Syllabus Internal course on Causal Inference

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Summary

This document contains the contents of the internal course "Causal Inference". The complete course is designed to be open source, and therefore makes use of free materials available online. It is based on learning by doing, so lots of exercises.

A lot of material has been evaluated for its usefullness in this course. This document ends with a list of all evaluated references to various resources / papers / tutorials.

Intro / potential outcomes

Week 1

Study: We read Chapter 9 of Gelman & Hill which contains an introduction to causal inferences in the potential outcomes framework. Exercise: We make the exercises 1-7.

Optional: watch videos on Coursera for Week 1

week 2

Exercise: Make exercises 8-14 from Gelman Ch 9. Datasets are in `code/ARM_Data`.

Pearl's Causal graphs

week 3

We read the chapter on causal graphs by Elwert t/m p12. Exercise: custom exercises 1-3.

week 4

Second half of Elwert: pages 13-18 (blz 262). Rest of Elwert is optional reading. Exercise: custom exercises 4-7.

Estimation: matching

Week 5

This includes (conceptually) also Inverse probability treatment weighting. We read Gelman Chapter 10 up to section 10.2 Exercise: Ex 10.1 (the classic Lalonde dataset and Deheija & Wahba paper)

Estimation: Regression Discontinuity Design

week 6

We read Gelman section 10.3 and Steiner, graphical models for Quasi-experiment designs. Exercise: Ex 10.2 (simulated RDD)

Estimation: Instrumental variables

week 7

Special course by Milan Pleus. We read Gelman section 10.4 and beyond. Exercise: Ex 10.3 and 10.4

Estimation: Heterogeneous Treatment Effects (GRF/ML)

Week 8

Athey & Wager, BART. Exercises: ?

References / additional reading

By topic

- Overview
  - Pearl 2009: Causal inference in statistics: An overview
  - Pearl 2018 Book of Why
  - Harvard: causality & misconceptions: https://www.cfa.harvard.edu/smg/Website/UCP/causal/causal_assumptions.html assumptions about causal patterns that impede science learning
- Potential outcomes
  - Rubin 2005: Potential outcomes
  - ICE, ACE, ATT, ACC
  - Gelman & Hill Chapter 9: Potential outcomes (Exercises!!) http://www.stat.columbia.edu/~gelman/arm/chap9.pdf
  - Causality in Python pt 1: Potential outcomes
- Causal assumptions:
  - SUTVA, ignorability, exchangeability
  - Week 1 of Coursera
  - Chapter 2 of ECI (advanced)
- Graphical models:
  - Week 2 of Coursera
  - D-separation (dagitty.net: d-separation without tears)
  - Chapter 21 Shalizi
  - Table 2 fallacy: mutual adjustment (dagitty.net)
- Identifying causal effects using SCMs:
  - Back-door criterion
  - Front-door criterion
  - Chapter 22 Shalizi
  - Disjunctive cause criterion (VanderWeele & Robins 2011)
  - Simpson's paradox
  - Elwert chapter on Graphical causal models

  - do-calculus (Ferenc blog, BoW)
- Estimation: propensity scores
  - Week 3 of Coursera
  - Shalizi Chapter 24: Estimating Causal effects from observations
- Estimation: Inverse probability weighting (IPW)
  - Week 4 of coursera
  - Austin 2011: PSM vs IPW
- Estimation: Instrumental variables
  - Week 5 of Coursera
  - Shalizi & Gelman chapters
- Causal inference & machine learning
  - ECL
  - Athey & Wagner

Exercises / practicals

- Exercises on causal inference: web.abo.fi
- Pearl, Glymour & Jewell:bayes.cs.ucla.edu chapter previews & solution manual
- DoWhy Python library:identify estimand & estimate it
- Causal inference with Python part 1: Potential outcomes
- Causal inference with Python part 2: Causal Graphical models
- Causal inference with Python part 3: Frontdoor adjustment

References

- Pearl 2009: Causal inference in statistics: an overview
- Shalizi book: Advanced data analysis from an Elementary Point of View
- Gelman & Hill: Chapters 9 & 10
- Peters et al 2018: Elements of Causal Inference
- Hernan & Robins book on Causal inference
- Shalit & Sonntag ICML 2016 slides
- Pearl: understanding Simpon's paradox
- Paul Bauer, (Applied) Causal Analysis (Bookdown.org)
- Tran, Ruiz, Athey, Blei: Model criticism for Bayesian Causal Inference
- Wang & Blei: The blessings of Multiple Causes
- Ferenc Huszar (ML@Twitter): ML beyond curve fitting: an intro to causal inference and do-calculus
- Michael Nielsen 2012 blog
- Textor et al: Causal Inference in Statistics: A companion for R users