

Teoria dos Jogos em Computação

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1/2025

Agenda

- What is game theory?
- Computer Science applications
- Course program
- Grading
- References
- Goals

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- **What is game theory?**
- Computer Science applications
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Before we start...

- This course is not about...



Before we start...

- This course is about modeling

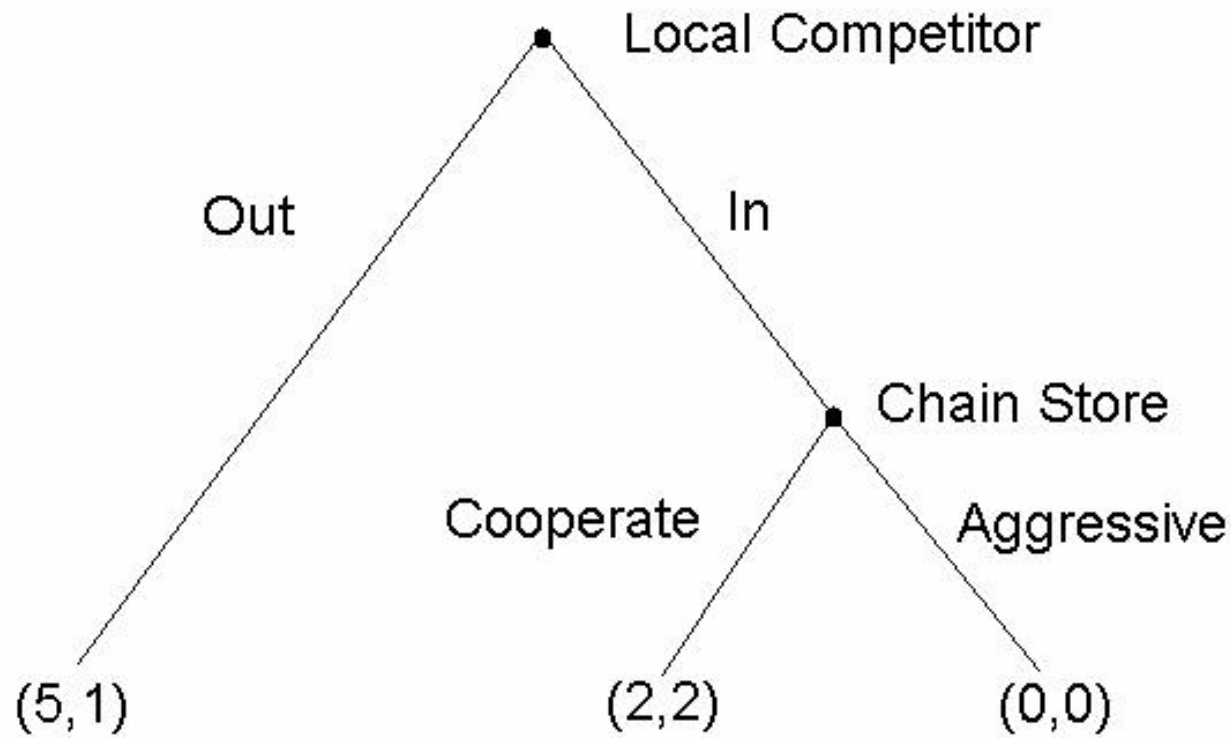


Before we start...

- This course is about modeling
 - Should a local competitor open a store next to a chain store?

Before we start...

- This course is about modeling



What is game theory?

- Game theory studies settings where multiple players (agents) each have
 - different preferences (utility functions)
 - different actions that they can take

What is game theory?

- Let's play a game...
 - Each student should write a number between 0 and 100 on a paper
 - The student who gets closer to the average wins

What is game theory?

- Let's play another game...
 - Each student should write a number between 0 and 100 on a paper
 - The student who gets closer to **half** the average wins

What is game theory?

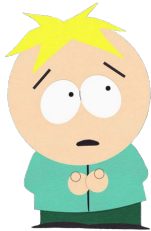
- Let's play another game...
 - Each student should write a number between 0 and 100 on a paper.
 - The student who gets closer to **half** the average wins
- What is the solution of this game?

What is game theory?

- Let's play a final game...
 - Each student should write a number between 0 and 100 on a paper
 - Two winners
 - The student who gets closer to **half** the average
 - The student who gets closer to the amplitude (biggest difference)

What is game theory?

- Three kids must choose a cell phone



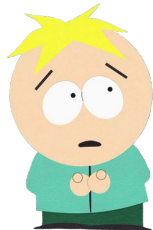
What is game theory?

- Who are the players?



What is game theory?

- What are their strategies?



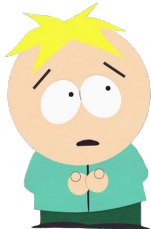
What is game theory?

- What are the possible outcomes?



What is game theory?

- The action of an agent can influence the strategy of another?



What is game theory?

- What are the possible payoffs for each agent?



What is game theory?

- Each agent's utility (potentially) depends on all agents' actions
- What is optimal for one agent depends on what other agents do

What is game theory?

- Each agent's utility (potentially) depends on all agents' actions
- What is optimal for one agent depends on what other agents do
 - Very circular!

