Syllabus, Fall 2021, for OIDD 319: Advanced Decision Systems: Agents, Games, and Evolution (AGE)

1:45–3:15p.m., Tuesdays and Thursdays. Room: JMHH 270 and online

Canvas:

https://canvas.upenn.edu/courses/1600665

Professor Steven O. Kimbrough, Instructor
Office hours: T & R 10:30–12:00 and by appointment

August 20, 2021

Contents

1 In a nutshell...

OIDD 319, "Agents, Games, and Evolution," is about interdependent decision making, also known as strategic or game-theoretic decision making. The main goal of the course is to survey the topic of strategic decision making and, in doing so, to teach how to do it well by arranging for experiences and reflections on them (i.e., we'll play games in the course). The course has two main foci. The first is strategic decision making "in the wild," as evidenced in war, foreign policy, business, governance, romance, etc. The second is modeling of contexts of strategic interaction. Here our principal tools will be Game Theory and its analytics results, and game simulations. We shall touch lightly on Game Theory, although its essential concepts will be useful throughout the course. We will conduct simulations using Agent-Based Modeling and NetLogo. Prior programming experience is not required. Students will, however, be exposed to agent-based models (ABM) and related AI techniques.

2 Class Description

OPIM 319, "Agents, Games, and Evolution," explores applications and fundamentals of strategic behavior.

The course is about strategic decision making in the sense of game theory. That is, we study decision making situations in which what an agent gets depends upon its decisions as well as decisions made by other agents.

The main goal of the class is:

- To deepen the student's understanding of strategic interactions—games—in the social and economic spheres.

To this end, our objectives are to study and explore:

1. The key concepts and findings of the theory of games (broadly, the study of interdependent decision making, subsuming game theory).

   These will be useful for understanding and analyzing contexts of strategic interaction.

2. Strategic analysis.

   This is the interpretation of circumstances in terms of agents, interests, strategies, and interaction. We will study good examples of strategic analysis and we will undertake exercises in it.

3. Strategy discovery and selection.

   This is about how to play games and play them successfully. We will study this by playing games and by observing computational investigations of games.

4. Institution design.

   This is about choosing rules of play that result in desired outcomes. We will focus on common pool resource problems.

5. Strategic modeling and explanation.

   This is about developing game models that can explain observed phenomena. We focus on problems of cooperation as well as a variety of other phenomena.

The design of the course emphasizes learning about decision making in games by actually playing (making decisions in) games and reflecting upon what ensues. Thus, the new design of the course makes it resemble in many ways the design of the negotiations courses. There, students engage in a series of negotiations and discussions about them. Here, we will engage in a series of games calling for careful strategic decision making, and we will discuss what happened after play is complete. The games we play and discuss will range across a variety of applications, including business applications. Throughout, we will emphasize games that are realistic representations of real world situations, rather than stylized, very abstract games.

The course will continue to include topics that arise throughout the social sciences. The topics include—and we shall study—trust, cooperation, market-related phenomena (including price equilibria and distribution of wealth), norms, conventions, commitment, coalition formation, and negotiation. They also include such applied matters as design of logistics systems, auctions, and markets generally (for example, markets for electric power generation).

In addressing these topics we focus on the practical problem of finding effective strategies for agents in strategic situations (or games). Our method of exploration will be experimental: we review and discuss experiments on the behavior of agents in strategic (or game-theoretic) situations.

Computer programming is neither required nor discouraged for the course. The instructor invites, and will support, projects using NetLogo (as well as other environments). Many of the computational demonstrations and experiments we will examine are available as NetLogo programs (http://ccl.northwestern.edu/netlogo/). Students are not, however, at all required to undertake programming exercises, in NetLogo or in any other environment.

Students completing the course can expect to come away with:

- Substantial experience with decision making in realistic games.
- Solid understanding of what is known and what is not known about the problem of designing procedures for strategic behavior,
- Familiarity with the principal methods, and results of applying those methods, for the modeling of human agents and design of artificial agents in strategic contexts, and
- Deepened appreciation for contexts of strategic interaction.

