Causal thinking

Stensrud Mats Julius

Summary
This course will give a unified presentation of modern methods for causal inference. We focus on concepts, and we will present examples and ideas from various scientific disciplines, including medicine, computer science, engineering, economics and epidemiology.

Content
Association vs. causation
Definitions of causal effects
- Causal models
- Counterfactuals and potential outcomes
- Individual level causal effects vs. average causal effects
- Population causal effects
Study design
- Randomisation and experiments
- Observational studies
Causal graphs
- Causal Directed Acyclic Graphs
- Single World Intervention Graphs
Identification of causal effects
- Identifiability assumptions
- SWIGs
Causal mechanisms
- Mediation and path specific effects
- Instrumental variables
Applications
- Medical interventions, including pharmaceuticals
- Experiments in technology industry and engineering
- Experiments in life sciences
- Causal effects and mechanisms in the social sciences.
Estimation of causal effects
- Estimation using classical statistical models
- Estimation using machine learning

Keywords
Causality; Causal inference; Randomisation; Design of experiments; Observational studies; Causal Graphs

Learning Prerequisites

Required courses
The course is intended for students from a range of different disciplines, including computer science, engineering, life science and physics. The students are expected to know the basics of statistical theory and probability theory (such as the second year courses in probability and statistics for engineers).

Recommended courses
Courses in statistical inference.

Important concepts to start the course
Familiarity with basic concepts in probability and statistics.

Learning Outcomes
• Design experiments that can answer causal questions.
• Describe the fundamental theory of causal models.
• Critique assess causal assumptions and axioms.
• Distinguish between interpretation, identification and estimation.
• Describe when and how causal effects can be identified and estimated from non-experimental data.
• Estimate causal parameters from observational data

Teaching methods
Classroom lectures, where I will use a digital blackboard and slides.

Assessment methods
Final written exam. 1-2 graded homeworks.

Supervision
Office hours   Yes
Assistants    Yes
Forum         Yes

Resources
Bibliography
Cambridge University Press.

Ressources en bibliothèque
• Causal inference in statistics, social, and biomedical sciences / Imbens
• Causal Inference / Hernan
• Causality / Pearl

Moodle Link
• https://go.epfl.ch/MATH-352