

High Dimensional Data Analysis

University of Iowa

BIOS:7240

Spring 2025

Credit: 3 s.h.

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Office hours: 1:00p - 2:00p Monday
2:30p - 3:30p Wednesday
Or e-mail to set up an appointment
Lecture: 1:00p - 2:20p
Tuesday & Thursday
C217 CPHB

Course description: Increasingly, the data collected in many fields is high-dimensional, in the sense that many characteristics, or features, are recorded for each instance. The collection of this kind of data is a relatively recent phenomenon, and it poses many challenges that traditional statistical methods are incapable of addressing. This course will cover the analysis of high-dimensional data, with an emphasis on the use of penalized regression models. The primary topics of the course include large-scale hypothesis testing and the estimation of false discovery rates, the concept of penalized likelihood and its connections with Bayesian statistics, the lasso, elastic net, and nonconvex penalties such as MCP and SCAD. In addition, we will cover approaches to inference for penalized regression models, models with “structured sparsity” such as the group lasso, fused lasso, hierarchical penalties, and penalized interactions, as well as the extension of penalties to generalized linear models, time-to-event models, and semiparametric models.

Objectives: My objectives with this course are:

- To broaden your mind in terms of thinking about penalized likelihood methods, how they can be useful in statistics, and why they are particularly useful for high-dimensional data
- To introduce useful statistical methods for high-dimensional data
- To familiarize you with important topics in high-dimensional data that you may wish to research
- To bring you up to speed concerning terminology and concepts in high-dimensional data analysis and penalized regression so that you can more easily read research articles in the field

Textbook: *High-Dimensional Regression Modeling* (in progress), BREHENY, P. and HUANG, J. CRC Press.

Prerequisite: One year of graduate-level mathematical statistics (e.g., STAT 5100 and 5101), a basic course in regression (e.g., BIOS 5720), and a working knowledge of R.

Course website: The course notes, assignments, data sets, and other relevant materials will be made available on the course web site: <http://myweb.uiowa.edu/pbreheny/7240/s25>

Homework: The course is divided into “topics”, with each topic lasting for one to two weeks, depending on the amount of material. There will be one homework assignment per topic. Most assignments will have a mix of three types of problems: (1) Mathematical concepts and derivations (2) Simulation studies and computational aspects (3) Analysis of real data.

Final project: As a final project, you will read a paper in the field of penalized regression that we have not covered in class (or that we only briefly mentioned) and prepare a 15-minute presentation with 5 minutes for questions and answers. These presentations will take place during finals week (exact date to be determined by the University’s finals schedule). You may work in groups of two or three. You are free to find your own article, or I can suggest some.

Grade: Your final grade is a weighted combination: 80% homework, 20% final project.

Computing: The simulation study and real data analysis portion of each project will involve a computer. I assume that you are familiar with the basics of R programming; I will introduce and demonstrate helpful additional functions and code during class.

Corrections: Despite my best efforts, I am sure that both the book and the notes have mistakes. If you spot a mistake, I very much want you to let me know about it so that I can correct it. I will award one bonus point (to be added to your homework total) for pointing out a typographical error and three bonus points for an error in content. Corrections will be made to the online version of the book/notes.

Attendance: Regular attendance in this course is expected. No direct penalty will be applied for missing lectures. However, assignments will be based on what we cover in lecture, so skipping lecture is likely to hurt your grade (and, of course, your understanding of the material). And it will hurt my feelings.

Electronic communication: I will occasionally send e-mails to the class (to the account listed for you in the campus directory), so please check that account regularly.

Course schedule: See <http://myweb.uiowa.edu/pbreheny/7240/s25/notes.html> for the schedule of topics.

Academic misconduct: You may discuss the assignments and your solutions with other students, but your writeup must be your own. Specifically, any copying of mathematical solutions, or copy/paste operations on typed documents or code are strictly forbidden. Doing so will be considered plagiarism. The University of Iowa takes plagiarism very seriously, and has in place a number of rather severe academic sanctions: <http://dos.uiowa.edu/policies/academic-misconduct>.

I look forward to getting to know you, and I hope that we have a great semester together!

PhD in Biostatistics Competencies:

- Demonstrate an increased level of knowledge and understanding of current statistical theory, methods, and practices in the health sciences.
- Design, manage data, analyze and interpret data from a variety of experimental and observational studies.
- Communicate research findings, including new statistical methods developed, effectively to various audiences in writing and through oral presentation.

Concerns: Students with suggestions or complaints should see me first, and if we cannot come to an agreement, I will direct you to the Departmental DEO, Prof. Joseph Cavanaugh, N332 CPHB, joe-cavanaugh@uiowa.edu. Students may also contact the Undergraduate Program Director (if appropriate) or the Associate Dean for Academic Affairs in the College of Public Health. Another resource for students is the Office of the University Ombudsperson. If a complaint cannot be resolved at the departmental and/or collegiate level, students may file a formal complaint utilizing the procedure specified in Section II, Chapter 29.7 of the Operations Manual: <http://opsmanual.uiowa.edu>.

Accommodations for students with disabilities: If you have a diagnosed disability or any other condition that impacts your ability to complete the course requirements, please inform me as early in the semester as possible, preferably at least two weeks prior to the scheduled activity. For additional information, see <https://sds.studentlife.uiowa.edu/students/apply>.

Administrative home: This course is given by the College of Public Health. This means that class policies on matters such as requirements, grading, and sanctions for academic dishonesty are governed by the College of Public Health. Students wishing to add or drop this course after the official deadline must receive the approval of the Associate Dean for Academic Affairs in the College of Public Health. Details of the University policy of cross enrollments may be found at: <https://www.provost.uiowa.edu/sites/provost.uiowa.edu/files/crossenroll.pdf>.

University policies and resources: At the University of Iowa, we strive for a climate that encourages learning while also protecting the freedoms and rights of our students and faculty. Please review the following course policies, expectations, and resources at <https://provost.uiowa.edu/student-course-policies>. Visit the Dean of Students website for additional student policies and procedures.

- Absences for religious holy days
- Basic needs and support for students
- Classroom expectations
- Free speech and expression
- Mental health
- Nondiscrimination in the classroom
- Sexual harassment/misconduct and supportive measures
- Sharing of class recordings