I will buy what
Cartman buys!



I won't buy what
Butters buys!

What is game theory?

- Game theory studies how agents can rationally form beliefs over what other agents will do, and (hence) how agents should act

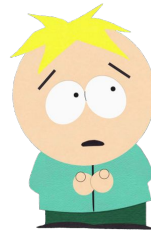
What is game theory?

- Game theory studies how agents can rationally form beliefs over what other agents will do, and (hence) how agents should act
 - Useful for acting as well as predicting behavior of others

Butters don't have
money
to buy an iPhone!
That's the one I'll get it!

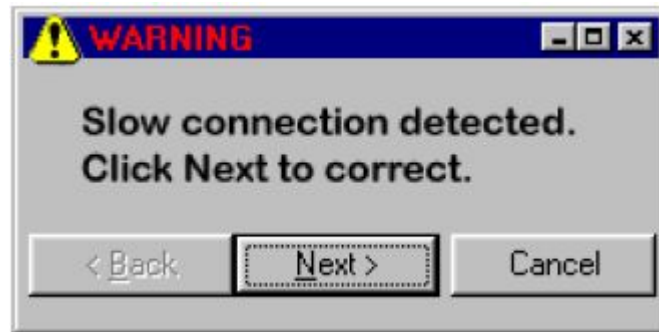


Cartman is a show-off!
If I use my college
funds,
I can buy an iPhone!



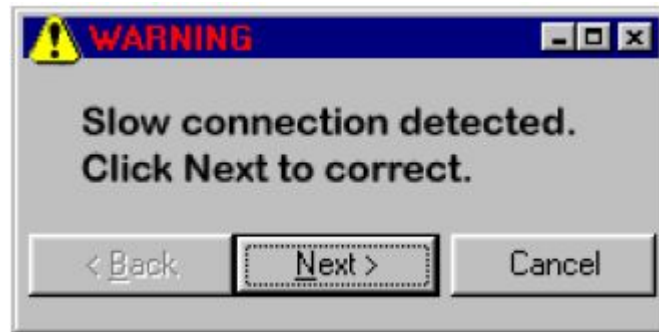
What is game theory?

- TCP Backoff game



What is game theory?

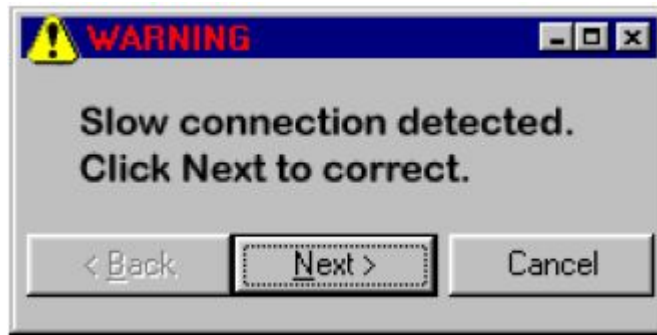
- TCP Backoff game



- **Question:** Should you send your packets using correctly-implemented TCP (which has a “backoff” mechanism) or using a defective implementation (which doesn’t)?

What is game theory?

- TCP Backoff game



- This problem is an example of what we call a two-player game:
 - both use a correct implementation: both get 1 ms delay
 - one correct, one defective: 4 ms for correct, 0 ms for defective
 - both defective: both get a 3 ms delay.

What is game theory?

- TCP Backoff game
 - What action should a player of the game take?
 - Would all users behave the same in this scenario?
 - What global behavior patterns should a system designer expect?
 - For what changes to the numbers would behavior be the same?
 - What effect would communication have?
 - Repetitions? (finite? infinite?)
 - Does it matter if I believe that my opponent is rational?

On the media



CRASH

Teoria dos Jogos: a arma mais letal contra a máfia das empreiteiras

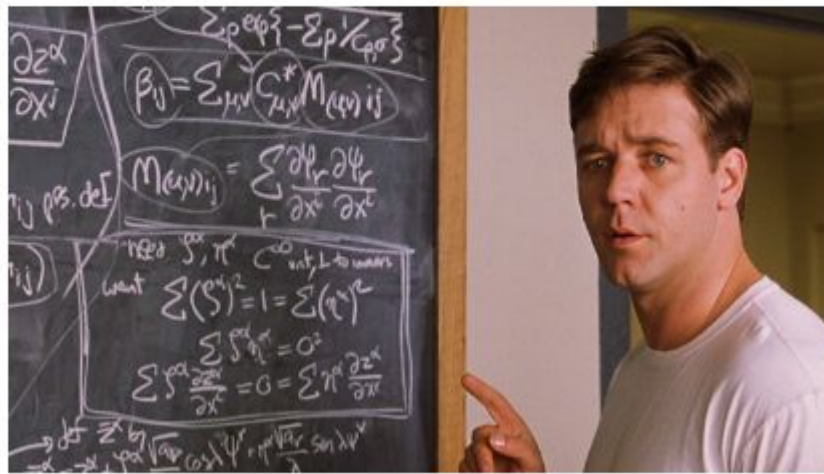
POR Alexandre Versignassi | ATUALIZADO EM 21/06/2016

