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Exact penalty results on sparse recovery models based on partial regularization

In the context of sparse recovery, it is known that most of existing regularizers such as L1 suffer from some bias incurred by some leading entries (in magnitude) of the associated vector. We propose a class of models with partial regularizers to neutralize this bias for recovering sparse vectors. We also study some theoretical properties for these models including sparsity inducing, local or global recovery and also stable recovery. Under some suitable assumptions, we show that the penalty formulation based on a partial regularization is an exact reformulation of the original problem in the sense that they both share the same global minimizers. Furthermore, we show that any local minimizer of the original problem is a local minimizer of the penalty reformulation. In addition, a first-order feasible augmented Lagrangian (FAL) method is proposed for solving these models, in which each subproblem is solved by a nonmonotone proximal gradient (NPG) method. The global convergence of this method is also established. Numerical results on compressed sensing and sparse logistic regression demonstrate that the proposed models substantially outperform the widely used ones in the literature in terms of solution quality.