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Abstract: Interpretable Scalar-on-Image Linear Regression Models via the Generalized Dantzig Selector

The scalar-on-image regression model explores the relationship between a scalar response and a two-dimensional predictor by estimating a bivariate coefficient function. Traditional methods usually assume smoothness of the coefficient function across the image domain, which helps reduce noise but limits interpretability, especially in cases where sparsity-only certain image regions affecting the response-is important. Despite the wide range of applications requiring sparse and smooth coefficient estimation, methods that simultaneously address both constraints remain limited. In this paper, we propose the Generalized Dantzig Selector (GDS) method, which estimates the coefficient function while balancing smoothness and sparsity. Our approach identifies regions of the image that do not influence the response (zero regions in the coefficient function), improving interpretability without sacrificing stability. The proposed GDS method demonstrates superior performance compared to existing techniques in both simulations and real data analyses. Furthermore, we provide theoretical support, including non-asymptotic bounds on the estimation error, for the proposed method.