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Causal reasoning in survival analysis: Re-weighting and local independence graphs

Survival analysis is becoming an increasingly complex field with individuals followed over long periods of time, with several events occurring for each individual and with various covariate and marker processes being observed in parallel. There is also an increasing emphasis on drawing causal conclusions when possible. The now classical theory of causal Bayesian networks is not suitable for handling the stochastic processes involved. We here propose to use another type of graph based on the concept of local independence. This concept replaces the notion of conditional independence in Bayesian networks with a dynamic concept suitable for understanding the relationship between several stochastic processes. We show that a theory analogous to causal Bayesian networks can be developed. In particular, we use the notion of delta-separation which is in important respects similar to d-separation. We present criteria for when independent censoring is preserved in the presence of unmeasured confounder processes, and when causal effects can be estimated. The criteria are based on checking graphical properties in the local independence graphs. The criteria are intended to formalize and clarify the requirements for a valid analysis of complex survival data. There will be examples from studies on cervical and prostate cancer.