Compartilhar 10 mil

Twostar

27

COMENTAR (110)



On the media

The Economist[World politics](#)[Business & finance](#)[Economics](#)[Science & technology](#)[Culture](#)

Free exchange

Economics




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From the archives

Nash's Nobel prize

May 24th 2015, 17:37 BY THE ECONOMIST | LONDON

  10K

Our coverage on the award of the Nobel prize for economics to John Nash in 1994



On the media



FOREIGN AFFAIRS THE GAME THEORY OF TERRORISM PEDRO OLMO STANCIO
Jacob Olidort

SNAPSHOT December 10, 2015 Terrorism & Counterterrorism

The Game Theory of Terrorism

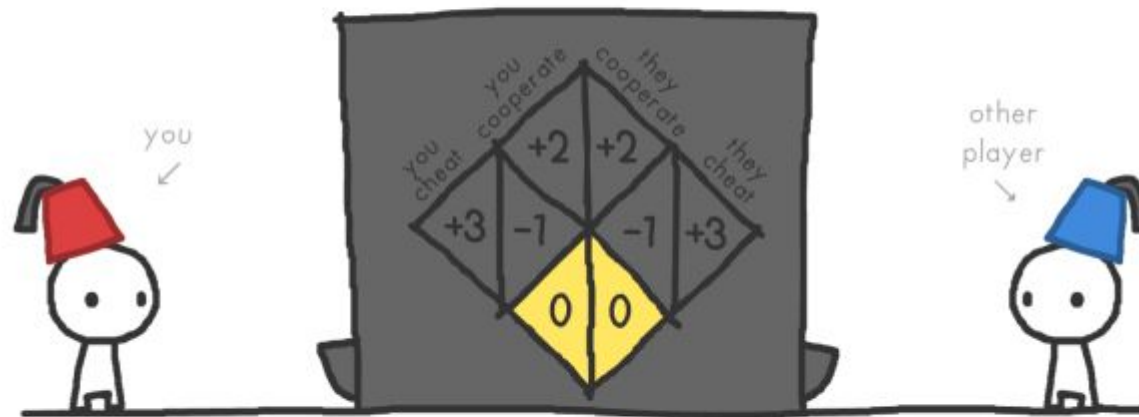
How ISIS Radicalizes Others

By Jacob Olidort

On the media

- The evolution of trust
 - <http://ncase.me/trust/>

Now, let's play for real. You'll be playing against 5 different opponents, each with their own game "strategy". With each opponent, you'll play anywhere between 3 to 7 rounds. (You won't know in advance when the last round is) Can you trust them? Or rather... can they trust *you*?



Pick your first, *real* move. Choose wisely.

On the media



Using math

• 36

Nicky Case makes games that might just teach you something. There are topics ranging from **voting** to **coming out** to **two-dimensional matrices**.

This most recent game hits pretty hard right now, when the world seems bad and people in it seem bad.

On the media



**Bloomberg
View**

Markets

Tech

Pursuits

Politics

Opinion

Businessweek

OPINION | [OIL](#)

