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k-t FOCUSS: a novel dynamic MRI technique using compressed sensing theory

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Dynamic MR imaging of time-varying objects, such as beating hearts or brain hemodynamics, requires a significant reduction of the data acquisition time without sacrificing spatial resolution. The classical approaches for this goal include parallel imaging, temporal filtering and their combinations. These methods have limitations to reconstruct high resolution dynamic images when the acceleration factor is large. Recently, model-based reconstruction methods called k-t BLAST and k-t SENSE have been proposed, which largely overcome the drawbacks of the conventional dynamic imaging methods without a priori knowledge of the spectral support. Another recent approach called k-t SPARSE also does not requires exact knowledge of the spectral support. However, unlike the k-t BLAST/SENSE, k-t SPARSE employs the so-called compressed sensing theory rather than using training.

The main contribution of this paper is a new theory and algorithm that unifies the abovementioned approaches while overcoming their drawbacks. Specifically, we show that the celebrated k-t BLAST/SENSE are the special cases of our algorithm, which is asymptotically optimal from the compressed sensing theory perspective, in which perfect reconstruction is possible even from severely limited number of samples below Nyquist limit when the signal is sparse in some domain. More specifically, we employed FOCUSS (FOCal Underdetermined System Solver) algorithm to solve L1 optimization problem. In order to make images much sparser in some basis and achieve higher acceleration ratio, we have considered several different transform for spatio-temporal domain signal, and employed RIGR (Reduced-encoding Imaging by Generalized-series Reconstruction) algorithm as a prediction step to make the residual signal much sparser.

Experimental results show that the new algorithm can successfully reconstruct a high resolution cardiac sequence even from severely limited k-t samples without incurring any aliasing artifacts often observed in conventional methods.