Identifying causal effects via context-specific independence relations

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Graphical models are an important aspect of causal inference. In a typical setting of causal effect identification, the causal model is represented by a directed acyclic graph (DAG) which completely characterizes the conditional independence properties exhibited by the available data via d-separation. However, a more general type of independence known as context-specific independence (CSI) cannot be represented via DAGs. In the simplest case, CSI means that X and Y are independent given $Z = 0$ but dependent given $Z = 1$. In other words, X and Y are independent in the context $Z = 0$. More generally, context refers to a set of variables that have been assigned to some values.

In this talk, we use a graphical model known as labeled directed acyclic graph (LDAG) for taking CSI relations into account and show that deciding causal effect non-identifiability is NP-hard in the presence of CSI relations. We present a calculus similar to standard do-calculus for causal effect identification in LDAGs and a search procedure over the rules of the calculus [1]. The search procedure has been implement a as a part of R package `dosearch` [2]. With the approach we can obtain identifying formulas that were unobtainable previously. We demonstrate that a small number of CSI-relations may be sufficient to turn a previously non-identifiable instance to identifiable.

References

[1] S. Tikka, A. Hyttinen, J. Karvanen (2019). Identifying causal effects via context-specific independence relations, *33rd Conference on Neural Information Processing Systems (NeurIPS 2019)*, http://papers.nips.cc/paper/8547-identifying-causal-effects-via-context-specific-independence-relations.pdf

[2] S. Tikka, A. Hyttinen, J. Karvanen (2020). *dosearch: Causalausal Effect Identification from Multiple Incomplete Data Sources*, R package version 1.0.6, https://cran.r-project.org/package=dosearch