ECON 509: Numerical Methods in Economics

Spring 2016: Monday/Wednesday/Friday 10:00 - 10:50
Room: 68 (Computer Lab)

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Course Overview

Course Objective: The objective of this course is to familiarize you with the fundamentals of computation, and a set of state-of-the-art methods for both empirical and numerical work. In this course you should learn why we need computational methods for certain types of problems, the theory behind the methods, and most importantly, how to use them in practice. The course begins with the basics of computing, then moves into optimization and methods for dynamic economic models, and finishes with Monte Carlo methods and empirical techniques. The beginning of the course is heavy on theory to understand what is happening inside your machine when solving numerical models. As we begin studying techniques to solve economic problems you will also apply them in practice. This is not a programming course. Beyond the first week we will be solely focusing on numerical methods and not programming tips.

Prerequisites: ECON 500 and ECON 501, or ECON 600 and ECON 601.

Readings: Miranda and Fackler (2002) will be referred to frequently is are recommended. Nocedal and Wright (2006) is also highly useful as a detailed reference for optimization routines. Miranda and Fackler (2002) and Nocedal and Wright (2006) are available as eBooks in the ISU library. The remainder of the readings will be from journal articles or excerpts from texts which will be accessible online.

Grading: 20% of your grade is class participation, 30% of your grade is the final project, and 50% of your grade is the problem sets.

Lab Sessions: We will occasionally hold lab sessions in class to practice the methods we learn. These classes will be located in the department computer lab. In the lab sessions we will be using MATLAB. These environments and packages were selected due to their ease of learning for computing novices, and that many packages exist for these environments to employ the methods we will learn and practice. Much of what we do can be ported to R, Python, Julia, C++ and other popular languages in economics.

Office Hours: By appointment.

Contacting Me: Please put ECON 509 in the subject line of all e-mails and I will respond within 24 hours.

Assignments

1. Problem sets will be due periodically. You must submit your code on blackboard as well as a separate pdf of your output and results. You may work in a group **no larger than three people**. Groups should turn in one assignment with all members' names on the front page of

your submitted pdf. You may use any programming language you wish as long as the code is *clearly commented.*

2. There will be a final project for the course, due at the end of the semester, where each student will submit the beginning of a research paper. In week 9 each student will present a short proposal for the final project to obtain feedback from the class. In week 15 each student will present their completed work which should have a first-take at a numerical model and preliminary results. The paper should be 5-10 pages and should:
    - Clearly state the economic question you are answering and why it is important
    - Have a one page literature review
    - Analytically develop the model
    - Describe how you solve the model
    - Display results

Course Schedule

1 MATLAB Tutorial

2 Introduction to Computation

Theory

Miranda and Fackler (2002, Chapters 1, 2, and 5); Judd (1998, Chapters 2, 3 and 7)

3 Rootfinding and Optimization: Basics and Advanced Methods

Theory

Miranda and Fackler (2002, Chapters 3 and 4); Judd (1998, Chapter 4 and 5); Nocedal and Wright (2006, Chapters 3-6, 18-19)

Golden Search, BFGS, Nelder-Mead, Simulated Annealing, Simplex, Subplex

4 Optimal Control: Theory, Methods, and Applications

Theory

Caputo (2005); Judd (1998, Chapter 10); Trimborn et al. (2008); Brunner and Strulik (2002)

Application

Goulder and Mathai (2000); Lemoine and Rudik (2014)

5 Dynamic Programming: Methods and Applications

Theory

Ljungqvist and Sargent (2004); Adda and Cooper (2003)
Bellman equations, contraction mappings, euler equations

Application

Rudik (2015); Lemoine and Traeger (2014); Traeger (2014); Springborn and Sanchirico (2013); Cai et al. (2015)

6 Final Project Proposals

7 Methods for Accelerating and Improving Approximation in Dynamic Programming

Theory

Smolyak (1963); Judd et al. (2014); Puterman and Shin (1978); Carroll (2006); Malin et al. (2011); Judd et al. (2011a,b, 2015); Winschel and Kratzig (2010); Maliar and Maliar (2015)

8 Maximum Likelihood

9 Markov Chain Monte Carlo

https://www.mathworks.com/help/stats/examples/bayesian-analysis-for-a-logistic-regression-model.html

Theory

Chib and Greenberg (1995, 1996)

Application

Orlik and Veldkamp (2014); Lieli and Springborn (2012); Lemoine, Rosenthal, and Rudik (Learning the Climate Sensitivity)

10 Final Project Presentations

Grade Policy:

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Important dates:

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References

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Brunner, Martin and Holger Strulik (2002) "Solution of perfect foresight saddlepoint problems: A simple method and applications," *Journal of Economic Dynamics and Control*, Vol. 26, No. 5, pp. 737–753.

Cai, Yongyang, Kenneth L Judd, and Thomas S Lontzek (2015) "The Social Cost of Carbon with Economic and Climate Risks," *arXiv preprint arXiv:1504.06909*.

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Chib, Siddhartha and Edward Greenberg (1995) "Understanding the Metropolis-Hastings Algorithm," *The American Statistician*, Vol. 49, No. 4, pp. 327–335.

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Lieli, Robert P. and Michael Springborn (2012) "Closing the Gap between Risk Estimation and Decision-Making: Efficient Management of Trade-Related Invasive Species Risk," *Review of Economics and Statistics*, Vol. 95, No. May, pp. 632–645.

Ljungqvist, Lars and Thomas J Sargent (2004) *Recursive macroeconomic theory*: MIT press.

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Puterman, Martin L. and Moon Chirl Shin (1978) "Modified Policy Iteration Algorithms for Discounted Markov Decision Problems," *Management Science*, Vol. 24, No. 11, pp. pp. 1127–1137.

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Winschel, Viktor and Markus Kratzig (2010) "Solving, Estimating, and Selecting Nonlinear Dynamic Models Without the Curse of Dimensionality," *Econometrica*, Vol. 78, No. 2, pp. 803–821.