Causal Discovery for Practitioners
Spring 2018

Instructor Information

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1 Course Information

Course Description

Which genes cause cancer? Does cholesterol cause heart attacks? Computational causal discovery (especially from observational data) is a recently developed and developing field at the intersection of statistics and machine learning, with numerous and important untapped applications in scientific and medical research. This course provides a foundation for students to go on to apply causal discovery methods to their own data sets. The focus of this course is on developing the students' ability to identify when and why to use computational causal discovery methods, how to determine what methods are appropriate to use in a given context, and how to interpret and report the results. Students in this course will gain hands-on experience applying causal discovery algorithms, develop an understanding of the computational challenges one faces when using causal discovery algorithms, and learn the best practices for using causal discovery algorithms.

Time and Location

Th, 12:00pm - 3:00pm
PWB 6-210

Goals and Objectives

After completing this course, all students should be able to do the following:

1. Identify when it is appropriate to use causal discovery methods.

2. Identify appropriate causal discovery methods to use for a given problem, in a given context.

3. Apply causal discovery methods to data.

4. Interpret the output of causal discovery methods.

5. Understand and utilize important causal discovery concepts and terms.

6. Understand how causal discovery differs from other kinds of graph learning methods.

Requirements

- PUBH 6450 (Biostatistics I) or HINF 5531 (analytics and data science) or equivalent

- Alternatively, can get instructor permission

- Laptop capable of running Java that you can bring into class

Teaching methods

In-class activities: lectures, computing exercises, programming exercises, project presentations
Outside-of-class activities: reading primary and secondary literature, homework assignments, class project

Assignments

- Homework assignments will include a mix of programming tasks and computational exercises.

- For some classes, students will need to come prepared with specific software installed and working on their laptops, in order to receive full credit for that day's in-class activities.

- There will be a final project where students investigate an unsolved causal discovery problem of their choice. The findings will be reported to the class through in-class presentations, and written up in a final paper.

Evaluation

In-class activities: 15 points
Homework assignments: 50 points
Final project presentation: 10 points
Final project paper: 25 points

Recommended Books

These books are not required, but will be useful references for students taking this course.
Spirtes, P., Glymour, C. N., and Scheines, R. (2000). Causation, prediction, and search. MIT press.
Pearl, J. (2009). Causality. Cambridge university press.

Readings

All readings are available online through the University Libraries system. Links to articles will be provided on the course Moodle site.

2 Schedule

The following schedule includes some flex time, since some topics may take longer than a week to cover. Depending on the rate at which the material is covered, we might spend up to two weeks covering additional causal discovery topics.

Weekly Outline

Date	Summary	Examples
Week 1	**What is Causal Discovery?** Review syllabus. What is causation?	
Week 2	**What is Causal Discovery?** Software demo. Methodology scheme.	
Week 3	**Interpreting Causal Graphs.** Describe relationships among variables with causal graph. Graph terminology. Tetrad GUI.	Mechanisms of diabetes, gene regulatory network of ovarian cancer.
Week 4	**Interpreting Causal Graphs.** Causal questions.	Does smoking cause lung cancer? What causes people to use health technology?
Week 5	**Interpreting Causal Graphs.** Types of graphs.	Does our data contain all the important variables? Can we always determine causal direction?
Week 6	**Choosing an Algorithm.** Types of data. R code.	What algorithms will run on gene expression data? Clinical survey data? Lab panels?
Week 7	**Choosing an Algorithm.** Types of algorithm.	What type of algorithm should we use to learn about the causes and symptoms of schizophrenia?
Week 8	**Choosing an Algorithm.** Score/test types.	What score should we use for clinical data? What test should we use for genomic data?
Week 9	**Choosing an Algorithm.** Algorithm performance.	If an algorithm says depression causes alcohol consumption, can we trust it? If depression causes alcohol consumption, will the algorithm find out?
Week 10	**Running the Algorithm.** PC, FGES, GFCI. Tetrad, R.	
Week 11	**Running the Algorithm.** Bootstrapping, parameter selection, evaluation.	What parameter values should I use on a small clinical data set? What parameter should I use on an enormous national data set?
Week 12	**More Uses for Causal Graphs.** Causal feature selection for predictive modeling.	What variables will best predict suicide attempts?
Week 13	**More Uses for Causal Graphs.** Post-processing of graphs. Hubs, betweenness, connectedness, etc.	What is the most important symptom to focus on when treating a patient with alcohol use disorder?
Week 14	**Flexible.** TBD based on student interest.	
Week 15	**Project Presentations.**	

3 Course Policies

Late Assignments and Requests for Extensions

Students are allowed two flex days for late homework assignments, meaning that one assignment can be two days late or two assignments can be one day late each. Once these flex days are spent, homework assignments lose 15 points for each additional day that they are late. Exceptions are made only for documented extreme circumstances that are reported in a timely manner.

