Causal inference from multivariate time series: Principles and problems

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In time series analysis, inference about cause-effect relationships among multiple time series is commonly based on the concept of Granger causality, which exploits temporal structure to achieve causal ordering of dependent variables. One major and well known problem in the application of Granger causality for the identification of causal relationships is the possible presence of latent variables that affect the measured components and thus lead to so-called spurious causalities. This raises the question about whether Granger causality is an appropriate tool for causal learning; indeed, there are many researchers that deny any such claim.

To answer the question in more depth, we present a graph-theoretic approach for describing and analysing Granger-causal relationships in multivariate time series that are possibly affected by latent variables. It is based on mixed graphs in which directed edges represent direct influences among the variables while dashed edges—directed or undirected—indicate associations that are induced by latent variables. We show how such representations can be used for inductive causal learning from time series and discuss the underlying assumptions and their implications for causal learning. Finally we will discuss non-Markovian constraints imposed by latent variable structures and how these can be exploited for causal inference.

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