Causal validity of Marginal Structural Models for event history data and causal local independence graphs

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Survival analysis has become one of the fundamental fields of biostatistics. Such analyses are almost always subject to censoring. This necessitates special statistical techniques and forces statisticians to think more in terms of stochastic processes. The theory of stochastic integrals and martingales have therefore been important for the development of such techniques.

Causal inference has lately had a huge impact on how statistical analyses based on non-experimental data are done. The idea is to use data from a non-experimental scenario that could be subject to several spurious effects and then fit a model that would govern the frequencies we would have seen in a related hypothetical scenario where the spurious effects are eliminated. This opens up for using the Nordic health registries to answer new and more ambitious questions. However, there has not been so much focus on causal inference based time-to-event data or survival analysis.

The now well established theory of causal Bayesian networks is for instance not suitable for handling such processes. Motivated by causal inference event-history data from the health registries, we have introduced causal local independence models. We show that they offer a generalization of causal Bayesian networks that also enables us to carry out causal inference based on non-experimental data when there is continuous-time processes involved.

The main purpose of this work in collaboration with Vanessa Didelez, is to provide new tools for determining identifiability of causal effects of event history data that is subject to censoring. It builds on previous work on local independence graphs and delta-separation by Vanessa Didelez and previous work on causal inference for counting processes by Kjetil RÃ¸ysland.

We provide a new result that gives quite general graphical criteria for when causal validity of a local independence model is preserved in submodels. If the observable variables, or processes, form a causally valid submodel, then we can identify most relevant causal effects by re-weighting the actual observations. This is used to prove that the continuous time marginal structural models for event history analysis, based on martingale dynamics, are valid in a much more general context than what has been known previously.