Causal Discovery form Observational Multivariate

Nov 15, 2022
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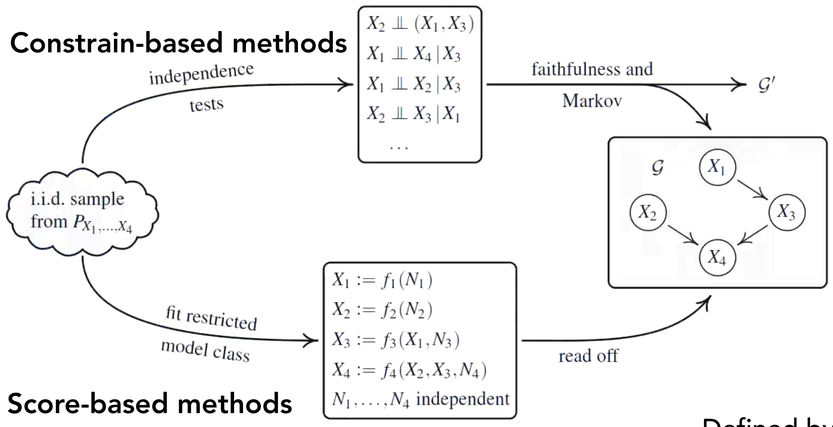
(Background)

Causal discovery is a fundamental problem in science.

Socioeconomic mechanisms come from observational multivariate.

(Methodology)



Defined by Judea Pearl

Problem: Markov equivalence class(MEC), i.e., causal structure is not unique.

Solution: Identify causal direction by bi-variate methods with further assumptions.

Then, the main types of assumptions:

A prior restriction of the model class

- LiNGAM(Linear Non-Gaussian Acyclic Model)
- ANM(Nonlinear Additive Noise Models)

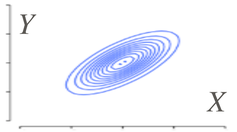
Independence assumption of cause and mechanism

- IGCI(Information-Geometric Causal Inference)
- Trace condition

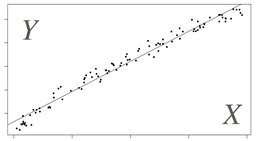
(LiNGAM)

Assume that $P_{X,Y}$ admits the linear model $Y = \alpha X + N_Y$ with continuous random variables X, N_Y and Y. Then exit $\beta \in \mathbb{R}$ and a random variable N_X such that $X = \beta Y + N_X, N_X \perp\!\!\!\perp Y$, iif N_Y and X are Gaussian.

e.g.: To identify
$X \to Y, or Y \to X$



Unidentifiable pattern
Joint gaussian noise distribution



Identifiable pattern
Gaussian noise on a Uniform distribution

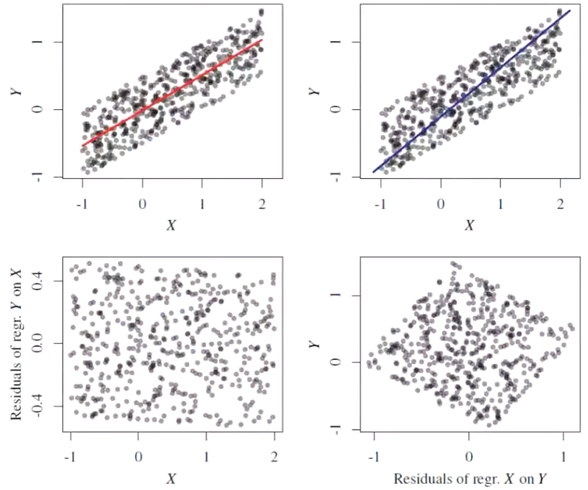
(ANM)

The joint distribution $P_{X,Y}$ admits an ANM from X to Y if there is a measurable function f_Y and a noise variable N_Y such that $Y = f_Y(X) + N_Y, X \perp\!\!\!\perp N_Y$

* ANM in practice:

Remark 1: If X and N_Y are gaussian, we can not identify the causal direction only when f_Y is linear.

Remark 2: If we know a prior $P_{X,Y}$ admits an ANM of $C(\text{cause}) \to E(\text{effect})$, then generically, there will not be an ANM of $E \to C$.



(Others, to be continued)

Reference: K. Zhang et al. Nonlinear functional causal models for distinguishing cause from effect. Statistics and Causality: Methods for Applied Empirical Research, pp. 185-202, 2016.