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Robust graphical modeling under data contamination

High-dimensional data generated by modern multi-sensor systems call for statistical methods able to capture complex dependency structures. Graphical models are a popular tool for this purpose, as they represent conditional relationships between variables through a network. However, classical estimation techniques can be severely affected by the presence of outliers. Traditional contamination models primarily assume rowwise outliers (entirely anomalous observations), whereas cellwise outliers (individually corrupted data entries) are more challenging, as their effects can propagate across variables and severely affect high-dimensional estimation. This work presents a comprehensive evaluation of robust graphical model estimators under both types of contamination. Motivated by the observed limitations, we introduce a novel estimation strategy that integrates robust covariance estimation with sparse precision matrix recovery via adaptive graphical lasso and stability-driven model selection. An extensive simulation study demonstrates that the proposed robust framework substantially improves both structural graph recovery and precision matrix estimation compared to classical methods, particularly under cellwise contamination. An application to a case study on monitoring hourly traffic flow data further illustrates the practical advantages of the method, which provides more interpretable and stable network structures with fewer spurious connections, enabling more effective anomaly detection.

Special/ Invited session

Classification

Both methodology and application

Keywords

High-dimensional inference, Cellwise outliers, Robust covariance estimation

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