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Course taught with Chase and Tom at PHBS for 2020-2021 school year

Module 2

Runs from November 19 to January 19

We have 18 class periods

Convex Optimization 1 (Th, November 19)

Sources and tools:

- Chapters 1-3 of Stephen Boyd's text.
- scipy.optimize.linprog
- "Labs for Foundations of Applied Mathematics Volume 2" by Jeffrey Humpherys and Tyler J. Jarvis

Topics to be mastered:

- · Convexity of sets and functions
- Linear programming problems
- Standard form of linear programs
- Product mix problem

Transportation problem

Convex Optimization 2 (M, November 23)

Sources and tools:

- Chapters 1-3 of Stephen Boyd's text.
- scipy.optimize.linprog
- CVXpy: https://www.cvxpy.org
- "Labs for Foundations of Applied Mathematics Volume 2" by Jeffrey Humpherys And Tyler J. Jarvis
- Cedric Villani on optimal transport https://www.youtube.com/watch?v=zo46TEp6FB8I (start at minute 28)

Topics to be mastered:

- Optimal transport
- Primal and dual problem
- cvxpy
- · Simplex algorithm

Convex Optimization 3 (Th, November 26)

• Linear programming applications (Finance that Tom + RAs have put together)

Stats 1 (M, November 30)

Topics to be mastered:

- · Population vs samples
- · Direct and inverse problems
 - Simulation
 - Inference
- David Kreps's "Totrep" story
- Bayesian vs Frequentist
 - How a frequentist sees the world
 - · How a Bayesian sees the world
- Maximum likelihood/posterior estimates

Stats 2 (Th, December 3)

Topics to be mastered:

- Frequentist inference
- Frequentist model evaluation
- Regression
- `statsmodels`

Convex Optimization 4 (M, December 7)

Sources and tools:

- · Chapters 4-5 of Stephen Boyd's text.
- CVXpy
- scipy.optimize

Topics to be mastered:

- Quadratic programming
- Nonlinear programming
- Nonlinear regression

Convex Optimization 5 (Th, December 10)

• Examples of quadratic and non-linear programs. See boyd examples from Tom

Stats 3 (M, December 14)

Topics to be mastered:

- · Applications of Bayesian updating to decision making
 - Job search with learning
 - The classic problem that stumped Milton Friedman
 - How Abraham Wald solved Milton Friedman's problem

Multivariate normal and applications

From Tom. QuantEcon notebook

Stats 4 (Th, December 17)

Topics to be mastered:

- Bayesian inference
 - Metropolis-Hastings
 - NUTS
- Bayesian model evaluation
- Using `pymc3` and `pystan`
 - Examples with `pymc3` and `pystan`

Stats 5 (M, December 21)

Topics to be mastered:

- Hierarchical models
- "Funnel of death"

Data visualization 2 (Th, December 24)

Note: This lecture is a slight break from math heavy lectures

Sources and tools:

- · Class notes
- · Chapter 9 of Python for Data Analysis
- https://datascience.quantecon.org/applications/maps.html

Topics to be mastered:

• Interactive web-based visualizations, and dashboards using plotly and altair — As an example of what could be done, see Mike Waugh's webpage

Data Harvesting (M, December 28)

Sources and tools:

- Class notes
- https://scrapy.org/
- https://camelot-py.readthedocs.io/en/master/
- https://www.crummy.com/software/BeautifulSoup/bs4/doc/

Topics to be mastered:

- · Integrating with Web APIs
- Scraping data from websites without an api (scrapy)
- Extracting data from PDFs (camelot)

Finance 1: Portfolio Theory (Th, December 31)

Sources and tools:

https://python.quantecon.org/black_litterman.html

Topics to be mastered:

- · Portfolio theory and its challenges
- The Black Litterman model and its relationship to Bayesian statistics and robust control theory

Data Engineering (M, January 4)

Sources and tools:

- · Class notes
- https://airflow.apache.org/
- https://www.sqlalchemy.org/

Topics to be mastered:

- Basic introduction to databases (using SQLite through sqlalchemy)
- Automation and data pipelines using Apache Airflow
- We will illustrate these tools by creating an automatically updating database on one of a few potential topics. Our choice of topic will depend on class interest.

Case studies, I (Th, January 7)

Sources and tools:

- http://www.tomsargent.com/research/ReadMe_Pub.pdf
- https://datascience.quantecon.org/applications/
- Chapter 14 of Python for Data Analysis
- https://datascience.quantecon.org/applications/recidivism.html

Topics to be mastered:

- Combine the tools learned in this class to generate automatically updated databases and visualizations, covering topics such as
 - Inequality data
 - U.S. bond data and term structure of interest rates; see Hall, Payne, Sargent bond dataset

Dynamic Equilibrium Models, I

Sources and tools:

- https://python.quantecon.org/cattle_cycles.html
- https://python.quantecon.org/rosen_schooling_model.html

Topics to be mastered:

- Cattle Cycles
- The Rosen schooling model

Sharing results and more case studies, II (M, January 11)

Sources and tools:

- pgmpy: https://www.youtube.com/watch?v=DEHqlxX1Kq4
- https://link.springer.com/chapter/10.1007/978-94-011-2410-2_19

Topics to be mastered:

- How to save models
- Automatically updating data
- Dashboard building (streamlit)
- Using Bayes to infer who wrote the Federalist papers?
- Probabilistic graphic models with the Python package ${\tt pgmpy}$
- · From political science: the Law of Cubic Proportions

Student presentation of projects (Th, January 14)

Students present their projects

Wrapping up and looking forward (M, January 18)

Sources and tools:

· Lectures notes on duality between filtering and control

Topics to be mastered:

- Student presentations of class projects
- Useful math and going forward
 - Why "forecasting" and "decision" are related mathematically
 - How this can be exploited