* * *

Strategic, or game-theoretic, topics arise throughout the social sciences. The topics include—and we shall study—trust, cooperation, market-related phenomena (including price equilibria and distribution of wealth), norms, conventions, commitment, coalition formation, and negotiation. They also include such applied matters as design of logistics systems, auctions, and markets generally (for example, markets for electric power generation).

In addressing these topics we focus on the practical problem of finding effective strategies for agents in strategic situations (or games). Our method of exploration will be experimental: we review and discuss experiments on the behavior of agents in strategic (or game-theoretic) situations.

In focusing on the design and behavior of artificial agents in strategic (or game-theoretic) situations, we will be especially concerned with strategic contexts of commercial import, such as markets, bargaining, and repeated play. We shall dwell on effective agent learning techniques, including evolutionary methods and reinforcement learning. A main theme in the course is the inherent difficulty, even unknowability, of the problem of strategy acquisition.

We will rely mainly on computational experiments (or simulations), in distinction to analytic mathematical methods, for studying strategy formation and strategic behavior (either by individuals or by groups). Much of the class work will be devoted to discussing and interpreting computational experiments that have been reported in the literature, or that can be undertaken

with tools provided in class. In doing so, we draw upon the rapidly growing literature in agent-based modeling and agent-based simulation. Agent-Based Computational Economics (for example, `http://www.econ.iastate.edu/tesfatsi/ace.htm`) and other terms have come to denote active communities of research and application. We shall draw upon them.

Computer programming is neither required nor discouraged for the course. The instructor invites, and will support, projects using NetLogo (as well as other environments). Many of the computational demonstrations and experiments we will examine are available as NetLogo programs (`http://ccl.northwestern.edu/netlogo/`). Students are not, however, at all required to undertake programming exercises, in NetLogo or in any other environment.

3 Required Texts and Materials

There is nothing necessary to purchase. Our main texts will be:

- *Agents, Games, and Evolution,* by Steven Orla Kimbrough, (Kimbrough, 2012). ISBN-13: 9781439834701, ISBN-10: 1439834709

  This should be available as an ebook on Canvas via the library.

  See `https://github.com/stevenokimbrough/AGE/` *errata1.zip* for fixes to earlier printings of the book.

- NetLogo. Software tool for agent-based modeling. Available at `https://ccl.northwestern.edu/netlogo/`.

- Teaching notes for most classes will be posted on Canvas. These notes are required or suggested readings, as indicated. "Instructor handout" in the syllabus normally refers to material that appears in these notes.

In addition, various other readings will be assigned. These will generally be handed out or made available online. Including excerpts from *The Evolution of Cooperation,* by Robert Axelrod, (Axelrod, 1984), *Growing Artificial Societies,* Joshua Epstein and Robert Axtell, (Epstein and Axtell, 1996) and *Decision Games* by Clark and Kimbrough.

Other readings and handouts will be freely available on Canvas.

4 Class Schedule

4.1 Module I: Starters. Introduction and overview of the course

Interdependent decision making and strategic interaction: how we study it and use it.

Read: "Contexts of Strategic Interaction," (Kimbrough, 2012, chapter 1).

4.2 Canonical games

- Read: "The Lady, or the Tiger?" by Frank Stockton http://www.gutenberg.org/ebooks/396
- Examples of standard games. Handout and exercise. How would you play?
- Strategic (normal) form games. Nash equilibrium. Pareto optimality. Conditions of play: one-shot, anonymous, payoffs, utility, etc.

4.3 A Brief on Orthodox Game Theory, 1

- Instructor handout.
- Required reading (Kimbrough, 2012, Appendix A; B.3).
- Recommended reading: Ross, Don, "Game Theory", *The Stanford Encyclopedia of Philosophy (Spring 2006 Edition),* Edward N. Zalta (ed.), URL = http://plato.stanford.edu/archives/spr2006/entries/game-theory/.

4.4 A Brief on Orthodox Game Theory, 2

- See previous class for materials.

