UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Causal Networks

2223-2-F1801Q161

Aims

The course aims to provide a gentle introduction to causal inference and in particular to causal newtworks and structural causal models.

In particular, the course gives strong motivations because, at the current state-of-the-art, modern machine learning experts need causality, and tools from causal modeling, to correctly address and effectively solve problems of decision making under uncertainty.

Contents

Main contents are as follows; the potential outcome framework, main definitions and properties of probabilistic graphical models with specific reference to Bayesian networks, causal networks and structural causal models, randomized experiments, nonparametric identification of causal effect, estimation of causal effect, unobserved confounding, instrumental variables, structural learning from observational data and from observational and intervention data, basic concepts of tranfer learning and transportability, and finally a basic introduction to counterfactuals.

Detailed program

- **Introduction to causality and why causality matters**
- **The potential outcome framework;** the fundamental problem of causal inference, ITE, ATE, main properties as ignorability, exchangeability, ...
- **Bayesian networks;** definition, collider, chain and fork, factorization, ...
- **Causal models;** do.operator, backdoor adjustement, structural causal models.

- **Randomized control trials;** comparability and covariate bancing, exchangeability, no backdoor paths.
- **Nonparametric identification;** frontdoor adjustment, identification from the graph structure.
- **Estimation;** conditional outcome modeling, grouped conditional causal modeling, propensity score and inverse probability weighting.
- **Unobserved counfounding;** no assumptions bound, optimal treatment selection, sensitivity analysis.
- **Instrumental variables;** nonparametric identification of ATE, nonparametric identification of local ATE.
- **Causal discovery from observational data;** constraint-based and score-based algorithms.
- **Causal discovery from interventional data;** structure interventions, parametric interventions, interventional Markov equivalence.
- **Transfer learning and transportability**.
- **Counterfactuals**.

Prerequisites

Basic knowledge of graph theory, optimization, probability and statistics, programming; mainly R and Python.

Teaching form

The course is expected to be delivered in presence, even if at the current stage of knowledge, due to the pandemic, we could well say "**hic sunt leones**".

Textbook and teaching resource

Slides from teachers and additional reading material.

Semester

First semester, in particular September 2022

Assessment method

Single assignment and final oral examination.

Office hours

Just send me an email message at fabio.stella@unimib.it

Sustainable Development Goals