The final project presentations occur during scheduled class times and cannot be extended. Final project papers also cannot be extended so that student grades can calculated and reported to the university on time.

Attendance

Attendance is not strictly required, however there will be graded in-class activities. Failure to be present for these activities without prior written approval will result in a 0 on those activities.

Student Conduct Code

The University seeks an environment that promotes academic achievement and integrity, that is protective of free inquiry, and that serves the educational mission of the University. Similarly, the University seeks a community that is free from violence, threats, and intimidation; that is respectful of the rights, opportunities, and welfare of students, faculty, staff, and guests of the University; and that does not threaten the physical or mental health or safety of members of the University community.

As a student at the University you are expected adhere to Board of Regents Policy: Student Conduct Code. To review the Student Conduct Code, please see:
http://regents.umn.edu/sites/regents.umn.edu/files/policies/Student_Conduct_Code.pdf

Note that the conduct code specifically addresses disruptive classroom conduct, which means "engaging in behavior that substantially or repeatedly interrupts either the instructor's ability to teach or student learning. The classroom extends to any setting where a student is engaged in work toward academic credit or satisfaction of program-based requirements or related activities."

Use of Personal Electronic Devices in the Classroom

Using personal electronic devices in the classroom setting can hinder instruction and learning, not only for the student using the device but also for other students in the class. To this end, the University establishes the right of each faculty member to determine if and how personal electronic devices are allowed to be used in the classroom. For complete information, please reference: http://policy.umn.edu/education/studentresp.

Scholastic Dishonesty

You are expected to do your own academic work and cite sources as necessary. Failing to do so is scholastic dishonesty. Scholastic dishonesty means plagiarizing; cheating on assignments or examinations; engaging in unauthorized collaboration on academic work; taking, acquiring, or using test materials without faculty permission; submitting false or incomplete records of academic achievement; acting alone or in cooperation with another to falsify records or to obtain dishonestly grades, honors, awards, or professional endorsement; altering, forging, or misusing a University academic record; or fabricating or falsifying data, research procedures, or data analysis. (Student Conduct Code:
http://regents.umn.edu/sites/regents.umn.edu/files/policies/Student_Conduct_Code.pdf) If it is determined that a student has cheated, the student may be given an "F" or an "N" for the course, and may face additional sanctions from the University. For additional information, please see:
http://policy.umn.edu/education/instructorresp

The Office for Student Conduct and Academic Integrity has compiled a useful list of Frequently Asked Questions pertaining to scholastic dishonesty: http://www1.umn.edu/oscai/integrity/student/index.html. If you have additional questions, please clarify with your instructor for the course. Your instructor can respond to your specific questions regarding what would constitute scholastic dishonesty in the context of a particular class-e.g., whether collaboration on assignments is permitted, requirements and methods for citing sources, if electronic aids are permitted or prohibited during an exam.

Makeup Work for Legitimate Absences

Students will not be penalized for absence during the semester due to unavoidable or legitimate circumstances. Such circumstances include verified illness, participation in intercollegiate athletic events, subpoenas, jury duty, military service, bereavement, and religious observances. Such circumstances do not include voting in local, state, or national elections. For complete information, please see:
http://policy.umn.edu/education/makeupwork

Appropriate Student Use of Class Notes and Course Materials

Taking notes is a means of recording information but more importantly of personally absorbing and integrating the educational experience. However, broadly disseminating class notes beyond the classroom community or accepting compensation for taking and distributing classroom notes undermines instructor interests in their intellectual work product while not substantially furthering instructor and student interests in effective learning. Such actions violate shared norms and standards of the academic community. For additional information, please see: http://policy.umn.edu/education/studentresp

Grading and Transcripts

The University utilizes plus and minus grading on a 4.000 cumulative grade point scale in accordance with the following:

Grade	Points	Description
A	4.000	Represents achievement that is outstanding relative to the level necessary to meet course requirements
A-	3.667	
B+	3.333	
B	3.000	Represents achievement that is significantly above the level necessary to meet course requirements
B-	2.667	
C+	2.333	
C	2.000	Represents achievement that meets the course requirements in every respect
C-	1.667	
D+	1.333	
D	1.000	Represents achievement that is worthy of credit even though it fails to meet fully the course requirements
S		Represents achievement that is satisfactory, which is equivalent to a C- or better.