4.5 Strategy and the American Civil War: Antebellum and Overview

- View (before class): Civil War Animated Map: https://www.battlefields.org/learn/maps/civil-war-animated-map, as background reading.

  This is problematic in many ways, but worth the 27 minutes for an overview of the event highlights.
- Fort Sumter: https://www.battlefields.org/learn/civil-war/battles/fort-sumter
- Battle of Shiloh Animated Map: https://www.battlefields.org/learn/civil-war/battles/shiloh
- Instructor handout.

4.6 Gettysburg

- View before class: Gettysburg Animated Map https://www.battlefields.org/learn/civil-war/battles/gettysburg
- Instructor handout.

4.7 Vicksburg

- View before class: Vicksburg Animated Map https://www.battlefields.org/learn/civil-war/battles/vicksburg.

  A little hokey, but ok for starters, before the class.

- Instructor handout.

4.8 Statecraft and Military Strategy

- Recommended: *The Grand Design: Strategy and the Civil War* Stoker (2010), available as an ebook in the Penn libraries.

- Ancillary recommendations: *The Grand Strategy of the Byzantine Empire* by Edward N. Luttwak, Harvard University Press, Cambridge, MA, 2009. Sears, S. W. (1988). George B. McClellan: The Young Napoleon. Ticknor & Fields.

4.9 Culture and Evolution

- Assigned: The Civil War (1861-1865): A History Podcast. (2021). https://civilwarpodcast.org/

  The charge of the 1st Minnesota on July 2 at Gettysburg. Episode 356, that is https://civilwarpodcast.libsyn.com/356-battle-of-gettysburg-part-the-forty- From 13:50 to 23:19. On Apple podcasts: https://podcasts.apple.com/us/podcast/356-battle-of-gettysburg-part-the-forty-second/.

- Assigned: The Civil War (1861-1865): A History Podcast. (2021). https://civilwarpodcast.org/

  The colors. Willingness to die. Why did they fight? "Gone for a Soldier" http://www.civilwarpodcast.org Episode 51, that is http://civilwarpodcast.org/2013/11/24/civil-war-podcast-episode-51/. Has much about colors too.

- Recommended: McPherson, J. M. (1994). What They Fought For 1861—1865. Louisiana State University Press.

- Recommended: Ezra KleinShow podcast https://www.nytimes.com/2021/07/20/opinion/ezra-klein-podcast-annie-murphy-paul.html

  "Our Workplaces Think We're Computers. We're Not." July 20, 2021.

  https://podcasts.apple.com/us/podcast/our-workplaces-think-were-computers-w id1548604447?i=1000529445434

- Recommended: Waring, T. M., & Wood, Z. T. (2021). Long-term gene–culture coevolution and the human evolutionary transition. Proceedings of the Royal Society B: Biological Sciences, 288(1952), 20210538. https://doi.org/10.1098/rspb.2021.0538

4.10 Module II: Cooperation.The Problems of Cooperation, 1

Read: "The Tragedy of the Commons," by Garrett Hardin (Hardin, 1968) (File: `hardin-tragedy-commons.pdf`) and "Cues of Being Watched Enhance Cooperation in a Real-World Setting" (Bateson et al., 2006). File on Canvas: *Biology Letters 2006 Bateson.pdf.*

4.11 Cooperation, 2: Axelrod's Tournaments

- Read: (Axelrod, 1984, chapers 1–2), available at Course Materials@Penn Libraries via Canvas.
- Recommended: (Axelrod, 1984, chapers 1–3 and appendix B).
- Recommended: (Axelrod and Hamilton, 1981) (posted on Canvas as Axelrod-Hamilton-Science-1981-1685895.pdf).

4.12 Cooperation, 3

- Read: (Axelrod, 1984, chapters 1–2), available at Course Materials@Penn Libraries via Canvas.
- Recommended: (Axelrod, 1984, chapters 1–3 and appendix B).
- Recommended: (Axelrod and Hamilton, 1981) (posted on Canvas as Axelrod-Hamilton-Science-1981-1685895.pdf).

