION (SNIPR) FOR WHOLE-HEART CORONARY MRA

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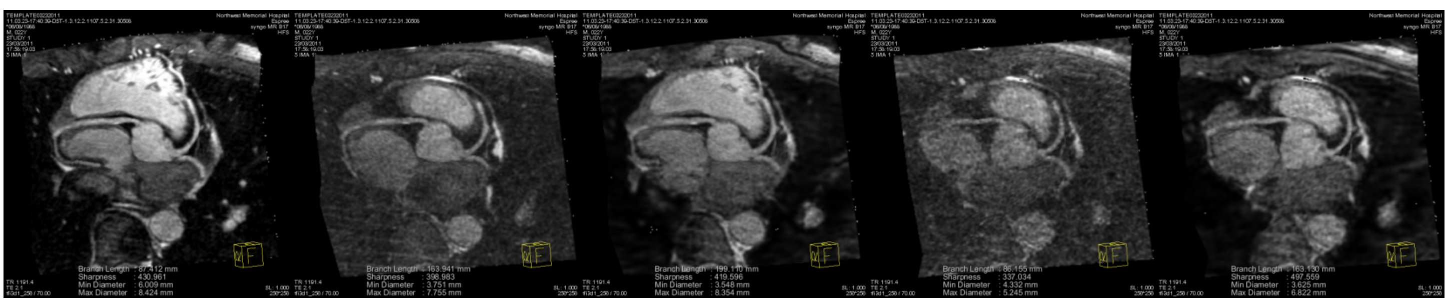
Introduction

Whole-heart coronary MRA (CMRA) has multiple advantages over volume-targeted approaches, including easier setup, more comprehensive coverage and the ability to generate arbitrary views. However, due to the large amount of data required, the scan time is relatively long. Employing an undersampled 3D projection reconstruction (3DPR) trajectory [1] will reduce scan time, although at the cost of introducing streaking artifacts that mimic noise and reduce the apparent signal-to-noise ratio (SNR). In this work, we propose to use non-Cartesian sensitivity encoding [2] for 3DPR-acquired CMRA with the goal of minimizing streaking artifacts while maintaining a high acceleration factor.

Methods

MR data was collected using an ECG-triggered, navigator gated, T2-prepared, fat-saturated bSSFP pulse sequence with a 3DPR trajectory and a 12 channel receiver coil array. Imaging parameters are as follows: TR/TE=3.2ms/1.6ms, FOV=260–300 mm^3, matrix size=256^3, flip angle=90°, readout bandwidth=781 Hz/pixel, total number of projections=16000 to 16384, imaging time=14.0±2.95 minutes. The data was then retrospectively R-fold undersampled with R=2 and R=4, corresponding to three to six-fold acceleration from the Nyquist rate. Five sets of images were reconstructed for each subject: gridding and SNIPR reconstruction from the two undersampled datasets, and gridding from the full dataset. The 3DPR trajectory has a densely sampled k-space central region, which was used to generate low resolution single-channel images for coil sensitivity map estimation [3]. The generalized SENSE framework described in [2] was extended to 3D for iterative image reconstruction using the conjugate-gradient method [4]. Four healthy volunteer scans were performed on a clinical 1.5T scanner (MAGNETOM Avanto, Siemens AG Healthcare, Erlangen, Germany) with IRB approval and written consent obtained before each scan. Offline reconstruction programs were coded in MATLAB (The Mathworks, Natick, MA). Images were reformatted and measured using CoronaViz software (Siemens Corporate Research, Princeton, NJ).

Results



(a) (b) (c) (d) (e)

Figure 1: Reformatted images from one subject.
From left to right: gridding from the full dataset, gridding and SNIPR with R=2, gridding and SNIPR with R=4.

	Gridding, full dataset	Gridding, R=2	SNIPR, R=2	Gridding, R=4	SNIPR, R=4
Image quality score	3.0±0.50	2.2±0.58	2.5±0.50	0.83±0.58	2.1±0.63

Table 1: Image quality score (0-4) results for different reconstruction methods and undersampling factors

Simple gridding from the undersampled datasets resulted in considerable streaking artifacts with a noise-like appearance. The drop in SNR is readily appreciable in the image (b) with two-fold undersampling, and four-fold undersampling makes the image (d) difficult to interpret. The SNIPR reconstruction (c) and (e) reduces the pseudo-noise from streaking, thus increases apparent SNR and provides better image quality. Notably, two-fold undersampling with SNIPR reconstruction appears to provide similar vessel delineation as the fully sampled image (a), therefore cutting imaging time in half with little to no sacrifice in image quality.

Discussion and Conclusions

We have shown a promising method that combines 3D non-Cartesian sensitivity encoding and a highly-undersampled projection reconstruction trajectory to greatly accelerate whole-heart coronary MRA. No separate calibration scans are needed since the densely sampled k-space central region allows direct sensitivity map estimation from image data. Results show that the SNIPR reconstruction reduces streaking artifacts, hence allows a shorter scan time by acquiring less k-space samples, while minimizing the loss in image quality. However, a careful study of the conditioning of the reconstruction, such as a g-factor analysis, should be carried out to optimize the imaging protocol and to determine the maximum feasible undersampling that yields diagnostic image quality, given the number of receiver channels. A detailed study of the behavior of the iterative reconstruction program is also desired to ensure fast convergence.

References

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