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Screen-and-Relax for Sparse Support Identification

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Abstract: Sparse modeling arises in various application fields such as machine learning, signal processing and inverse problems, among others [1]. In this context, it is of tantamount interest to solve convex optimization problems of the form

$$\mathbf{x}^* \in \arg \min_{\mathbf{x}} f(\mathbf{x}) + \lambda g(\mathbf{x})$$

where $f(\cdot)$ is a loss function and $g(\cdot)$ is a sparsity-inducing regularization whose strength is driven by the parameter $\lambda > 0$. The latter problem can be addressed with first-order optimization methods such as Proximal Gradient (PG), Coordinate Descent (CD) or Alternating Direction Method of Multipliers (ADMM) [2]. A popular strategy to exploit the problem structure is to enhance these algorithms with *screening tests* to detect the position of *zeros* in \mathbf{x}^* . This allows shrinking the problem dimensionality and saving computational resources during the resolution process [3]. We propose a complementary strategy, dubbed *relaxing*, to detect the position of *non-zeros* in \mathbf{x}^* . Leveraging this knowledge, we partially smooth the objective function of the problem which allows performing second-order iterations instead of first-order ones. In particular, this allows reaching *super-linear* convergence rates in finite time although only *sub-linear* or *linear* convergence rates are typically accessible for such optimization problems. By implementing screening and relaxing tests together in any solution method, we thus expect a double acceleration resulting from the dimensionality reduction and the convergence rate improvement. The proposed method is assessed on both synthetic and real-world datasets of varying characteristics and we observe an acceleration factor of up to three orders of magnitude compared to a vanilla implementation of the PG, CD and ADMM algorithms.

References

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