

6.S091: Causality

Policy Evaluation, Structure Learning, and Representation Learning

IAP 2023
Instructor: Chandler Squires
TA: Katherine Matton

Course Information

Description

In this course, we will cover introductory material from three active research areas related to causality and machine learning. In the first third of the course, we will discuss the fundamentals of policy evaluation, where a known causal structure is used to estimate causal quantities such as (conditional) average treatment effects. In this section, we will cover algorithms for identification of causal estimands in both the non-parametric and parametric setting. In the second third of the course, we will consider causal structure learning, i.e., the estimation of an unknown causal structure from data. We will cover classical algorithms such as the PC algorithm, as well as newer methods which incorporate interventional data. We will also cover experimental design techniques for causal structure learning. In the final third of the course, we will discuss the emerging field of causal representation learning, highlighting recent papers which connect machine learning with more traditional causal principles.

Recommended Pre-requisites

Knowledge of probability (level of 6.3700) and statistics (level of 18.650) is generally assumed. Familiarity with Python is also assumed.

Grading and Problem Sets

This course will be graded during MIT IAP for 6 units under P/D/F grading. Receiving a passing grade requires a total of 18 points on the problem sets, out of 30 possible points.

Problem Sets

There will be 3 problem sets, each worth 10 points. Take note of the following:

- Problem sets **must** be written in LaTeX.
- Printed problem sets must be turned in at the beginning of lecture. If you are unable to attend, please have a classmate turn it in for you.

References

- *Elements of Causal Inference* by Jonas Peters, Dominik Janzing, and Bernhard Schölkopf
- *Graphical Models* by Steffen Lauritzen
- *Causality* by Judea Pearl

Schedule

Week 1

Tuesday, Jan. 10

- *Lecture 1.* Introduction to Structural Causal Models

Thursday, Jan. 12

- *Lecture 2.* Policy Evaluation I: Non-parametric Identification
- *Problem Set 1 released.*

Week 2

Tuesday, Jan. 17

- *Lecture 3.* Policy Evaluation II: Parametric Identification

Wednesday, Jan. 18

- Study session, 5:30 - 7:30 in 24-307.

Thursday, Jan. 19

- *Lecture 4.* Causal Structure Learning I: Identifiability
- *Problem Set 1 due at 1pm EST.*
- *Problem Set 2 released.*

Week 3

Tuesday, Jan. 24

- *Lecture 5.* Causal Structure Learning II: The PC Algorithm and Score-based Approaches

Wednesday, Jan. 25

- Study session, 5:30 - 7:30 in 24-307.

Thursday, Jan. 26

- **LECTURE CANCELLED.**
- *Problem Set 2 due at 1pm EST.*
- *Problem Set 3 released.*

Week 4

Tuesday, Jan. 31

- *Lecture 6.* Causal Structure Learning III: Experimental Design

Wednesday, Feb. 1

- Study session, 5:30 - 7:30 in 24-307.

Thursday, Feb. 2

- *Lecture 7.* Causal Representation Learning: Learning Latent Causal Structure

Friday, Feb. 3

- *Problem Set 3 due at 11:59pm EST.*