OPEC's Game-Theory Dilemma

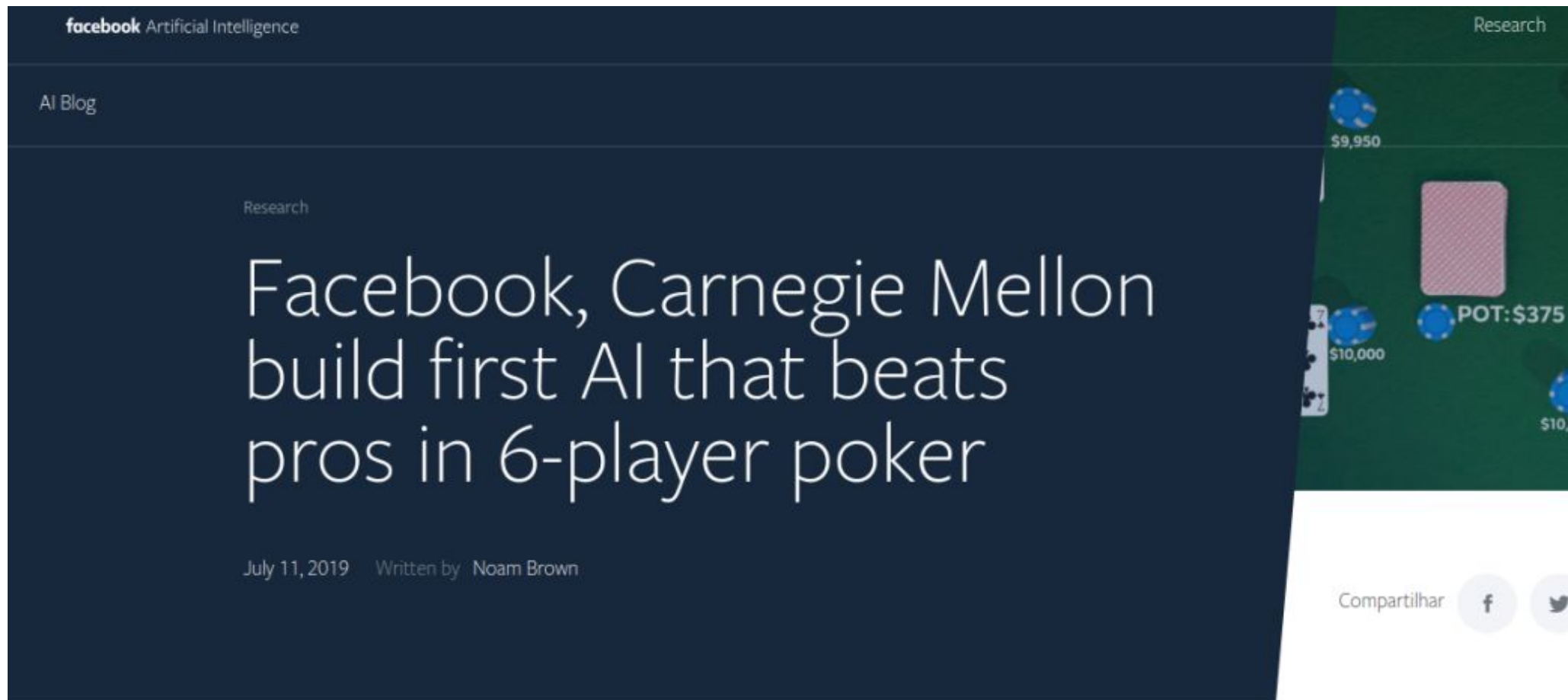


Cartel members are being pushed to seek ever-broader coalitions to secure an orderly influence on oil prices.

By [Mohamed A. El-Erian](#)

2 de agosto de 2017 02:30 BRT

On the media



<https://www.technologyreview.com/lists/innovators-under-35/2017/inventor/ian-goodfellow/>

On the media

` Ian Goodfellow, 31

Google Brain Team

Invented a way for neural networks to get better by working together.

A few years ago, after some heated debate in a Montreal pub, Ian Goodfellow dreamed up one of the most intriguing ideas in artificial intelligence. By applying game theory, he devised a way for a machine-learning system to effectively teach itself about how the world works. This ability could help make computers smarter by sidestepping the need to feed them painstakingly labeled training data.

On the media

MIT Technology Review



PIXABAY

Prisoner's dilemma shows exploitation is a basic property of human society

A new analysis of the famous game-theory puzzle finds that even when the players seem equal, one can learn to profit at the other's expense—and the victim will cooperate.

by Emerging Technology from the arXiv May 30, 2019

https://www.technologyreview.com/s/613585/prisoners-dilemma-shows-how-exploitation-is-a-basic-property-of-human-society/amp/?_twitter_impression=true

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Where is game theory used?

- Economics (& business)
 - Auctions, exchanges, price/quantity setting by firms, bargaining, funding public goods, ...
- Political science
 - Voting, candidate positioning, ...
- Biology
 - Stable proportions of species, sexes, behaviors, ...
- Philosophy
 - Conventions, ethics, ...

And in Computer Science?

- Artificial Intelligence

- Beat the Cheater: Computing Game-Theoretic Strategies for When to Kick a Gambler out of a Casino, AAI'14
- Towards a game theoretic approach for defending against crime diffusion, AAMAS'14
- On influence, stable behavior, and the most influential individuals in networks: A game-theoretic approach, Elsevier Artificial Intelligence, 2014

And in Computer Science?

- Computer Networks

- Game-Theoretic Topology Control for Opportunistic Localization in Sparse Underwater Sensor Networks, IEEE Trans. On Mobile Comp., 2014
- Selfish behavior and stability of the internet:: a game-theoretic analysis of TCP, Sigcomm'02
- Topology Design of Communication Networks: A Game-Theoretic Perspective, IEEE/ACM Trans. On Networking

And in Computer Science?

- Security
 - Game-Theoretic Analysis of DDoS Attacks Against Bitcoin Mining Pools, Financial Cryptography and Data Security, 2014
 - A Cryptographic Solution to a Game Theoretic Problem, Advances in Cryptology, 2014
 - RRE: A Game-Theoretic Intrusion Response and Recovery Engine, IEEE Transactions on Parallel and Distributed Systems, 2013

And in Computer Science?

- Complex networks and Web
 - Centrality and power in social networks: a game theoretic approach, Mathematical Social Sciences, 2003
 - Price Competition in Online Combinatorial Markets, WWW'14
 - Modeling collaboration in academia: a game theoretic approach, WWW'14 Companion

And in Computer Science?

- Data Mining and Big Data
 - Large human communication networks: patterns and a utility-driven generator, KDD'09
 - A Game Theoretic Framework for Analyzing Re-Identification Risk, Plos One, 2015
 - Game-Theoretic Strategy Analysis for Data Reliability Management in Cloud Storage Systems, Software Security and Reliability (SEME'14)

And in Computer Science?

- Robotics

- Game theoretic controller synthesis for multi-robot motion planning Part I: Trajectory based algorithms, IEEE International Conference on Robotics and Automation (ICRA'14)

- Computer Vision

- A Game-Theoretic Probabilistic Approach for Detecting Conversational Groups, ACCV'14

And in Computer Science?

