Title: Coil combination for high-quality phase images from routine prescans

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Structured Abstract:

Introduction: Due to its clinical utility imaging vasculature and iron, interest in MRI phase images has increased in recent years. This has occurred parallel to the development of multi-channel radio frequency (RF) arrays for accelerated imaging. Using RF arrays for phase imaging with suboptimal combination will lead to destructive interference and poor phase image quality. Existing phase methods commonly rely on a post-acquisition combination of multiple images, for example, singular value decomposition (SVD) combination. This post-acquisition operation is time consuming and has high computational costs. However, it is possible to use the SVD of a low-resolution prescan to determine the relative sensitivities and align the phase of a larger image set in real time while the imaging is being completed. This is achieved through the fitted SVD sensitivities method that uses a low resolution SVD and solid harmonic interpolation to provide computationally efficient, phase sensitive, coil combination.

Methods: The prescan used to derive relative sensitivity estimates via SVD was a 10 image 8mm isotropic prescan and is routinely collected at the beginning of each imaging session. Once calculated, these relative sensitivity estimates were corrected for shared signal using a weighted combination of the sensitivities. This was done to ensure that the sensitivities did not contain extraneous phase from other sources or phase singularities common to all sensitivities. Relative sensitivities were fit to the solid harmonics using an iterative least-squares fitting algorithm. These fits can be stored as coefficients of solid harmonics and permit interpolation of relative sensitivities to any image size and geometry. This interpolation can be used to align the phases of the receiver channels in subsequent acquisitions for improved phase sensitive combination.
 All images were collected on the Siemens Magnetom 7T head-only MRI system located at the Centre for Functional and Metabolic Mapping. A symmetric whole head coil with 32 receive channels was used to collect both the routine 10 image prescan and gradient echo data (1mm resolution). The efficacy of the method was evaluated using visual inspection for complete signal loss after the phase images were unwrapped and comparing the phase signal-to-noise ratio drop between our proposed method and the ideal method.

Results: This method successfully removes the complete signal loss artefact and the phase signal-to-noise ratio is 0.94 ± 0.09 (mean ± standard deviation) of the ideal combination across the brain.

Discussion: This method allows for a phase sensitive combination to be used for multiple scans during an imaging session. It is computationally efficient, requires minimal computer storage, and is fully automated. This allows for phase-based contrasts to be routinely collected on the MRI system.