Soc 952 / EdPsych 711-005

Graphical Models for Causal Inference

Spring 2013
Time: Wednesday 2:30-5:30
Room 486, Van Hise

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Course Description

Social scientists routinely ask causal questions. “Does job training cause higher earnings?” “Does divorce impede children’s academic progress?” “Does No-Child-Left-Behind increase student achievement scores?” “Does retaining kindergartners for one year (instead of promoting them) impede their future achievements?” Questions such as these are as old as science. But how can we answer these causal questions given that data alone cannot prove cause-effect relationships (“correlation does not equal causation”)?

This course discusses a powerful mathematical tool of causal inference: directed acyclic graphs (DAGs). DAGs are visual representations of causal models that encode researchers’ beliefs about how the world works. The two primary uses of DAGs are (1) determining the identifiability of causal effects from observed data, and (2) deriving the testable implications of a causal model. DAGs are also helpful for understanding the causal assumptions behind widely used estimation strategies, such as regression, matching, and instrumental variables analysis. This means that DAGs are also useful for choosing an appropriate study design, deciding which covariates to measure and control for, and deciding which covariates not to control for.

This course covers the theoretical foundations of DAGs through a close reading of Judea Pearl’s book “Causality: Models, Reasoning, and Inference” (2009, 2nd edition) and related articles. We will focus on DAG’s main uses, discuss central principles, and give applied examples.

Although this course has clear and direct implications for applied causal inference from observational data, we will not discuss the practical side of estimation (no data analysis, no software packages!). Instead, we will discuss the conditions under which causal treatment effects is possible to begin with.

A word of warning: A central contribution of DAGs is to spotlight implicit assumptions and inherent limitations in study designs and statistical methods. Consequently, many methodologists embrace the lessons of the new literature on causality as a call for
analytic modesty. This may be discouraging to applied folks at first. Yet an improved understanding of current limitations also prepares the way for novel solutions that stand on firmer ground than previous practice. We will encounter numerous such solutions in this course. The goal is to sensitize you to conceptual issues in applied work, and to develop guiding intuitions that may empower the independent study of appropriate designs and methods for own empirical research projects.

Class structure
Class meetings will be a mixture of lecture presentations and discussions of the required readings.

Requirements
Readings: You commit to completing all required readings prior to the class meeting, and will make an effort to look at some of the optional readings as well.

Abstracts: Every week, you will submit a one-page (single-spaced) abstract of the required reading. Every abstract has two parts. First, you will highlight the key insight from your readings and explain it in your own words. Second, you will address topics you didn’t entirely understand. Please proof your abstracts for content, style, spelling, and grammar. Abstracts need to be uploaded at Learn@UW as pdf or .docx documents by Tuesday 6pm. Overall, you will write 14 one-page abstracts.

Assignments: You will complete 6 homework assignments. Assignments will actively be discussed in class. Assignments will be weighted according to difficulty.

Grading
Grades will follow this breakdown: 30% participation, 20% abstracts, 50% assignments. Since this is a graduate course, straight As are reserved for consistently excellent work. Students who continuously work hard and show a good understanding of the material will receive an AB. Consistently hard work is a prerequisite for a B.

Prerequisites
Basic knowledge of probability theory is required (e.g., marginal & conditional probabilities, law of total probability, Bayes Theorem, independence, expectation, conditional expectation). Basic knowledge of common statistical methods in observational data analysis is required (e.g. linear regression, categorical data analysis, instrumental variables analysis).

A note on reading methodological and statistical literature
There is real pleasure in reading literature on methods and statistics—but reading such literature is a different beast from reading applied work in the social sciences. Most of assigned readings are best read slowly with pencil and paper. Note the definitions of all symbols as they first appear in the text for your reading reference. Then scan for the central insight explained in the text. Then understand how the accompanying equations cement the insight. Then figure out how the author arrives at the insight. Lastly, attempt to transfer the abstract insights of the readings to concrete applications in your own
research by searching for a homologous problem in a substantive area that you understand well.

A fruitful reading of 10 pages in Pearl’s book may require anywhere between 2-10 hours of work, depending on your technical preparedness. You’ll often skip back and forth to remind yourself of previous steps in a deductive chain, and you’ll find yourself wanting to reread the entire thing once you’ve finally made it through for the first time.

It’s impossible to skim the assigned readings in the hour before your abstract is due.

**Required Textbook and Other Course Material**

Papers and lecture notes will be uploaded at Learn@UW.

**More Books on Causation & Causal Inference**

*Philosophy*

*Design & Analysis*
Schedule
(Subject to change!)

(1) Jan 23: Introduction to Graphical Models for Causal Inference I
  Required reading
  ⇒ Epilogue of Pearl (2009, p 401ff): The Art and Science of Cause and Effect
  Read entire: skim pp. 41-46.

(2) Jan 30: Introduction to Graphical Models for Causal Inference II
  Required reading
  Read: pp. 1-4, 11-end.

(3) Feb 6: Exercises & Review of Probability Theory
  Required reading
  ⇒ Section 1.1 of Pearl (2009): Introduction to Probability Theory
  Optional reading
  ⇒ Brief reviews of probability theory can also be found in the Appendices of Wooldridge (2012): Introductory Econometrics, or Fox (2008): Applied Regression Analysis and Generalized Linear Models (Online Appendix:
  ⇒ More thorough introductions to probability theory can be found in more advanced textbooks on statistics or probability theory, e.g., Spanos (1999): Probability Theory and Statistical Inference, or Wooldridge (2010): Econometric Analysis.

(4) Feb 13: Graphs and Causal Models
  Required reading
  ⇒ Chapter 1 of Pearl (2009)

(5) Feb 20: Theory of Inferred Causation
  Required reading
  ⇒ Chapter 2 of Pearl (2009)

(6) Feb 27: Causal Diagrams & Identification of Causal Effects I
  Required reading
  ⇒ Chapter 3 of Pearl (2009), pp.65-81 & Section 11.3; (pp. 74-76 on “dynamic process control” are optional)

(7) Mar 6: Causal Diagrams & Identification of Causal Effects II
  Required reading
  ⇒ Remainder of Chapter 3 of Pearl (2009) with section 3.6.4 being optional

Optional reading

(8) Mar 13: Actions, Plans & Direct Effects I

Required reading
⇒ Chapter 4 of Pearl (2009), pp. 107-126

(9) Mar 20: Actions, Plans & Direct Effects II – Mediation Analysis: Identification

Required reading
⇒ Chapter 4 of Pearl (2009), pp. 126-132
Read pp. 1-7.

(10) Apr 3: Actions, Plans & Direct Effects III – Mediation Analysis: Designs & Analysis

Required reading

Optional reading

(11) Apr 10: Causality and Structural Equation Models

Required reading
The latter will be more helpful for social scientists.
⇒ Section 11.5.1 in Pearl (2009)

Optional reading

(12) Apr 17: Simpson’s Paradox, Confounding & Collapsability
Required reading
⇒ Chapter 6 of Pearl (2009)

(13) Apr 24: Structure-Based Counterfactuals
Required reading
⇒ Chapter 7 of Pearl (2009)

Optional reading

(14) May 1: Selected Topics (from Chapters 8 to 10 or other topics)
   Required reading
   TBA

(15) May 8: Summary & Review