

Sparse averaging to improve low SNR acquisitions

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Introduction: Although the impact of CS acceleration can be greater at higher resolutions [1], the SNR penalty that comes with smaller voxels is a significant barrier to such applications. We propose using CS and k-space averaging, and hypothesize that imaging time can be used more effectively for signal averaging rather than for full sampling for low SNR acquisitions. We tested this and expanded this approach to non-uniform averaging in k-space.

Methods: A high-resolution 2D FFE scan of a grapefruit was made with a 3T MRI scanner (Philips Ingenua) using the following parameters: TR=11.8ms, TE=5.7 ms, FA = 25°, NSA=100, matrix=256x256, resolution=0.5x0.5mm², ST=1mm. Scan data was undersampled retrospectively using a variable-density mask. To achieve different noise levels we used subsets of the data combining different numbers of NSAs.

The final subsets were generated using either uniform averaging for all k-points (method 1), or an unequal distribution of averages with more averaging in the border (method 2) or the center (method 3) of k-space. Higher accelerations were given more signal averages such that every reconstruction used the same number of sampling points. Reconstruction was done with a nonlinear conjugate gradient algorithm modified to include a weighting matrix containing the NSA per k-point. The CS regularization factor was modified based on the number of averages.

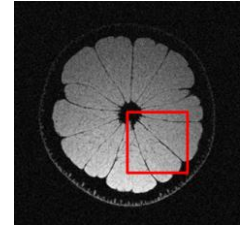


Figure 1: phantom reference image

Results and discussion: Figure 1 shows details of reconstructions for varying noise levels (rows) and undersampling factors of 1, 3 and 5 (columns). As hypothesized, the phantom fruit gets more easily distinguishable for higher undersampling and NSA factors, especially for the high-noise case. Quality metrics SSIM and PSNR, shown in Figure 3, improve with acceleration for the two cases with the lowest SNR levels, and are highest at 5 times undersampling for the low-noise case. However the extent to which these metrics convey image quality needs further research. Figure 3 shows the effect of varying undersampling throughout k-space. Due to the already high SNR in the center of k-space, we expected averaging more on the outside of k-space to perform best. However, this technique performed poorly, with most notable artefacts and a SSIM of 0.32, while averaging uniformly and more in the center performed similarly, both having SSIM values of 0.35. **Ref** [1] *arXiv:1302.0561*

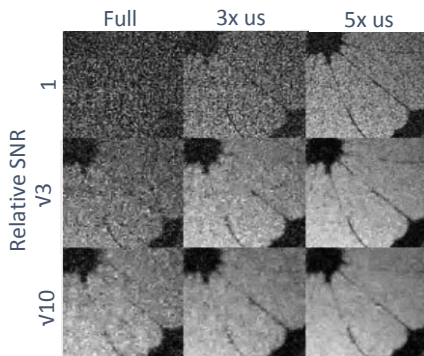


Figure 2: Uniform undersampling/averaging (method 1) at different noise levels.

Figure 3: Quality measures, for experiment 1. Relative SNR: yellow v10; red: v3; blue: 1

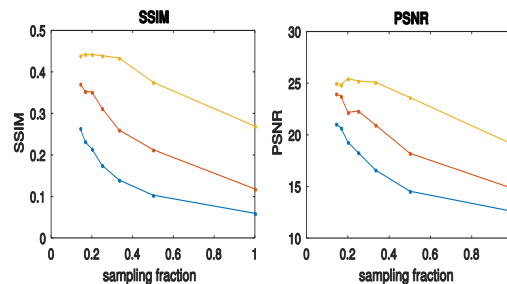


Figure 4: variable averaging in k-space using method 1 (top), method 2 (middle) and method 3 (bottom).