- Information Retrieval
 - Towards a Game-Theoretic Framework for Information Retrieval, SIGIR'15
- Distributed Computing
 - Distributed computing meets game theory: robust mechanisms for rational secret sharing and multiparty computation, PODC '06
- Machine Learning
 - Goodfellow, Ian, et al. "Generative adversarial nets." Advances in neural information processing systems. 2014.

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Rationality



Decision and Utility Theory



Games



Types of games

Zero-sum games



coordination games

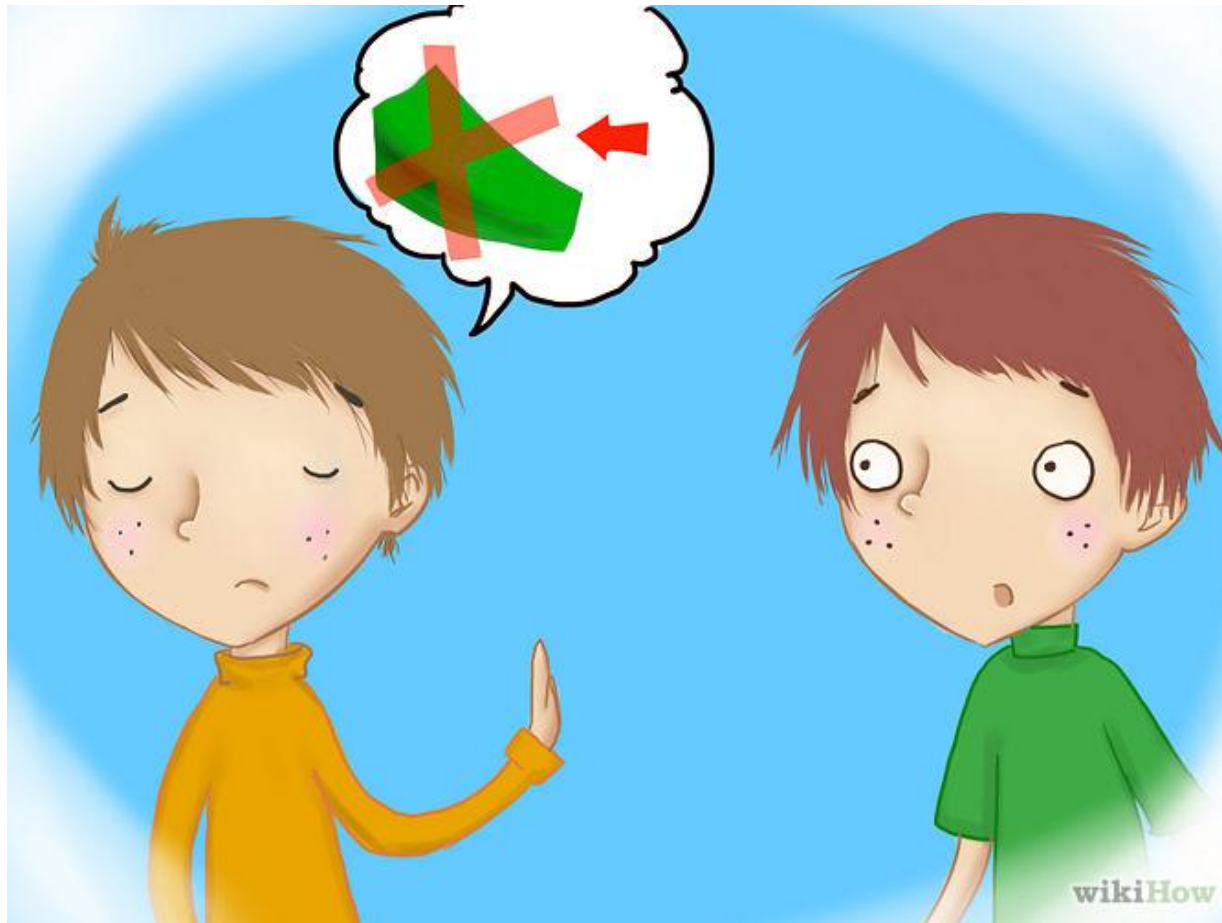
Game Solutions

- Should Grace celebrate her 91st birthday by jumping out of a plane strapped to this guy?



