Coil Array Compression in Coronary MRA

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Introduction: In coronary MRA signal-to-noise ratio (SNR) is of primary concern as it limits the achievable spatial resolution for a given, tolerable scan time. One approach to increase the base SNR has been the design and application of multi-element coil arrays featuring up to 128 independent receive channels [1]. With 32-element coil arrays becoming standard for cardiac imaging [2], attention has been drawn to processing data from large arrays with its associated increased memory consumption and computational load.

Coil array compression [3, 4] is a new technique for reducing the amount of data being processed by using a suitable linear combination of the physical coil elements creating a reduced set of virtual coils. The combination matrix is found by optimizing the SNR in a target region of interest. It has been demonstrated that array compression significantly outperforms simple coil selection in which fewer physical coils are utilized [3]. While initial simulation and in-vivo work has proven the efficiency of array compression, its applicability to coronary imaging remains to be evaluated.

In this work array compression is investigated for different compression factors applied to data from a 32-channel array. Relative SNR losses on the right coronary artery (RCA) and the left anterior descending artery (LAD) were evaluated in 10 healthy volunteers.

Methods: Data of the coronary arteries were acquired in 10 healthy volunteers (age 27 ± 6.7 years) using a 1.5T Philips Intera System (Philips Healthcare, Best, The Netherlands) with a 32 channel cardiac coil array. In each volunteer, standard navigator-gated 3D BTFE sequences were performed to acquire 20 slices covering the RCA, as well as the LAD. The sequence parameters were chosen as follows: TR = 6.1ms, TE = 3.1ms, flip angle = 110°, scan matrix = 270x272x20, FOV = 270x270x30 mm^2, 13 lines/ segment.

The channels are compressed to a set of virtual coils using a linear transformation *A*. Thereby the individual elements are linearly combined to form a virtual array consisting of fewer elements than the original array while utilizing all physical elements. Using coil sensitivities from a previous reference scan and noise covariance data, *A* is calculated to maximize the preserved SNR in a region-of-interest (*ROI*) defined around the heart by minimizing the image noise [3].

To compare the image quality quantitatively, the SNR was evaluated on the right and left coronary arteries depending on the number of virtual coil elements *m* used in image reconstruction.

Results: Reconstructed and reformatted images of the RCA and LAD for different compression factors are shown in Figure 1 (upper row). The original 32 coil elements were compressed to a virtual array consisting of 4, 2, and 1 element respectively. Even for high compression factors, the reconstructed images show little to no image distortions for the region of interest. The SNR evaluation for the RCA (Figure 1a) reveals a loss of 1.7 ± 0.7 % SNR when using four virtual coils (*m*=4), 8.7 ± 1.8 % for *m*=2, and 17 ± 3.3 % for *m*=1. The more anterior position of the LAD (Figure 1b) resulted in increased noise amplification with SNR decreasing by 5.2 ± 3.5 % (*m*=4), 15 ± 6.9 % (*m*=2), and 25 ± 7.8 % (*m*=1), respectively.

The raw data sizes used in image reconstruction decreased linearly with the number of virtual channels, resulting in a reduction from 200MB to 25MB for four virtual coils and only 6MB for a single virtual coil. Similarly, the time for image reconstruction with SENSE decreased linearly with decreasing number of virtual coil elements. The time for computing the compression matrix *A* was approximately 0.4s on standard PC hardware.

Discussion: Array compression allows for significant data reduction in image reconstruction with little impact on visible image quality and SNR relative to the uncompressed reference images. It has been demonstrated that for a reduction from 32 physical to 4 virtual elements, SNR in coronary imaging reduces by as little as 5%. In view of even greater numbers of channels becoming available, array compression facilitates time efficient image reconstruction with negligible SNR penalty.

References:
[1] Schmitt M, et.al. MRM 59(6): 1431-9 (2008)
[2] Hardy CJ, et al. MRM 55(5):1142-9 (2006)
[3] Buehrer M, et.al, MRM **57**(6):1131-9 (2007)
[4] Huang F, et. al, MRI **26**(1):133-141 (2007)

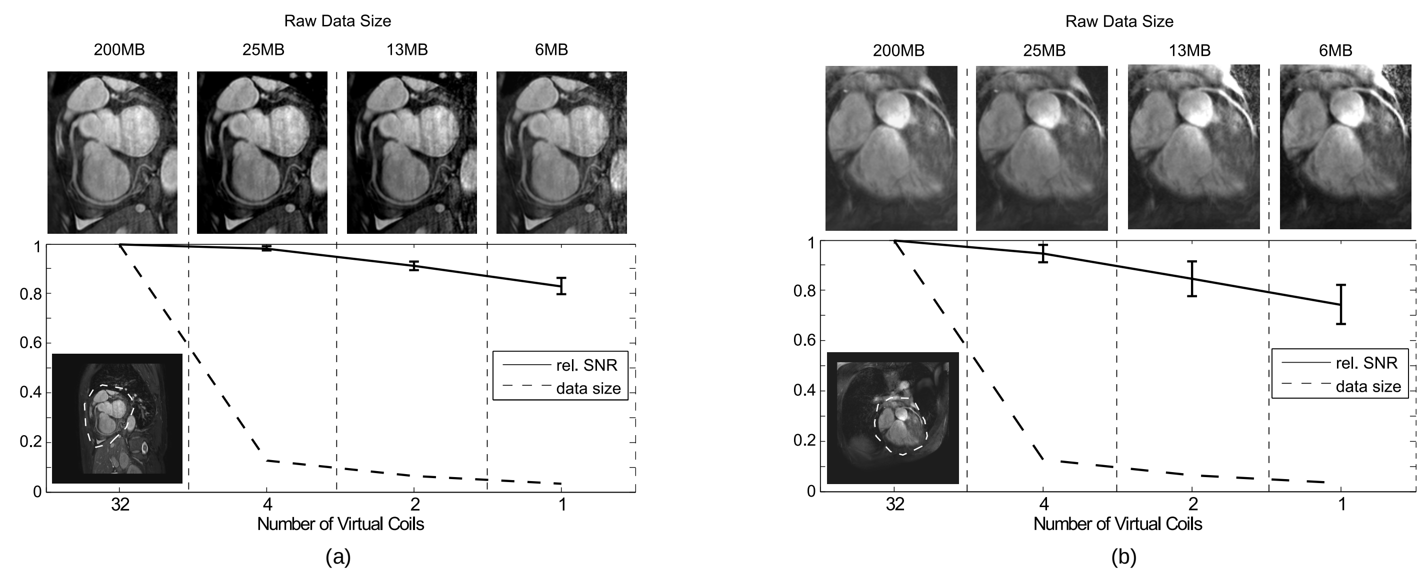

Figure 1:
Upper row: Exemplary images for the RCA (a) and LAD (b), reconstructed from the full data set (first image) and reduced to 4, 2 and 1 virtual coil.
Lower row: SNR dependence and data size before reconstruction for reduction from 32 to 4, 2 and 1 virtual coil.