New Greedy Algorithms With Efficient Recovery for Compressed Sensing

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Abstract

The inverse problem of sparse recovery in compressed sensing is a hard non-convex optimization problem. Convex relaxation yields excellent performance, albeit at the expense of slow convergence speed. Alternatively, many greedy algorithms offer fast, near-optimal recovery performances. Their recovery efficiency depends crucially on factors like quality of the measurement matrix, structure of the unknown vector, and the option to cooperate among multiple algorithms in a network.

In this dissertation, first, we propose a greedy algorithm for efficient sparse recovery using compressed sensing when the sensing matrix has correlated columns. Our algorithm employs a two-stage identification. First a set of atoms is preselected by the generalized Orthogonal Matching Pursuit (gOMP) identification. Then multiple Orthogonal Least Squares (mOLS) identification is applied to the preselected set. The proposed algorithm possesses the superior probability of recovery performance of mOLS in correlated dictionaries while enjoying low computational cost. We carry out a restricted isometry property (RIP) based recovery analysis of the proposed algorithm for both noiseless and noisy measurements. Furthermore, simulations are carried out to demonstrate the efficacy of the proposed method.

Next, we address the problem of block structured vector recovery with unknown block-boundaries with blocks often grouped together in clusters. We propose a two-stage modification of Block Orhthogonal Matching Pursuit (BOMP). The first stage identifies a coarse location of a cluster whereas the second stage recovers that cluster exactly. We carry out a recovery analysis of the proposed algorithm using state-of-the-art techniques. The intermediate analysis yields special signal structures which necessitate introducing a novel customized restricted isometry property. We perform simulations to demonstrate the superior recovery performance of the proposed modification over BOMP.

Finally, we propose extensions of the conventional Iterated Hard Thresholding (IHT) algorithm to the distributed diffusion network setting. Also, we extend the proposed algorithms to networks where only a few of the nodes are activated randomly to attain low communication complexity. We perform theoretical convergence analysis of the proposed algorithms and discuss the effect of the network topology on the convergence rates. Finally, we perform several simulations to demonstrate the superiority of the diffusion based extensions to their consensus based counterparts.

Keywords: Compressed sensing; correlated measurement matrix; block-sparsity; gOMP; mOLS; BOMP; IHT; RIP; distributed compressed sensing; diffusion; random-node-activation.