Artifact Reduction in undersampled BLADE/PROPELLER MRI by k-space extrapolation using parallel imaging

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Introduction: BLADE (a.k.a., PROPELLER) MRI method is an efficient acquisition and reconstruction technique that allows motion correction [1]. However, compared with conventional imaging the scan time is increased. Recently, k-space undersampling in BLADE/PROPELLER MRI has been proposed in order to reduce the imaging time [2]. However, this method introduces image artifacts. In this work, we present a reconstruction approach that allows one to reduce these artifacts. Our approach is based on a k-space extrapolation of acquired data using the parallel GRAPPA-Operator technique [3,4]. Compared to other approaches incorporating parallel imaging this method is totally self-calibrated.

Methods: TrueFISP BLADE imaging (19 blades, matrix size 21 x 256, TR 4.4 ms, TE 2.1 ms, flip angle 70°, FOV 250 x 250 mm^2, slice thickness 5 mm) was implemented on a 3T scanner equipped with a 12-channel head coil array (Siemens, Erlangen, Germany). Phantom experiments were performed using standard (21 lines per blade, 19 blades) and undersampled (13 lines per blade, 19 blades) BLADE acquisitions. A schematic of the undersampled BLADE acquisition is shown in Fig. 1a. For each blade the outer part of k-space was reconstructed using the GRAPPA-Operator technique (Fig. 1b) in order to obtain the standard BLADE pattern (Fig. 1c). Four k-space lines were added both in positive and negative phase encoding direction in each blade resulting in an acceleration factor of $R = 1.6$. The reconstruction parameters for the GRAPPA-Operator reconstruction were derived directly from each blade, so that no additional reference experiment was necessary. Additional experiments were performed using normal GRAPPA in each blade at 1.9x acceleration, followed by extrapolation as above (a net acceleration of $R = 3$).

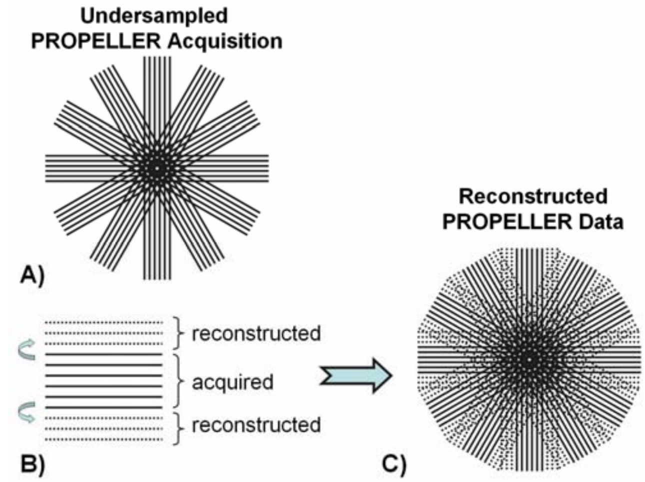

Figure 1: Reconstruction Scheme.

Results: Figure 2 shows the results of a phantom experiment. Displayed are the fully sampled (Fig. 2A) and the reconstructed image (Fig. 2B) using the proposed method with an acceleration factor of $R = 1.6$. Figure 2C shows the combination of conventional GRAPPA and the proposed method. At first, a normal GRAPPA reconstruction was performed, followed by the k-space extrapolation using the new GRAPPA-Operator technique. The total acceleration factor for this image is $R = 3$. The reconstructed images show nearly identical image quality compared to the standard BLADE image. The ring-like artifact near the center in all images is a TrueFISP artifact due to an inhomogeneous B0-field and are not related to this technique.

Discussion: In this work, a combination of parallel imaging and undersampled BLADE/PROPELLER MRI has been presented in order to reduce image artifacts. This method is based on a k-space extrapolation using the parallel GRAPPA-Operator reconstruction. Since the reconstruction parameters can be extracted directly from the undersampled BLADE/PROPELLER acquisition this method is totally self-calibrated. It is expected that the image quality further improves by increasing the number of coils in the detector array. In that case, higher acceleration factors could be achieved. In addition, as shown here blade extrapolation can be combined using conventional parallel imaging techniques to further reduce the scan time.

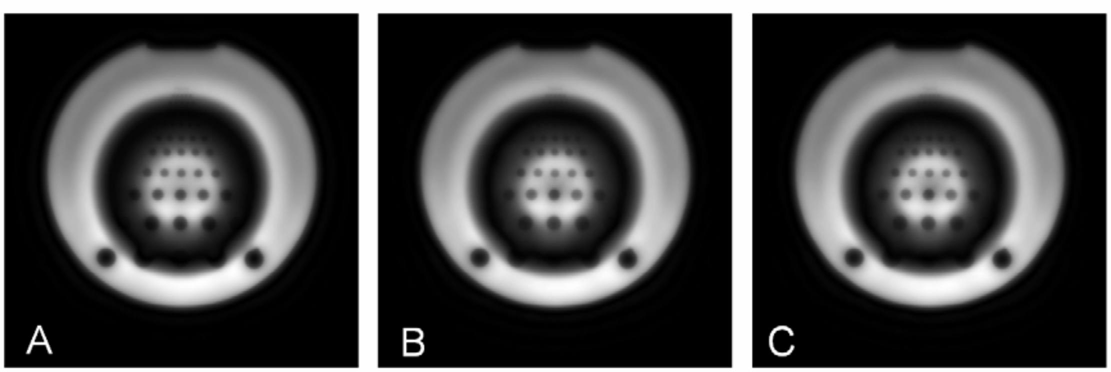

Figure 2: (A) Full BLADE acquisition, (B) undersampled BLADE acquisition ($R = 1.6$) with k-space extrapolation using the GRAPPA-Operator and (C) undersampled BLADE acquisition incorporating normal GRAPPA ($R_{GRAPPA} = 1.9$) followed by blade extrapolation using the GRAPPA-Operator ($R = 1.6$) resulting in a net acceleration factor of $R = 3$.

References:

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