Blade by Blade Compressed Sensing for PROPELLER

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Introduction

The PROPELLER sequence[1] is clinically used for T2 and DW imaging and can be motion corrected. Parallel imaging techniques have been used in axial PROPELLER imaging [3] to effectively widen the blade, thus reducing motion artifacts and improving general image quality. However, parallel imaging is not suitable for all image orientations with all available coils (e.g. PROPELLER spine imaging). We propose to use compressed sensing (c.s.) [4,5] to fill missing lines of individual blades which are then gridded together. By making use of the inherent data redundancy of PROPELLER, such a scheme is thought to greatly reduce the risk of losing image features, which can be a concern with iterative reconstruction methods. Performing c.s. on individual blades also keeps the reconstruction time reasonable thanks to the small dimensionality of the problem to solve.

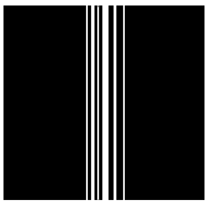

Fig. 1. Typical blade sampling pattern

Methods

As a simple proof of concept, simulated data were generated by gridding 2D k-space to 10 blades comprising 24 lines of 128 points. Half of those lines were discarded following a pseudo-random pattern with uniform probability distribution (except for the 3 central lines which are always collected, see Fig 1.). This simulates under-sampling in the blade width direction. An open-source c.s. demo [6] was modified to remove the aliasing in these under-sampled blades which were then Fourier transformed to k-space and gridded like normal blades. To speed up reconstruction, the sparsity was optimized directly in image space in 5 passes of 10 conjugate gradient iterations. The c.s. computation (implemented in Matlab) took roughly 6s per blade on an 2x2.66 GHz Dual-Core Intel Xeon Apple computer.

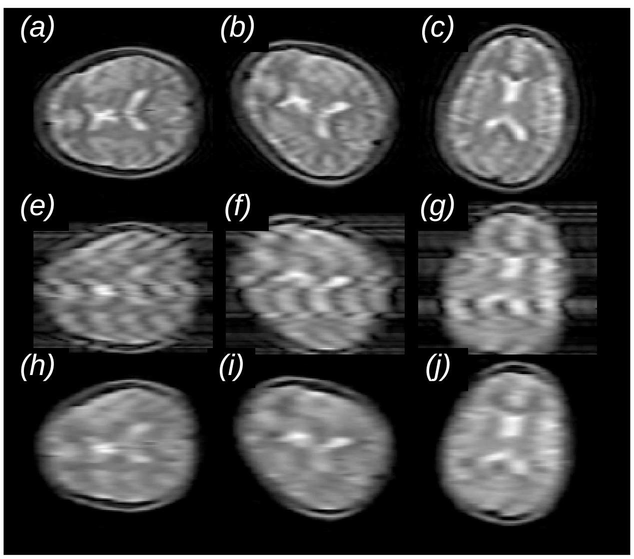

Fig. 2.. Blades images.

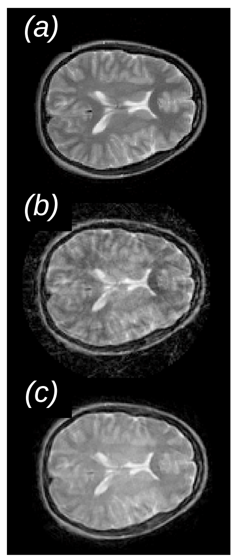

Fig. 3. Full images.

Experiments and Results

Fig 2. shows individual 24x128 blades images fully sampled (a,b,c), under-sampled (e,f,g) and after the c.s. reconstruction (h,i,j). The c.s. blades' quality is deemed suitable for motion correction while the aliased blades' quality is not. Fig 3. shows the full gridded 128x128 images from the fully sampled blades (a), from the under-sampled blades (b) and from the c.s. blades (c). A slight loss of contrast can be observed in the gridded c.s. image but image features are otherwise conserved. In Fig 3. (b) the uncollected lines were assigned a zero weight and in (c) the c.s. lines were assigned the same weight as the collected ones.

Discussion

Three objectives of this work were simplicity, robustness and reasonable reconstruction time. Because of the small number of lines used, this method will only work for relatively low levels of under-sampling. The advantage of the PROPELLER scheme is that the individual blade images do not need to be perfectly reconstructed for the final image to be of clinical value. Improvements could include the choice of a better under-sampling pattern. For simplicity in this example, the acquired lines were spaced by integer multiples of FOV^{-1}. This may not be optimally suited for the c.s. algorithm which tends to perform better in presence of low intensity, incoherent aliasing patterns [7].

References:

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Acknowledgements

This work was supported in part by GE Healthcare.