Repeated games

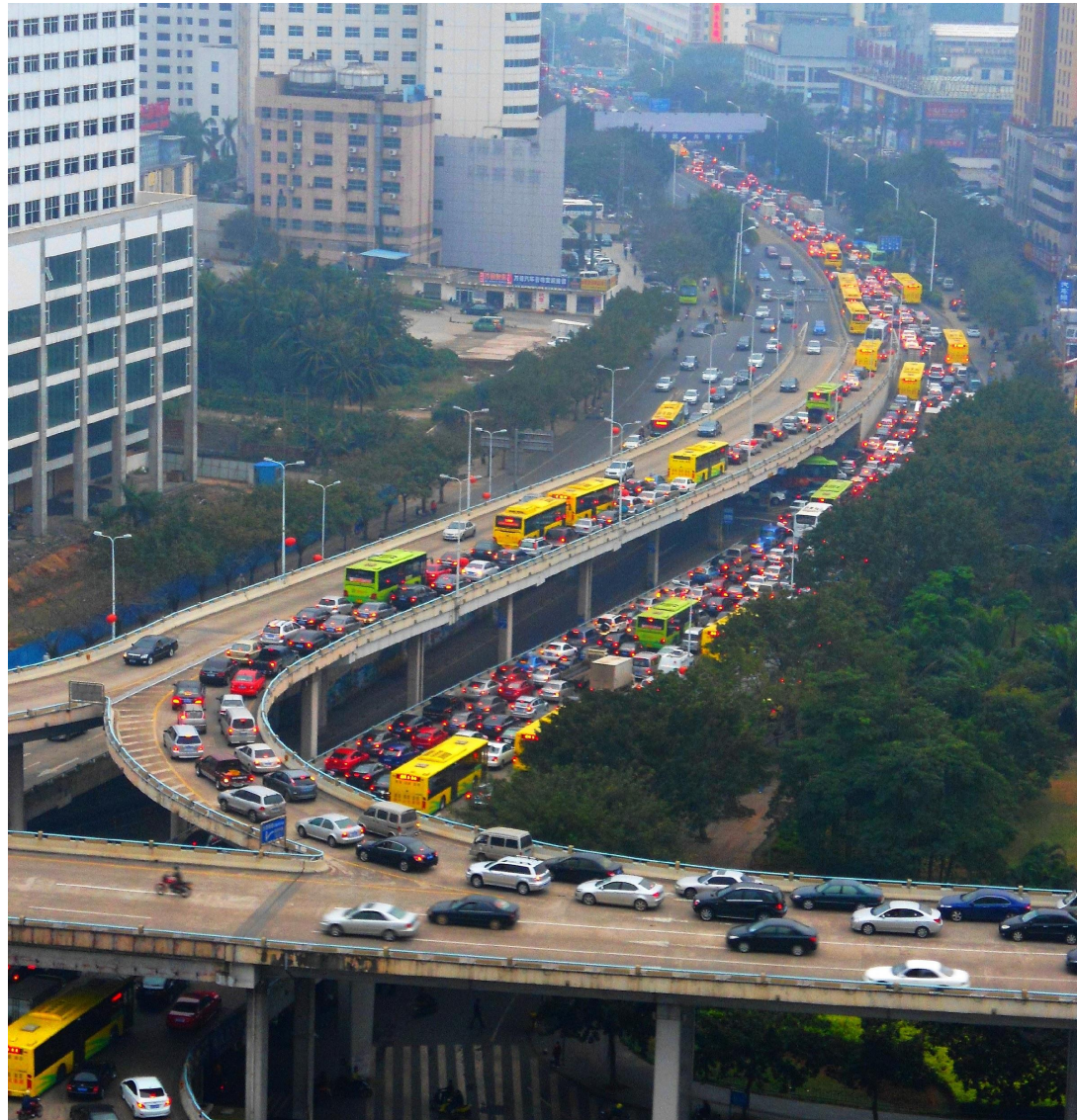
- Should AI lend some money to Bob?



Bayesian and imperfect information games

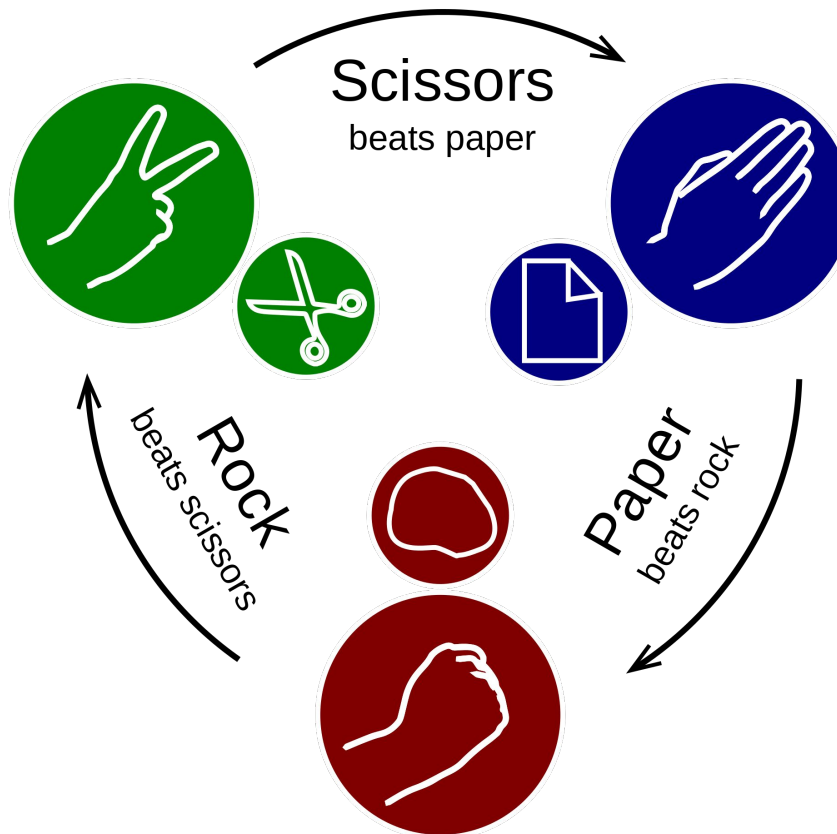


Congestion games



Learning and Teaching in games

- Can I design an algorithm to perform better than random in PRS?



