PURDUE
KRANNERT
SCHOOL OF MANAGEMENT

Agent-based Computational Economics

Tentative Syllabus for SPRING 2017

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Class Time:	TBA
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Overview

- Agent-based Computational Economics is the computational study of economic processes modeled as dynamic systems of interacting agents who do not necessarily possess perfect rationality and information (definition from Preface to Handbook of Computational Economics Volume 2, editors Leigh Tesfatsion and Kenneth Judd).

- The two main goals of this course are:
    1. To provide a foundation for implementing agent-based simulations in Python.
    2. To use agent-based approach to explain and/or complement findings from human subject experiments.
- The course will have two parts: The first part will provide numerical and simulation tools that are necessary to conduct simulation experiments. The second part will be devoted to applications of these tools in a variety of problems in experimental and computational economics such as the study of learning, repeated games, and market design.

Recommended Text:

Tesfatsion, Leigh, and Kenneth L. Judd, eds. *Handbook of computational economics: agent-based computational economics.* Vol. 2. Elsevier, 2006.

Course Materials:

Slides from class will be posted on blackboard. Other relevant links and information will be posted on the course resources page: http://web.ics.purdue.edu/~yrosokha/comp_econ_2017.html

Course Requirements:

1. Written responses to the readings (10%) [Starting the second week of class]:
By 9pm on the night before class, everyone must submit a brief question or comment about the readings via email. Use the subject line "Econ690 readings for [due date]". Credit will be

based on evidence that you have done the readings carefully. Acceptable responses include (but are not limited to):

- Insightful questions and critiques
- Clarification questions about ambiguities
- Possible extensions or related studies
- Thoughts on the paper's importance
- Summaries of the most important things you learned

2. Class participation (10%):
Students are expected to be present and participate actively in the discussions.

3. Oral presentation/discussion moderation (20%):
Each student will be expected to lead a discussion on one of the readings. The discussion can begin with a brief summary/overview of the important points in the readings, but the assumption is to be that everyone has already completed the readings. The student may either present material related to the readings (perhaps from an outside source) or moderate a class discussion about the readings. In the latter case, the student must be prepared to keep the conversation flowing.

4. Preliminary programming/simulation exercises (5) (20%):
Each student will be required to complete five weekly programming assignments of his/her own choosing. Use the subject line "Econ690 HW[#]". It is recommended that one exercise will be completed in conjunction with the student's oral presentation/discussion/moderation.

Grading criteria for programming assignments:

- 8 - Good job, but there is room for improvement
- 9 - Good analysis, results well presented
- 10 - Excellent, with interesting research issues identified. Doing more than what has been asked.

5. Final project (40%):
A more extensive final project, along with written report, will be due on the last day of class. Students will be expected to agree with the instructor on the topic of the project by about halfway through the module. Please email a copy of your code, your final report, and any relevant data by TBA.

Summary

Final Project	40%
5 Exercises	20%
Class Participation	10%
Written Response to the Readings	10%
Presentation	20%

[Tentative] Schedule:

Week	Class Contents	Readings	Due
Week 1	Overview of Agent-based Computational Economics. Introduction to Python. Monte Carlo Simulations.	1	HW0
	---------- Spring Vacation ----------		
Week 2	Reinforcement Learning. Temporal Difference Methods.	2	HW1
Week 3	Evolutionary Algorithms	3	HW2
Week 4	Quantal Response Equilibrium	4	HW3
Week 5	Networks	5	HW4
Week 6	Repeated Games	6	HW5
Week 7	Selected Topics	7	
Finals Week	**Final Project Due (No Later Than 11.59pm on TBA)**		

[Tentative] Reading List

Week 1. Introduction

A. Agent-based Computational Economics Overview

Read:

- Preface to *Handbook of Computational Economics 2(2006)*. Leigh Tesfatsion and Kenneth Judd.
- Chapter 16. Tesfatsion, Leigh. "Agent-Based Computational Economics: A Constructive Approach to Economic Theory." *Handbook of Computational Economics* 2 (2006): 831–80.
- Chapter 37. Some Fun, Thirty-Five Years Ago. Thomas Schelling. *Handbook of Computational Economics* 2 (2006): 1639–1644.

B. Introduction to Python

Resources:

- Main Website: https://www.python.org/
- Beginner's Guide: https://wiki.python.org/moin/BeginnersGuide
- Download: Anaconda (free Python distribution that includes many packages)
- Install: Jupyter (IDE supporting Python, R, and other programming languages)

C. Monte Carlo Simulations

Read:

- Judd, Kenneth L. Numerical Methods in Economics. MIT Press, 1998. Chapter 8: Monte Carlo and Simulation Methods

D. Zero Intelligence Agents

Read:

- Duffy, John. "Agent-Based Models and Human Subject Experiments." Handbook of Computational Economics 2 (2006): 949–1011. Chapters 19.1 and 19.2
- Gode, Dhananjay K., and Shyam Sunder. "Allocative Efficiency of Markets with Zero-Intelligence Traders: Market as a Partial Substitute for Individual Rationality." Journal of Political Economy, 1993, 119–37.
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More on Experimental-Computational Complementarities

Contini, Bruno, Roberto Leombruni, and Matteo Richiardi. "Exploring a New ExpAce: The Complementarities between Experimental Economics and Agent based Computational Economics." *Journal of Social Complexity* 3, no. 1 (2006). http://laboratoriorevelli.it/_pdf/wp45.pdf.

