6.S091: Causality
Policy Evaluation, Structure Learning, and Representation Learning

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, as well the principles behind state-of-the-art estimation methods based on double/de-biased machine learning. 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 and allow for unobserved confounding. 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

Schedule

Week 1

Tuesday, Jan. 10

- *Lecture 1.* Introduction to Structural Causal Models

Thursday, Jan. 12

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

Week 2

Tuesday, Jan. 17

- *Lecture 3.* Policy Evaluation II: Estimation of Causal Quantities

Wednesday, Jan. 18

- Study session, 5:30 - 7:30

Thursday, Jan. 19

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

Week 3

Tuesday, Jan. 24

- *Lecture 5.* Causal Structure Learning II: Recent Approaches

Wednesday, Jan. 25

- Study session, 5:30 - 7:30

Thursday, Jan. 26

- *Lecture 6.* Causal Structure Learning III: Experimental Design
- *Problem Set 2 due at 1pm EST.*
- *Problem Set 3 released.*

Week 4

Tuesday, Jan. 31

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

Wednesday, Feb. 1

- Study session, 5:30 - 7:30

Thursday, Feb. 2

- *Lecture 8.* Causal Representation Learning II: Domain Generalization
- *Problem Set 3 due at 1pm EST.*