Coalitional games



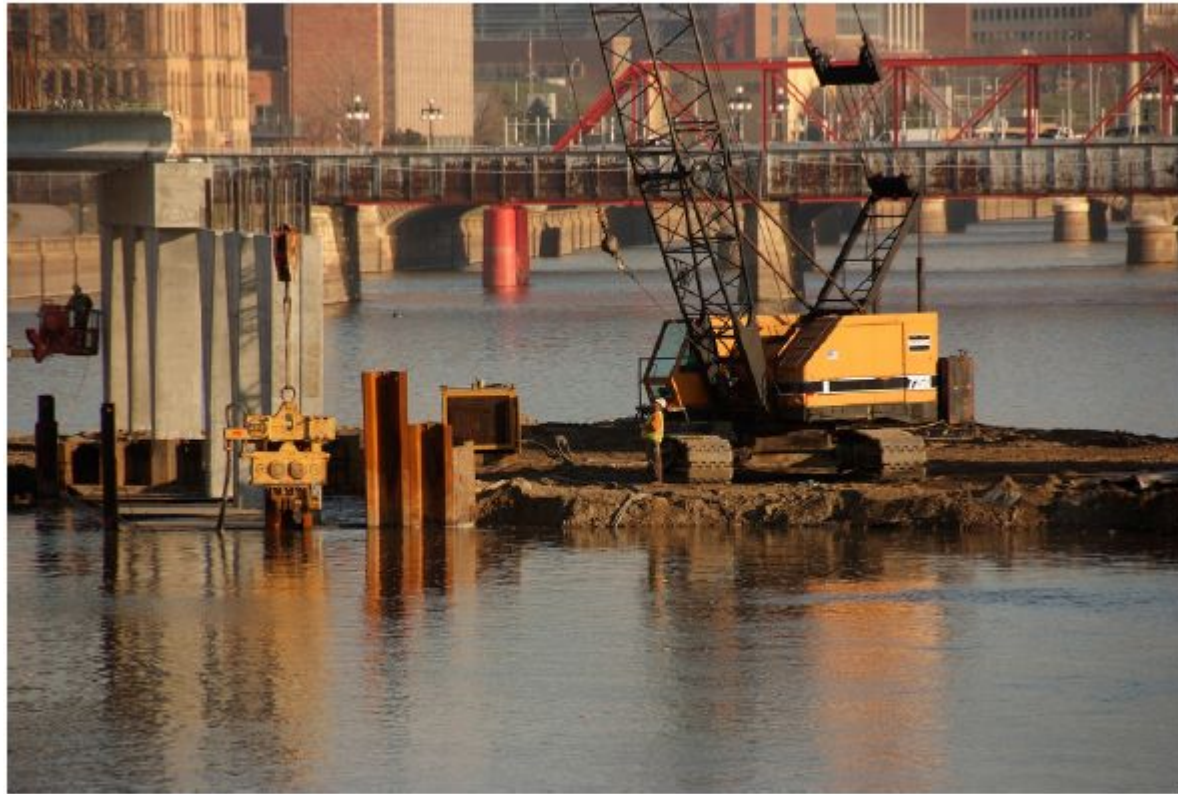
Social Choice

- In 2000, the US presidential election came down to Florida. George Bush won by 537 votes. But Ralph Nader got 97,421 votes. Twice as many Nader voters would have chosen Gore over Bush



Mechanism Design

- Businesses on both sides of a river need to decide whether to build a bridge, and if so how to pay for it



Auctions



Auction of bluefin tuna, Tsukiji Fish Market, Tokyo, 2008.

Game Theory in Computer Science

- Seminars



Course program

- Prerequisites
 - English
 - Discrete math
 - Basic set theory
 - Basic probability theory
 - Notions of algorithms

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Grading

- **2 Exams**
- Class project
- 3 Exercise lists
- Participation
- Seminar
- PD competition

Exams

- Mostly modeling questions
 - Given a situation, how game theory can be used to model it?
- Simple and easy questions
 - Don't require advanced math (e.g. calculus) to solve
- May require knowledge about every topic given in class, which are covered by the books as well

Class project (20)

- An attempt to do some original work on topics related to the course
- Alone or with colleagues (depends on the number of enrolled in the course)
- Theoretical or experimental
- Creativity is encouraged
- The final product is a writeup (in the form of a research paper)
- Some projects may lead to publishable papers

Class project (20)

- Consider your own research and its relationship to the course
 - Do you work on techniques that can be applied to any of the course's problems?
 - Can techniques in the course help your work?
- Take some result in the course that you like, and change the setting
 - Do things become easier (harder) if we look at a more restricted (more general) version of the problem?
 - Do analogous results hold in similar settings?