For additional information, please refer to: http://policy.umn.edu/education/gradingtranscripts.

Sexual Harassment

"Sexual harassment" means unwelcome sexual advances, requests for sexual favors, and/or other verbal or physical conduct of a sexual nature. Such conduct has the purpose or effect of unreasonably interfering with an individual's work or academic performance or creating an intimidating, hostile, or offensive working or academic environment in any University activity or program. Such behavior is not acceptable in the University setting. For additional information, please consult Board of Regents Policy:
http://regents.umn.edu/sites/regents.umn.edu/files/policies/SexHarassment.pdf

Equity, Diversity, Equal Opportunity, and Affirmative Action

The University provides equal access to and opportunity in its programs and facilities, without regard to race, color, creed, religion, national origin, gender, age, marital status, disability, public assistance status, veteran

status, sexual orientation, gender identity, or gender expression. For more information, please consult Board of Regents Policy:
http://regents.umn.edu/sites/regents.umn.edu/files/policies/Equity_Diversity_EO_AA.pdf

Disability Accommodations

The University of Minnesota views disability as an important aspect of diversity, and is committed to providing equitable access to learning opportunities for all students. The Disability Resource Center (DRC) is the campus office that collaborates with students who have disabilities to provide and/or arrange reasonable accommodations.

- If you have, or think you have, a disability in any area such as, mental health, attention, learning, chronic health, sensory, or physical, please contact the DRC office on your campus (UM Twin Cities - 612.626.1333) to arrange a confidential discussion regarding equitable access and reasonable accommodations.

- Students with short-term disabilities, such as a broken arm, can often work with instructors to minimize classroom barriers. In situations where additional assistance is needed, students should contact the DRC as noted above.

- If you are registered with the DRC and have a disability accommodation letter dated for this semester or this year, please contact your instructor early in the semester to review how the accommodations will be applied in the course.

- If you are registered with the DRC and have questions or concerns about your accommodations please contact your (access consultant/disability specialist).

Additional information is available on the DRC website or by e-mailing your questions:

- UM Crookston - https://www.crk.umn.edu/units/disability-resource-center - myers062@crk.umn.edu

- UM Duluth - http://www.d.umn.edu/disability-resources - access@d.umn.edu

- UM Morris -http://www.morris.umn.edu/academicsuccess/disability/ - hoekstra@morris.umn.edu

- UM Rochester -http://r.umn.edu/student-life/student-services/disability-resources - sdzavada@r.umn.edu

- UM Twin Cities - https://diversity.umn.edu/disability/ - drc@umn.edu

Mental Health and Stress Management

As a student you may experience a range of issues that can cause barriers to learning, such as strained relationships, increased anxiety, alcohol/drug problems, feeling down, difficulty concentrating and/or lack of motivation. These mental health concerns or stressful events may lead to diminished academic performance and may reduce your ability to participate in daily activities. University of Minnesota services are available to assist you. You can learn more about the broad range of confidential mental health services available on campus via the Student Mental Health Website: http://www.mentalhealth.umn.edu

Academic Freedom and Responsibility

Academic freedom is a cornerstone of the University. Within the scope and content of the course as defined by the instructor, it includes the freedom to discuss relevant matters in the classroom. Along with this freedom comes responsibility. Students are encouraged to develop the capacity for critical judgment and to engage in a sustained and independent search for truth. Students are free to take reasoned exception to the views offered in any course of study and to reserve judgment about matters of opinion, but they are responsible for learning the content of any course of study for which they are enrolled.

Reports of concerns about academic freedom are taken seriously, and there are individuals and offices available for help. Contact the instructor, the Department Chair, your adviser, the associate dean of the college, or the Vice Provost for Faculty and Academic Affairs in the Office of the Provost.