Focused Generalized Method of Moments for High-Dimensional Causal Structural Learning

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Abstract: We propose a new constraint-based causal structural learning algorithm for high-dimensional Gaussian linear causal graphical models. Existing constraint-based approaches like the PC algorithm remove edges between vertices by carrying conditional independence tests on all possible candidates of d-separation sets. This can be computationally expensive and have exponential worst-case complexity. To tackle these issues, we propose a regularized approach called Focused Generalized Method of Moments (FGMM) to identify d-separation sets between vertices in this paper. Regularized approaches have been used to identify Markov blankets in causal graphical models. However, Markov blankets contain spouses besides true neighbors, which also need to be removed by searching d-separation sets. Distinguished from existing regularized approaches, the FGMM approach utilizes the moment conditions to identify d-separation sets directly. We further propose skeleton and structural learning algorithms based on the FGMM method, and establish the consistency of the FGMM algorithm in high-dimensional settings. We further conduct Monte Carlo simulations on various benchmark networks and show advantages of the proposed FGMM algorithm both in accuracy and speed.