

6.S091: Topics in Causality

IAP 2024

Logistical Details

Room number: 24-115

Meeting time: 3:05 - 4:25 PM EST

Instructors:

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Website: github.com/kmatton/6.S091-causality-2024

Course Information

Description

In this course, we will cover a selection of foundational topics in causality, as well as more recent topics at the intersection of causality and machine learning. Two lectures will cover recent papers illustrating how these topics are relevant to active areas of research.

In the **first section** of the course, we will discuss the identification of treatment effects, where a causal model of a system is given, and then used to derive estimators for causal quantities such as (conditional) average treatment effects. In the **second section** of the course, we will consider causal structure learning, i.e., the estimation of an unknown causal structure from data. We will discuss limitations on the identifiability of such structure from only observational data, algorithms for learning the structure for data, and experimental design algorithms for learning structure using interventions. In the **final section** of the course, we will discuss topics at the intersection of causality and machine learning, demonstrating how ideas from causality can help to address open problems in machine learning such as out-of-distribution generalization.

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.

References

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

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.

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.

Schedule

Week 1

Tuesday, Jan. 9

- *Lecture 1.* Introduction to causality and structural causal models

Thursday, Jan. 11

- *Lecture 2.* Treatment effect identification and estimation
- *Problem Set 1 released.*

Week 2

Tuesday, Jan. 16

- *Lecture 3.* Causal structure learning

Wednesday, Jan. 17

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

Thursday, Jan. 18

- *Lecture 4.* Seminar-style reading group (paper TBD)
- *Problem Set 1 due at 3pm EST*
- *Problem Set 2 released*

Week 3

Tuesday, Jan. 23

- *Lecture 5.* Experimental design for structure learning

Wednesday, Jan. 24

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

Thursday, Jan. 25

- *Lecture 6.* Causal representation learning: identifiability and algorithms
- *Problem Set 2 due at 3pm EST*
- *Problem Set 3 released*

Week 4

Tuesday, Jan. 30

- *Lecture 7.* Causal representation learning: applications to machine learning

Wednesday, Jan. 31

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

Thursday, Feb. 1

- *Lecture 8.* Seminar-style reading group (paper TBD).

Friday, Feb. 2

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