Mathematics > Statistics Theory

# Counterfactual actions in graphical models based on local independence

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We show that one can do causal inference in a natural way for continuous-time scenarios using tools from stochastic analysis. This provides new alternatives to the positivity condition for inverse probability weighting. The probability distribution that would govern the frequency of observations in the counterfactual scenario can be characterized in terms of a so-called martingale problem. The counterfactual and factual probability distributions may be related through a likelihood ratio given by a stochastic differential equation. We can do inference for counterfactual scenarios based on the original observations, re-weighted according to this likelihood ratio. This is possible if the solution of the stochastic differential equation is uniformly integrable, a property that can be determined by comparing the corresponding factual and counterfactual short-term predictions.

Local independence graphs are directed, possibly cyclic, graphs that represent short-term prediction among sufficiently autonomous stochastic processes. We show through an example that these graphs can be used to identify and pro- vide consistent estimators for counterfactual parameters in continuous-time. This is analogous to how Judea Pearl uses graphical information to identify causal effects in finite state Bayesian networks.

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