Automatic coil element selection for parallel imaging of localized regions

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Introduction:

Recent developments in coil array design have shown a trend towards a large number of independent coil elements. The benefits of these large arrays are an improved performance of parallel imaging and increased signal-to-noise ratios (SNR) [1-2]. Potential drawbacks include the computational burden in reconstruction (increased memory usage, reconstruction time, etc.) and coupling issues between the individual coil elements. To address these problems it may be beneficial to select a reduced set of active coil elements given that an imaging region smaller than the covered area of the array is targeted [3]. This raises the question as to which coil elements to deactivate for a given imaging region without compromising the SNR significantly. This work introduces an efficient algorithm which allows reducing the number of active coil elements from a given array based on coil calibration data and finding the optimal element selection for a given imaging region.

Methods:

According to theory, the SNR in parallel imaging is always decreased when deactivating a coil element of an array [4]. However this decrease can be very small depending on the location of the imaging region relative to the coil. To this end an algorithm is proposed which allows specifying an upper limit for the acceptable SNR loss. An optimal subset of coil elements is then automatically determined by minimizing the following cost function:

$$f = \left(n - \frac{SNR_n}{SNR_{full}}\right) \cdot \left(\frac{a}{1 + e^{a \cdot \left(\frac{SNR_n}{SNR_{full}} - SNR_{limit}\right)}}\right)$$

where n=number of coils, SNR_n=SNR using n coils, SNR_{full}=SNR using all coils, SNR_{limit}=acceptable SNR loss, $a \to \infty$. The function f is minimized using a simulated annealing approach [5].

For evaluation of the algorithm, an in-vivo dataset of the right coronary artery was acquired using a 32-channel cardiac coil array covering approximately 30 cm in both feet-head and right-left direction. Images were obtained on a 1.5T Philips Intera System (Philips Medical Systems, Best, The Netherlands). A 3D free-breathing navigator-gated steady-state free precession sequence was used (TR=5.8ms, TE=2.9ms, flip angle=140°, scan matrix = 256x256x20, FOV = 270x270x30mm^3, T2-preparation, fat-suppression, 16 excitations per cardiac cycle). Sensitivity maps were obtained from a SENSE reference scan (TR=4.9ms, TE=1.1ms, flip angle=7°, scan matrix 64x64x20, FOV=270x270x30mm^3, 8 signal averages). As target volume the heart was selected and an optimally reduced coil array for that region of interest was determined for SENSE imaging with a reduction factor of 2 in feet-head direction for different acceptable SNR losses. Reconstruction results from high resolution coronary MRA using a reduced set of coils were compared relative to data reconstructed from all 32 coil elements.

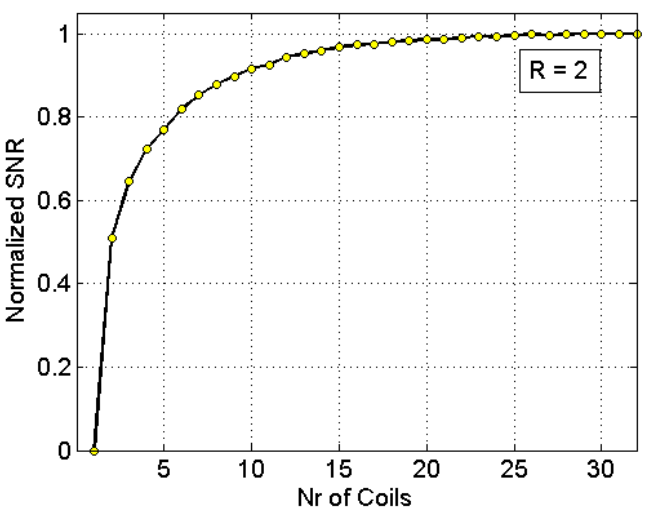

Figure 1: The SNR dependency on the number of coils for a 32 channel cardiac array. The reduction factor was 2 and the imaging region was the heart. It can be seen that there is only little SNR loss when removing up to 19 coils.

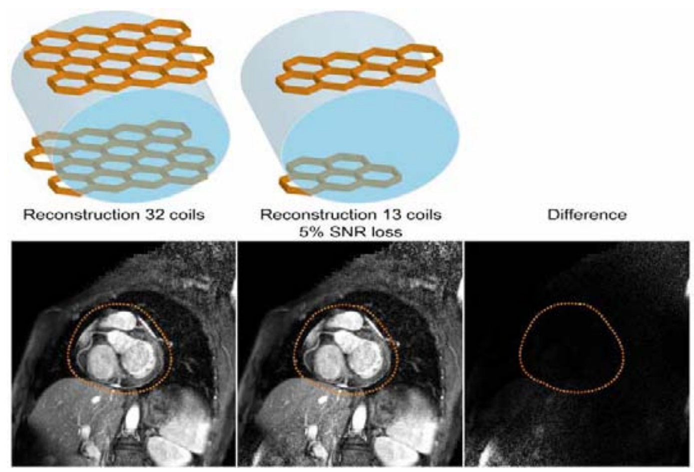

Figure 2: The reconstructed images of the right coronary artery for a reduction factor of 2. The first image shows a reconstruction using all 32 coils of the array shown in the upper row. For the second image only 13 coils were used accepting an SNR loss of 5%. The corresponding coil array is shown above the image. The dotted line marks the selected imaging area. Noticeable differences between the two reconstructed images are seen only outside the selected imaging area as displayed in the difference image.

Results:

The SNR dependency on the number of coils can be seen in Figure 1. For the given coil geometry and target area half of the coils in the array could be removed without a significant SNR loss. Reconstructed images of the right coronary artery for an acceptable SNR loss of 5% together with the corresponding array consisting of 13 coils only are shown in Figure 2. Relative to an image reconstructed from all 32 coil elements noticeable differences occur only outside the selected imaging area for which the coil array was optimized. The computation of the optimal coil array shown in Figure 2 took approximately 5s on standard PC hardware.

Discussion:

In SENSE imaging, the number of coils in an array can be significantly reduced without significant loss in SNR when focus is put on a region of interest smaller than the coverage of the array. Doing so, reconstruction time as well as memory consumption can be considerably decreased.

References:

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