Optimization for Statistical Learning

208424 · Semester 2/2026 · Donlapak Ponnoprat

Course information

- **Instructor:** Donlapak Ponnoprat
- **Lectures:** Tu & F, 13:00-14:30, STB205
- **Website:** donlapark.pages.dev/208424
  - schedule and slides
- **Canvas:** instructure.com/courses/31782
  - announcements, homework and questions

Prerequisites

- **Prerequisite courses:**
  - 206324; 208329 or 229351; 204217 or 229223
- You should be comfortable with multivariate calculus, linear algebra, and Python. Anyhow, we'll review them in the first two weeks.
- We mainly use numpy, scipy and cvxpy.

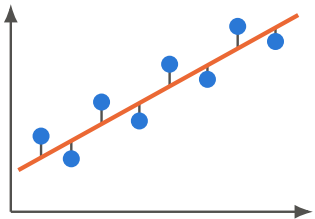
Grading

- **30%** homework
- **35%** midterm exam
  - TBA. Please fill in the excel file in Canvas.
- **35%** final exam
  - Sunday, March 21, 12:00 to 15:00
- Your final grade may be curved.

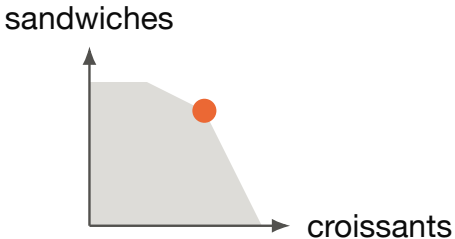
Homework

- Submit each homework on Canvas.
- **Deadline:** 23:59 on the due date.
- Late homework's score will be halved.

What this course is about



fit a model:
minimize the loss

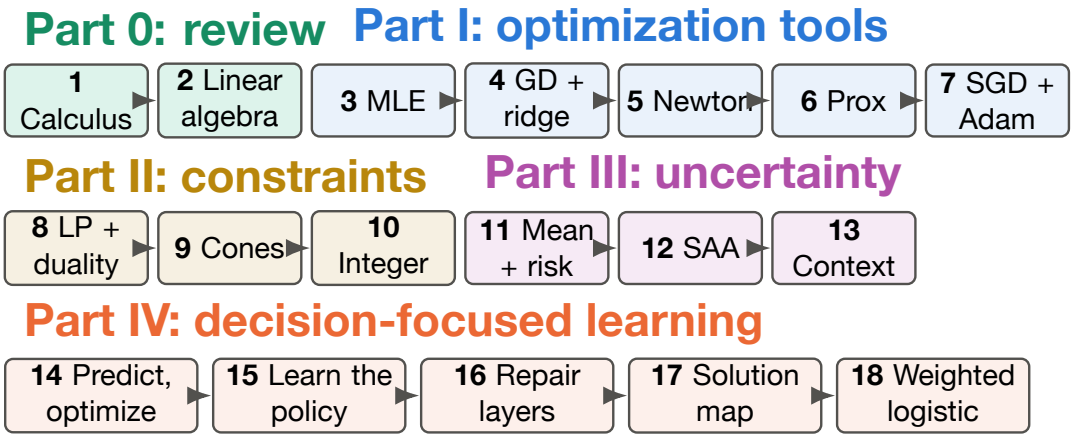


make a decision:
maximize the profit

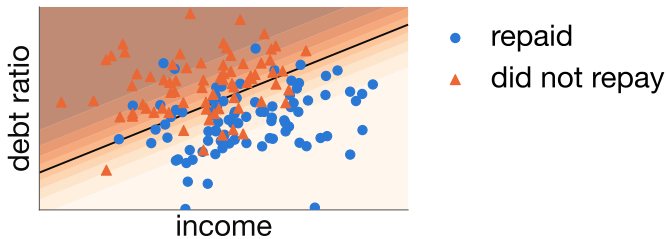
We use optimization to fit models to data.

We also use optimization to make decisions.

