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Regularized Monotonic Regression

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Abstract

Monotonic (isotonic) Regression (MR) is a powerful tool used for solving a wide range of important applied problems. One of its features, which poses a limitation on its use in some areas, is that it produces a piecewise constant fitted response. For smoothing the fitted response, we introduce a regularization term in the MR formulated as a least distance problem with monotonicity constraints. The resulting Smoothed Monotonic Regression (SMR) is a convex quadratic optimization problem. We focus on the SMR, where the set of observations is completely (linearly) ordered. Our Smoothed Pool-Adjacent-Violators (SPAV) algorithm is designed for solving the SMR. It belongs to the class of dual active-set algorithms. We proved its finite convergence to the optimal solution in, at most, n iterations, where n is the problem size. One of its advantages is that the active set is progressively enlarging by including, typically, more than one constraint per iteration. This results in solving large-scale SMR test problems in a few iterations, whereas the size of that problems was prohibitively too large for the conventional quadratic optimization solvers. Although the complexity of the SPAV algorithm is $O(n^2)$, its running time was growing in our computational experiments almost linearly with n.

Keywords: *Monotonic regression, Regularization, Large-scale optimization*

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