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Improving sub-Nyquist MRI reconstruction performance

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Abstract

The aim in sub-Nyquist MRI "compressed sensing" acquisition is to subsample the time- or K-space dimension in a way that causes incoherence with a basis or frame of image atoms, as this maximizes reconstruction performance. State-of-the-art practical applications are making increasing use of variable-density K-space patterns, which are empirically found to achieve superior reconstruction quality in comparison to uniform density patterns. Similarly, it was found that using spread spectrum techniques, implementable using a shim coil, can lead to superior reconstruction quality for many sampling patterns. In our reconstruction algorithm, we apply these ideas in a augmented Lagrangian optimization technique, regularized using the shearlet transformation, because of its optimally sparsifying properties. We will show that for some K-space patterns, an optimized image transformation, i.e. with better incoherence with the acquisition frame, can also yield better results. Results show that the algorithm is applicable not only to sub-Nyquist sampled K-space reconstruction, but also to MR image fusion and/or high quality resolution enhancement.

From a practical point of view, deterministic variable-density non-uniform K-space trajectories, such as spiral trajectories are very attractive and we will demonstrate that they yield very good reconstruction quality. For variable-density trajectories, the non-uniform Fourier transform (NUFT) becomes an invaluable tool, an algorithm well known in MRI literature as regridding, which we will briefly discuss.

While natural images can be accurately approximated as sparse signals, they are not. Natural image statistics of transform coefficients are more accurately modelled by a (generalized) Laplacian model. It is well known that natural image transform coefficients are spatially correlated, a fact that is not exploited in the basic sparse model. We will show that the improved estimators, which arise from these models, yield better reconstruction results.