More on Zero-Intelligence Agents and Market Design

Farmer, J. Doyne, Paolo Patelli, and Ilija I. Zovko. "The Predictive Power of Zero Intelligence in Financial Markets." *Proceedings of the National Academy of Sciences of the United States of America* 102, no. 6 (February 8, 2005): 2254–59. doi:10.1073/pnas.0409157102.

Walia, Vibhu, Andrew Byde, and Dave Cliff. "Evolving Market Design in Zero-Intelligence Trader Markets." In *E-Commerce, 2003. CEC 2003. IEEE International Conference on*, 157–64. IEEE, 2003.

Gode, Dhananjay K., and Shyam Sunder. "What Makes Markets Allocationally Efficient?" *The Quarterly Journal of Economics*, 1997, 603–30.

Week 2. Reinforcement Learning

A. Reinforcement Learning in Economics

Read:

- Duffy, John. "Agent-Based Models and Human Subject Experiments." Handbook of Computational Economics 2 (2006): 949–1011. Chapter 19.3

B. Reinforcement Learning in Computer Science

Read:

- Sutton, Richard S., and Andrew G. Barto. Reinforcement Learning: An Introduction. The MIT Press, 1998. Chapter 3-6.

Could be interesting for discussion:

Arifovic, Jasmina, Richard D. McKelvey, and Svetlana Pevnitskaya. "An Initial Implementation of the Turing Tournament to Learning in Repeated Two-Person Games." *Games and Economic Behavior* 57, no. 1 (2006): 93–122.

Ioannou, Christos A., and Julian Romero. "A Generalized Approach to Belief Learning in Repeated Games." *Games and Economic Behavior* 87 (September 2014): 178–203.

More Experiments on Learning

Arifovic, Jasmina, and John Ledyard. "Scaling up Learning Models in Public Good Games." *Journal of Public Economic Theory* 6, no. 2 (2004): 203–38.

Duffy, J., and N. Feltovich. "Does Observation of Others Affect Learning in Strategic Environments? An Experimental Study." *International Journal of Game Theory* 28, no. 1 (1999): 131–52.

Erev, Ido, and Alvin E. Roth. "Predicting How People Play Games: Reinforcement Learning in Experimental Games with Unique, Mixed Strategy Equilibria." *American Economic Review*, 1998, 848–81.

Feltovich, Nick. "Reinforcement-Based vs. Belief-Based Learning Models in Experimental Asymmetric-Information Games." *Econometrica* 68, no. 3 (May 1, 2000): 605–41.

Week 3. Evolutionary Algorithms

A. Genetic Algorithms

Read:

- Jasmina Arifovic (1994). "Genetic Algorithm Learning and the Cobweb Model." Journal of Economic Dynamics and Control, Special Issue on Computer Science and Economics, 18, no. 1 (January 1994): 3–28. doi:10.1016/0165-1889(94)90067-1.
- Marimon, Ramon, Ellen McGrattan, and Thomas J. Sargent. "Money as a Medium of Exchange in an Economy with Artificially Intelligent Agents." *Journal of Economic Dynamics and Control* 14, no. 2 (1990): 329–73.

Week 4. Computing Equilibria

A. Nash Equilibria

Read:

- Judd, Kenneth L. Numerical Methods in Economics. MIT Press, 1998. Chapter 4.9: Computing Nash Equilibria;

B. QRE

Read:

- McKelvey, Richard D., and Thomas R. Palfrey. "Quantal Response Equilibria for Normal Form Games." Games and Economic Behavior 10, no. 1 (1995): 6–38.

C. Equilibrium Distribution

Read:

- Huggett, Mark. "The Risk-Free Rate in Heterogeneous-Agent Incomplete-Insurance Economies." Journal of Economic Dynamics and Control 17, no. 5–6 (September 1993).

Week 5. Networks

Read:

- Kearns, Michael, Siddharth Suri, and Nick Montfort. "An Experimental Study of the Coloring Problem on Human Subject Networks." Science 313, no. 5788 (2006): 824–27.

More (Computational) Experiments on Networks

Corbae, Dean, and John Duffy. "Experiments with Network Formation." *Games and Economic Behavior* 64, no. 1 (September 2008): 81–120.

Goeree, Jacob K., Arno Riedl, and Aljaz Ule. "In Search of Stars: Network Formation among Heterogeneous Agents." *Games and Economic Behavior* 67, no. 2 (November 2009): 445–66.

Tesfatsion, Leigh. *A Trade Network Game with Endogenous Partner Selection*. Springer, 1997.

Watts, Duncan J., and Steven H. Strogatz. "Collective Dynamics of 'small-World' Networks." *Nature* 393, no. 6684 (June 4, 1998): 440–42.

Week 6. Repeated Games

A. Repeated Prisoner's Dilemma

Read:

- Axelrod, Robert. "The Evolution of Strategies in the Iterated Prisoner's Dilemma." The Dynamics of Norms, 1987, 1–16.
- Miller, John H. "The Coevolution of Automata in the Repeated Prisoner's Dilemma." Journal of Economic Behavior & Organization 29, no. 1 (1996): 87–112.

B. TBD

Week 7. Selected Topics

C. TBD

Read:

- TBD