Robust recovery of low-rank matrices with non-orthogonal sparse decomposition from incomplete measurements. (English) Zbl 07332899

Summary: We consider the problem of recovering an unknown effectively \((s_1, s_2)\)-sparse low-rank-\(R\) matrix \(X\) with possibly non-orthogonal rank-1 decomposition from incomplete and inaccurate linear measurements of the form \(y = A(X) + \eta\), where \(\eta\) is an ineliminable noise. We first derive an optimization formulation for matrix recovery under the considered model and propose a novel algorithm, called Alternating Tikhonov regularization and Lasso (A-T-LAS\(_{2,1}\)), to solve it. The algorithm is based on a multi-penalty regularization, which is able to leverage both structures (low-rankness and sparsity) simultaneously. The algorithm is a fast first order method, and straightforward to implement. We prove global convergence for any linear measurement model to stationary points and local convergence to global minimizers. By adapting the concept of restricted isometry property from compressed sensing to our novel model class, we prove error bounds between global minimizers and ground truth, up to noise level, from a number of subgaussian measurements scaling as \(R(s_1 + s_2)\), up to log-factors in the dimension, and relative-to-diameter distortion. Simulation results demonstrate both the accuracy and efficacy of the algorithm, as well as its superiority to the state-of-the-art algorithms in strong noise regimes and for matrices whose singular vectors do not possess exact (joint-) sparse support.

MSC:
90Cxx Mathematical programming
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low-rank and sparse recovery; bilinear compressed sensing; multi-penalty regularization; iterative soft-thresholding (LASSO)

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