4.13 Tournaments and RPS

Rock, Paper, Scissors game. Discuss the chapter from *Decision Games*, posted on Canvas as DecisionGamesMaster-RPS.pdf.

Read: (Kimbrough, 2012, Chapter 3), Read: (Axelrod, 1984, chapers 4–6)

4.14 Framing

Lecture from slides.

4.15 Affording Cooperation and Dual Inheritance Theory

"Affording Cooperation," (Kimbrough, 2012, Chapter 7)

Reading: (Hirsch, 1976, Chapters 1 and 2). File *Fred Hirsch - selections for FRG.pdf* on Canvas.

Recommended reading: (Ostrom et al., 1994, Chapters 1 and 2).

4.16 Module III: Simulation tools. ABM, 1

NetLogo. Instructor handouts.

Read: *Growing Artificial Societies: Social Science from the Bottom Up,* by Joshua Epstein and Robert Axtell, MIT Press, 1996, (Epstein and Axtell, 1996, Chapters 1-2-3).

4.17 ABM, 2

NetLogo. Instructor handouts.

4.18 ABM, 3

NetLogo. Instructor handouts.

4.19 ABM, 4

NetLogo. Instructor handouts.

4.20 Spatial and Evolutionary Models

Fairness and ultimatum games; commitment; reciprocity.

Read: (Kimbrough, 2012, chapter 4).

Read: Brian Skyrms, *Evolution of the Social Contract,* (Skyrms, 1996) chapters 1-2 ("Sex and Justice," pp. 1-21; "Commitment," pp. 22-44), Cambridge University Press, 1996. Posted on Canvas as `skyrms-evo-soc-contract-1and2.pdf`.

4.21 Trust, and the Stag Hunt

Read: Brian Skyrms, *The Stag Hunt and the Evolution of Social Structure,* (Skyrms, 2004) "Preface" (pp. xi-xiv) and chapter 1, "The Stag Hunt" (pp. 1-14), Cambridge University Press, 2004. (File: `Skyrms-StagHunt-Pref-Ch1.pdf`.).

4.22 The Stag Hunt

Read: "The Stag Hunt," (Kimbrough, 2012, Chapter 5) and Brian Skyrms, Skyrms (2004, pages 45–7)"Part II, Signals" in *The Stag Hunt and the Evolution of Social Structure*, file skyrms-staghunt-quorum.pdf on Canvas.

4.23 Module IV: Applications. Redistricting

Instructor handout.

4.24 Voting Systems

Instructor handout.

4.25 Markets: Competitive

Read: "Competitive Markets" (Kimbrough, 2012, chapter 8) and "Zero-Intelligence Agents," Gode and Sunder (1993) (file: `gode-sunder-1993.pdf` on Canvas).

Recommended reading: Gode and Sunder (1997) (file: `gode-sunder-1997.pdf` on Canvas).

4.26 Markets: Monopolies, Oligopolies

1. The Beer Game
2. Markets: Monopolies, Oligopolies.

   Read: "Monopoly Stories" (Kimbrough, 2012, chapter 9), "Oligopoly: Cournot Competition" and "Oligopoly: Bertrand Competition," (Kimbrough, 2012, chapters 10–11).

   Recommended skim: "Supply Curve Bidding," (Kimbrough, 2012, chapter 12).

4.27 Games, evolution and evolutionary algorithms

Read: (Kimbrough, 2012, chapter 18); (strongly recommended:) Darwin, concluding chapter of *The Origin of Species* Darwin-Origin-Chapt14-1st-ed.pdf on Canvas, online at `http://www.literature.org/authors/darwin-charles/the-origin-of-species/chapter-14.html`.

Briefly on ANNs (artificial neural networks).

Recommended: Excerpt from *Blondie24*, file `B-49127 Blondie 24.pdf`, on Canvas (Fogel, 2002); "Evolutionary Models," (Kimbrough, 2012, chapter 18).

