Virtual Body Coil Calibration for Phased-Array Imaging

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Introduction:

Image-based parallel imaging methods such as sensitivity encoding (SENSE) [1] require accurate coil sensitivity information. Calculation of coil sensitivity maps necessitates a homogeneous reference image to remove anatomy related structures in the single coil images. Commonly, such a reference image is provided by the body coil. This procedure, however, makes a separate reference scan necessary. In cases where the body coil reference is not available, the sum-of-square (SOS) image can be used as an approximation of a homogeneous reference. However, by doing so, object phase is discarded which results in the loss of phase in the reconstructed image. Furthermore the SOS image is usually not completely homogeneous but left with some signal weighting imposed by the single coil sensitivities.

In this work we present a method which extracts the complex sensitivity information from fully sampled single coil images without the need for acquiring additional body coil data, allowing for phase preserving SENSE reconstruction. The method is straightforwardly applicable to ultra high-field imaging where a body coil reference is not available or to k-t undersampling methods such as TSENSE [2] or k-t SENSE [3] where coil calibration data can be obtained from temporal DC information. It is demonstrated that phased-array data can be used to derive a virtual body coil reference permitting phase-sensitive image reconstructions for e.g. water/fat separation.

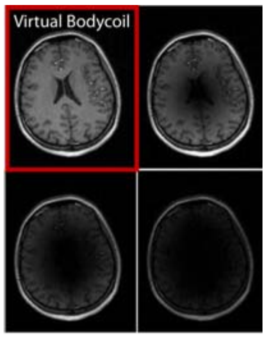

Figure1: The first 4 virtual coils of an 8-channel head array.

Methods:

Virtual body coil calibration employs the array compression principle [4] to produce a homogenous reference image for coil sensitivity calculation. Thereby all the coils of the array are compressed into one single virtual coil element using the coil images itself as input for calculating the compression matrix. By virtue of the array compression method, which maximizes the remaining SNR after reconstruction with a truncated virtual array (Figure 1), full compression yields a highly homogeneous map with respect to magnitude and phase resembling a body coil image (Figure 1, upper left image). Using the virtual coil as body coil replacement, sensitivity maps can be calculated allowing for phase preserving image reconstruction.

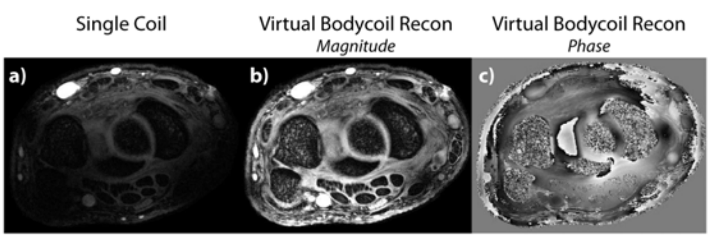

Figure 3: SENSE reconstruction of wrist images acquired on a 7T with an 8-channel coil array using the virtual body coil approach. a) An exemplary single coil image. b) The SENSE reconstructed magnitude image. c) The SENSE reconstructed phase image. Note that the virtual body coil approach results in a homogeneous intensity corrected reconstruction (b).

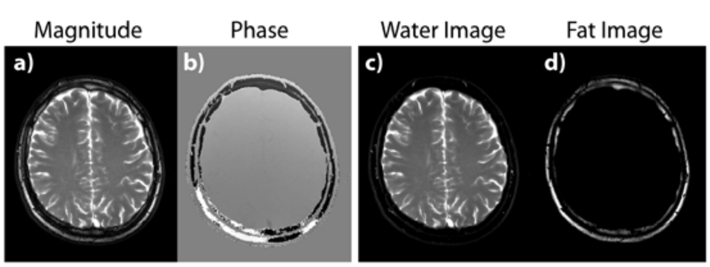

Figure 4: SENSE reconstruction of a gradient echo acquisition using the virtual body coil approach (a, b). The echo time of the scan was chosen such that water and fat are out-of-phase. Note that the phase is preserved in the reconstructed image (b) permitting water/fat separation (c, d).

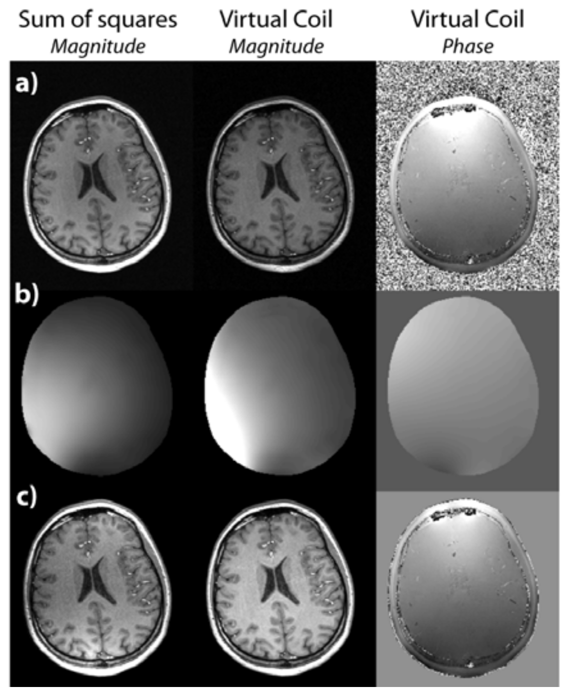

Figure 2: Comparison of a fully sampled SENSE reconstruction using the SOS approach (left column) and the virtual coil approach (middle/right column). Shown are: (a) the body coil approximation, (b) the resulting sensitivity map of an exemplary coil element, (c) the SENSE reconstructed images. The virtual coil approach preserves object phase information and provides accurate coil sensitivity maps resulting in a homogeneous image.

Results:

Figure 2 shows a comparison between two SENSE reconstructions (R=1) using the SOS image (left column) and the virtual body coil image (middle and right column) for brain data acquired using an 8-channel head coil array on a 3.0T Philips system (Philips Healthcare, Best, The Netherlands). The virtual body coil approach preserves image phase (Figure 2a, right column) and yields a more homogeneous image (Figure 2c) relative to the reconstruction using the SOS approximation of the body coil. Figure 3 shows a phase sensitive SENSE reconstruction of the wrist acquired on a 7T using an 8-channel coil array. The virtual body coil was calculated from the individual single coil images (Figure 3a) and used as homogeneous reference in the reconstruction process. The wrist coil array geometry was identical to the 3T version presented in [5]. Figure 4 shows a phase sensitive reconstruction of the brain acquired at 3.0T with water/fat separation in reconstruction.

Discussion:

The method presented enables derivation of a virtual body coil reference for phase-preserving SENSE reconstruction without the need for acquiring body coil data. Using this approach, phase-sensitive image reconstruction with auto-calibration becomes possible. The homogeneity of the virtual body coil image is dependent on the number of coil elements and coil array geometry. Symmetric coil arrangements with full coverage of the object of interest benefit virtual body coil calibration. It remains subject to further studies to investigate the performance of the virtual body coil approach in other body parts with different coil array configurations.

References:

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