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Sparse Recovery with Partial Support and Signal Value Knowledge and Applications in Dynamic MRI

Abstract:
In this work, we study the problem of reconstructing a sparse signal from a limited number of its linear projections when the following knowledge is available. (1) We are given partial, and partly erroneous, knowledge of the signal's support, denoted by T. (2) We are also given an erroneous estimate of the signal values on T. Alternatively, in recursive reconstruction applications, like real-time dynamic MRI, one can use the support estimate and the signal value estimate from the previous time instant. We presented algorithms by modifying Compressive Sensing (CS) using the partly erroneous support and also the erroneous signal estimate for both noiseless and noisy measurements. The idea of our proposed solution is to solve a convex relaxation of the following problem: find the signal that is sparsest outside the set T, while being ``close enough'' to the signal estimate on T and satisfying the data constraint. We obtain sufficient conditions for exact reconstruction using modified-CS and regularized modified-BP. These are much weaker than those needed for CS when the size of the unknown part of the support is small compared to the support size. We also propose solutions modified-BPDN and regularized modified-BPDN for noisy measurements using the similar idea. We obtain the computable and tighter bounds without any sufficient conditions for the reconstruction error. Simulation comparisons for both sparse and compressible signals are shown. In this work, we also study the application of CS based approaches for blood oxygenation level dependent (BOLD) contrast functional MR imaging (fMRI). In particular, we show, via exhaustive experiments on actual MR scanner data for brain fMRI, that our recently proposed approach for recursive reconstruction of sparse signal sequences, modified-CS-residual, outperforms other existing CS based approaches.