4.28 Strategic Analysis and Summing Up

Read: Kennan, "The Sources of Soviet Conduct" on Canvas (X, 1947), file: *KennanSourcesOfSovietConduct.pdf* posted on Canvas. View: 1988 PBS interview; transcript: *KennanDec211988part1ofinterivew.rtf* posted on Canvas.

Summing up and looking forward.

Read: "Summing up," (Kimbrough, 2012, chapter 20).

5 Grades and Conduct of Class

Grading will be based on several components, roughly as follows.

20% Class participation (including attendance, in-class exercises). There will be many in-class exercises, lightly graded, but they count.

80% Four module homework assignments, 20% each

Most of all, I want to see you engaged and involved in the class. I'll prepare lectures for the classes, but much prefer to conduct class with lots of interactive, give and take, and discussion.

Also: I like jazz and will improvise during the semester. The syllabus may well (will likely) change as we go along. I'll let you know when it does and the quiz dates will *not* be changed.

Two further items/requirements:

- Every student should come chat with me at least once during (online) office hours. If my posted hours conflict with your schedule, let me know and we'll make arrangements. Also, you need not come alone. It's fine to come with a group of up to four.
- You will occasionally need your laptop in class. I'll let you know ahead of time. However, during lectures and similar periods when we are not actively using them, use of laptops, PDAs, etc. are forbidden.

6 Computer Access for Non-Wharton Students

Here is the link you should include with your announcements and instructions on future syllabi.

This link works:
`https://whartonstudentsupport.zendesk.com/hc/en-us/articles/203165417-Create-Yo`

In plain text:
https://whartonstudentsupport.zendesk.com/hc/en-us/articles/203165417-Create-Your-Wharton-Account

*Wharton Class Accounts are needed so that when students try to login into the computers in the labs with their PennKey these PennKey link to active Wharton Class accounts. These class accounts also are needed if students intend to use the public printers.

*I have confirmed Study.net materials are all PennKey authentication now.

Also (for non-Wharton students): After you follow the link above and create a Wharton Class Account, you will then log in to the computers with your PennKey account. (But wait an hour the first time you try this.)

7 Calendar, fall 2021

Last class is on Thursday, December 9, 2021.

	0	1	2
0	—	R: 2021-09-30	T: 2021-11-09
1	T: 2021-08-31	T: 2021-10-05	R: 2021-11-11
2	R: 2021-09-02	R: 2021-10-07	T: 2021-11-16
3	T: 2021-09-07	T: 2021-10-12	R: 2021-11-18
4	R: 2021-09-09	T: 2021-10-19	T: 2021-11-23
5	T: 2021-09-14	R: 2021-10-21	T: 2021-11-30
6	R: 2021-09-16	T: 2021-10-26	R: 2021-12-02
7	T: 2021-09-21	R: 2021-10-28	T: 2021-12-07
8	R: 2021-09-23	T: 2021-11-02	R: 2021-12-09
9	T: 2021-09-28	R: 2021-11-04	—

Table 1: Class number :: date correlation, for Tuesday (T) and Thursday (R) classes, fall 2021. Penn academic calendar `https://almanac.upenn.edu/penn-academic-calendar`

References

Axelrod, R. (1984). *The Evolution of Cooperation*. Basic Books, Inc., New York, NY.

Axelrod, R. and Hamilton, W. (1981). The evolution of cooperation. *Science*, 211:1390–1396.

Bateson, M., Nettle, D., and Roberts, G. (2006). Cues of being watched enhance cooperation in a real-world setting. *Biology Letters*, 2:412–414. doi: 10.1098/rsbl.2006.0509 and `http://rsbl.royalsocietypublishing.org/content/2/3/412`.

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Hardin, G. (1968). The tragedy of the commons. *Science*, 162(3859):1243–1248.

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Skyrms, B. (1996). *Evolution of the Social Contract*. Cambridge University Press, Cambridge, UK.

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Stoker, D. (2010). *The Grand Design: Strategy and the U.S. Civil War*. Oxford University Press, New York.

X (1947). The sources of soviet conduct. *Foreign Affairs*, 25(4):566–582. Author: George F. Kennan.