Course map


Part 0: review
Part I: optimization tools
1 Calculus
2 Linear algebra
3 MLE
4 GD + ridge
5 Newton
6 Prox
7 SGD + Adam
Part II: constraints
Part III: uncertainty
8 LP + duality
9 Cones
10 Integer
11 Mean + risk
12 SAA
13 Context
Part IV: decision-focused learning
14 Predict, optimize
15 Learn the policy
16 Repair layers
17 Solution map
18 Weighted logistic

Part I: optimization tools



simulated data (Lecture 3)

A bank's model predicts who will not repay a loan.

To fit the model, we solve an optimization problem.

Lecture 4 solves this problem by gradient descent.

Card payments

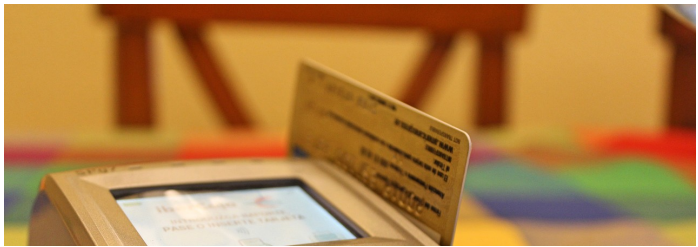


Photo: Mañico, CC0, Wikimedia Commons (cropped)

A bank checks every card payment for fraud.

The fraud model must update after each payment.

Lecture 7 teaches stochastic gradient descent.

Part II: constraints



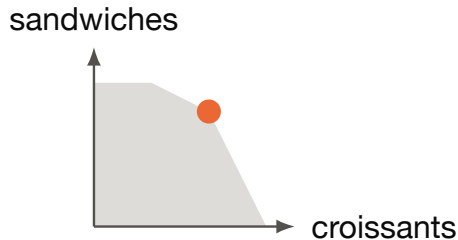


Photo: Jeremy Keith, CC BY 2.0, Wikimedia Commons

A bakery plans how many of each item to bake.

The oven and the staff have only 240 minutes a day.

Lecture 8 finds the plan with the maximum profit.

Plans with many constraints



airline crews



factories



delivery



train timetables

Photos (Wikimedia Commons): Goose Green Photography, CC BY 4.0; Shixart1985, CC BY 2.0; Syced, CC0; Inklein, CC0 (cropped).

Airlines plan crews, and factories plan production.

Each plan must satisfy many constraints.

Lectures 8 to 10 solve problems with constraints.

Part III: uncertainty



Photo: Thomon, CC BY-SA 4.0, Wikimedia Commons

A café orders croissants early in the morning.

The café does not know the demand for that day.

Lecture 11 maximizes the expected profit.

Nurses in an emergency room



Photo (nurses at Hua Hin Hospital, Thailand): Government of Thailand, CC BY 2.0, Wikimedia Commons

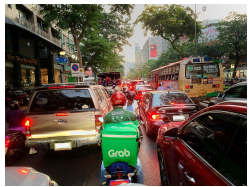
Ban and Rudin (2019), a hospital in the UK

A hospital plans its nurses before patients come.

Lecture 13 uses features such as the time of day.

Features saved 23% to 24% of the usual cost.

Part IV: decision-focused learning



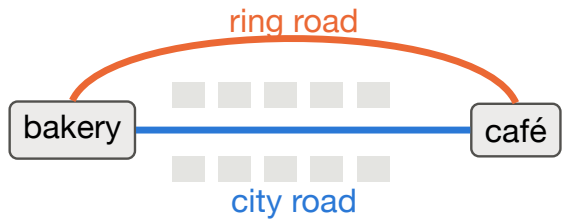


Photo: Chainwit., CC BY-SA 4.0, Wikimedia Commons

A delivery rider predicts how long each road takes.

When does a good prediction give a good decision?

Lectures 14 to 18 fit models for good decisions.

Medicines in Sierra Leone



Photo: Mattes, public domain, Wikimedia Commons (cropped)

Chung et al. (2022)

With decision-focused learning,
unmet demand was 1.3% in a test on past data.
With the existing tool, unmet demand was 15%.