Many questions in applied data analysis are causal in nature, yet answers to such questions are often elusive. A fundamental difficulty in causal inference is that we are not simply interested in measuring what happened in the past or predicting what will happen in the future, but rather need to understand what could have happened in a counterfactual universe where agents chose to act differently. The aim of this course is to present a formal theory of when and why it is possible to draw causal inferences from data, and to discuss how methods from machine learning and optimization can be used to design powerful tools for extracting causal signals from rich datasets.

Instructor: Stefan Wager, GSB E328, swager@stanford.edu.

Class Time: Tuesday and Thursday, 1:30–2:50 PM, in GSB M110.

Office Hours: Thursday, 3:00–4:00 PM, in GSB E328, and by appointment.

Grading: The grade for this class will be based on 3 homework assignments (20% each), and a final project (40%).

Collaboration Policy: You may discuss the homework questions with others, but need to write up solutions separately. If you do discuss a homework problem with someone, you must indicate it on your assignment (i.e., who you talked with and what you talked about).

Pass/Fail Workload: Students who take the class pass/fail may opt out of one assignment (i.e., one of the homeworks, or the final project).

The Stanford University Honor Code: The Honor Code is an undertaking of the students, individually and collectively: (1) that they will not give or receive aid in examinations; that they will not give or receive unpermitted aid in class work, in the preparation of reports, or in any other work that is to be used by the instructor as the basis of grading; (2) that they will do their share and take an active part in seeing to it that others as well as themselves uphold the spirit and letter of the Honor Code.

The faculty on its part manifests its confidence in the honor of its students by refraining from proctoring examinations and from taking unusual and unreasonable precautions to prevent the forms of dishonesty mentioned above. The faculty will also avoid as far as practicable, academic procedures that create temptations to violate the Honor Code.

While the faculty alone has the right and obligation to set academic requirements, the students and faculty will work together to establish optimal conditions for honorable academic work.

Students with Documented Disabilities: Students who may need an academic accommodation based on the impact of a disability must initiate the request with the Office of Accessible Education (OAE). Professional staff will evaluate the request with required documentation, recommend reasonable accommodations, and prepare an Accommodation Letter for faculty dated in the current quarter in which the request is being made. Students should contact the OAE as soon as possible since timely notice is needed to coordinate accommodations. The OAE is located at 563 Salvatierra Walk (phone: 723-1066, URL: http://oae.stanford.edu).
**Topics Covered:** The Neyman-Rubin causal model for observational studies. Randomization and potential outcomes, matching and stratification, the propensity score.

Large-sample theory for treatment effect estimation. Efficiency and double robustness, double machine learning, inference in partially linear models, estimating treatment effect heterogeneity.

Identification strategies for causal inference. Instrumental variables, regression discontinuities, mediation analysis.

Learning decision rules. Counterfactual risk minimization, sequential trials/bandits.

Causal inference in survival analysis.

**Textbook:** There is no textbook for this class; however, the following references may be useful.


**Final Project:** The second half of the class will involve student presentations based on recent research papers. A list of papers that may be presented include the following; if you want to present something not on the list, please come see me.


Egami, Naoki, and Kosuke Imai. *Causal interaction in factorial experiments: Application to conjoint analysis*, *working paper*. 


