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Identification in Graphical Continuous Lyapunov Models

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Graphical continuous Lyapunov models offer a new perspective on modeling the causally interpretable dependence structure in multivariate data by treating each independent observation as a one-time cross-sectional snapshot of the multivariate Ornstein-Uhlenbeck process in equilibrium. This leads to Gaussian models in which the covariance matrix is determined by the continuous Lyapunov equation. In this setting, each graphical model assumes a sparse drift matrix with support determined by a directed graph. We study the crucial problem of parameter identifiability in the class of graphical continuous Lyapunov models. Indeed, given a statistical model induced by a graph, it is essential for statistical analysis to clarify if it is possible to uniquely recover the parameters from the joint distribution of the observed variables.

We show that this question can be reduced to analyzing the rank of certain sparse matrices with covariances as entries. Depending on the graph under consideration, the structure of these matrices changes in subtle ways. We study the identifiability for different classes of graphs. In our main result we prove that global identifiability holds if and only if the graph is simple (i.e., contains at most one edge between any two nodes). Furthermore, we present intriguing examples of non-simple graphs for which the associated model has generically identifiable parameters.

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