01:220:424/16:220:570: ADVANCED ANALYTICS FOR ECONOMICS

Spring 2023
Rutgers University
Department of Economics

Instructor

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Class Meetings

Lecture: Mondays and Thursdays 10:20-11:40 , MU 204

Office Hour

by appointments

Prerequisite

It is expected that all students will have taken Econometrics (01:220:322); Calculus II (01:640:136 or 152); Computational Research Methods for Research in Economics (01:220:420) and principles of economics courses covering both microeconomics and macroeconomics (e.g. 220:102 and 220:103 or 220:200). Especially, students without a good command of the materials on Econometrics will meet a lot of challenges in assignments and exams.

Final Exam:

May 8 Monday, 8-11am.
The date for the final exam is set and you should not make travel plans or other commitments that interfere with the scheduled exam date.

Make-up exams

The make up exam will be given only in the event of legitimate excuses for missing an exam. "Legitimate excuses" here mean university recognized absences, and often only refer to medical emergency and religious events. You should discuss with me about your legitimate excuses (except for medical emergency) **at least one week ahead of time**. Other excuses such as "attending best friends' weddings" are not acceptable.

Course Overview & Learning Outcomes

This course is meant to introduce students to a number of advanced "machine learning" methods for data analysis in economics and finance, focusing on application of the methods to practical problems in economic forecasts, treatment effects, as well as financial asset pricing. The course will ask students to explore the broader implications for society of the application of these powerful tools.

This course will have two major emphasis: on one hand it will introduce several modern machine learning methodologies for statistical estimations, such as deep learning methods, dimension reductions, and unsupervised learnings. On the other hand, the course will focus on applications of these machine learning tools in economic and financial problems in the modern data-rich environment. The students are anticipated to learn both the machine learning methodologies and their applications to some of the topics that of central concerns in modern economic and financial studies. Specifically, we shall apply the developed methodologies to economic models with the following applications:

- Heterogeneous binary choice models

- High-dimensional selection of economic control variables

- Application of deep neural networks to economic treatment effects

- Boosting as an ensemble learner in instrumental variables regressions

- Portfolio allocation theories and volatility estimations using unsupervised learning

- Tests for market mean-variance efficiency

- Big data forecasts using economic diffusion indices

- Double machine learning inference for economic control variables

Textbook

(HTF) Trevor Hastie, Robert Tibshirani and Jerome Friedman, *The Elements of Statistical Learning: Data Mining, Inference, and Prediction.*, 2nd Edition, Springer.

(HTW) Trevor Hastie, Robert Tibshirani and Martin Wainwright, *Statistical Learning with Sparsity: The Lasso and Generalizatio*, CRC Press

Computings

Examples in class will be coded in Python. Students can also choose their own packages to work on the assignments.

Lecture outline

1. Training Machines and Learning Errors

   Errors in machine learnings

   Model complexity

2. Classification Methods

   Support vector machine

   The Bayes classifier, logistic regression

   Binary choice models

   reading: (HTW ch 3; HTF ch 4)

3. Neural Networks and Deep Learning

   Projection Pursuit Regression

   Neural networks

   Deep Learning

   Convolutional NN

   Computations: Deep learning in TensorFlow

   Economic treatment effect estimations

   reading: (HTF ch11)

4. Boosting

   AdaBoost

   Boosting as an ensemble learner

5. Random Forests

   Regression trees

   Boosting trees

   Bootstrap

   Random Forests

   reading: (HTF ch 10, 15)

6. Unsupervised learning

   Autoencoders

   Principal components analysis

   Factor analysis

   Modern portfolio allocation theories and Volatility estimations

   Tests for mean-variance market efficiency

   Big data forecasts of economic indices and US treasury bonds

   reading: (HTW ch 8)

7. High-dimensional variable selections and forecasts

   Economic control variables

   The lasso

   Double machine learning inference

   reading: (HTF ch 17; HTW ch 9)

Policy on Attendance

Students are required to attend all classes. If you expect to miss a class because of illness or a family emergency, please use the University absence reporting website to indicate the date and reason for your absence **ahead of time**. An email is automatically sent to me.

https://sims.rutgers.edu/ssra/

No need to report absence for excused religious holidays:

http://www.state.nj.us/education/genfo/holidays1718.pdf

Assessment

For undergraduate students, the grading is based on three parts:

Table 1: Grading components for undergraduate students

Items	%
weekly assignment	40%
final exam	60%

Table 2: Grading scale

Items	%
$\geq 90\%$	A
$[80, 90)\%$	B or B+
$[70, 80)\%$	C+ or B
$[60, 70)\%$	C
$< 60\%$	D+ or lower

- **Weekly assignment** is due in a week. I do NOT take late submissions. If due to some personal issues that you cannot make a deadline of the week, communicate with me **before the deadline**, unless the issue was emergent (e.g., accident, unanticipated events).

- We will NOT curve.

- Final exam will be closed book. Students are allowed to bring a 2-sided formula sheet and a calculator to the exams.

For graduate students, the grading is based on three parts:

Table 3: Grading components for graduate students

Items	%
weekly assignment	40%
final exam	40%
term project	20%

- In addition to the weakly assignments and exams, graduate students / students registered via 570 are also required to work on a term project and submit their project-paper by the end of the summer (August 31). Students are required to conduct big data forecasts on either economic or financial datasets. They can either compare the predictability among several introduced machine learning methods on predicting economic/financial indices, or conduct detailed studies of some policy effects using economic data.

- **For those who enroll in Econ 570:** you will receive "IN" grade prior to September 1st. This is because you are required to submit a term paper whose deadline is August 31. I will then grade all papers and give your formal letter grades on September 1st.

Academic Integrity

The university expects all students to adhere to the University Honor Pledge: *I pledge on my honor that I have not given or received any unauthorized assistance on this assignement/examination.*

PLEASE NOTE

Laptops and cell phones may not be used at any time, for any purpose, during exams. Anyone who does not conform to this requirement will be removed from the classroom. Likewise, anyone talking to other members of the class during exams will be removed from the classroom. Anyone removed from the classroom will not be readmitted to the classroom without prior consultation with the instructor and the dean of students."