Class project (20)

- On its simplest form:
 - Find a non trivial scenario
 - Describe this scenario informally: players, actions, conflicts, utilities, complications
 - Model one or more configurations for this scenario formally
 - game type
 - players
 - strategies
 - payoffs
 - solutions
 - Discussion and conclusions

Class project (20)

- Algorithmic game theory:
 - Pick a type of game
 - Implement one or more algorithms to find solutions in that type of game
 - Evaluate how these algorithms perform when the game grows
 - (optional) Change the algorithms for any given (positive) purpose
 - (optional) Evaluate such change

Seminar (20)

- Alternative class project

- Find an interesting research paper that (uses / deals with) game theory
- Look for papers published in top venues:
 - https://scholar.google.com.br/citations?view_op=top_venues&hl=en&vq=eng_gametheorydecisionscience
- Alternatively, find a topic that was not cover in class
- Make a didactic presentation, explaining the paper or the topic in details
- Expected length of the presentation: 20 minutes

Participation (10)

- Points are given on my best judgement (sorry!)
- Lower bounded by:
 - I will ask for students to participate in several activities during classes
 - Games, quizzes, exercises
 - You will get points by your participation and performance in those activities

Games

- Students will be called randomly
- Every time you do not participate, you lose 2 points
- Every time you perform better than the baseline outcome, you gain 1 point
- Every time you perform worse than the baseline outcome, you lose 1 point
- For every game, I will show what is the baseline outcome

Grading

- **2 Exams (25 + 25)**
- 1 Seminar or Class Project (20)
- 3 exercise lists (20)
- Participation (10)

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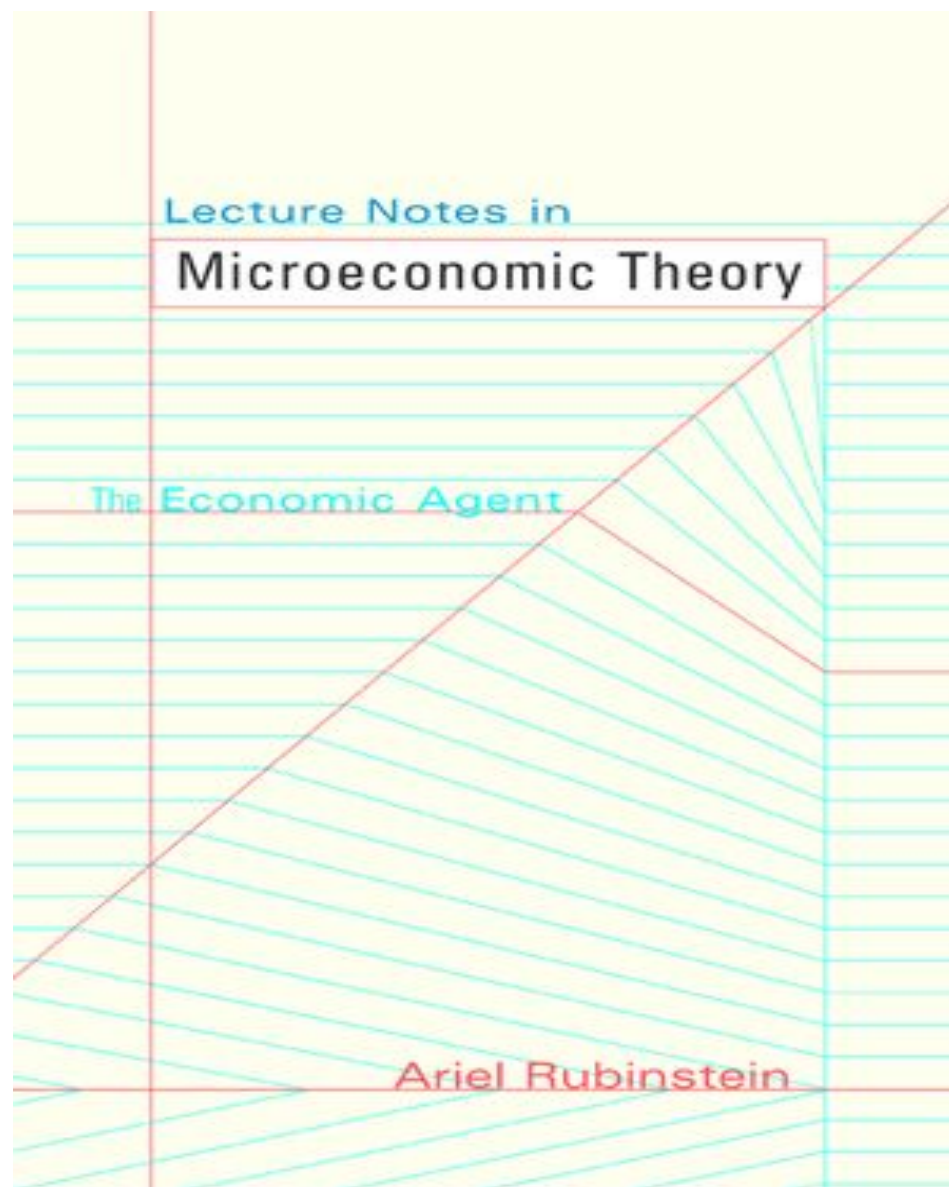
References

- Slides
- Books
- Courses
- Papers

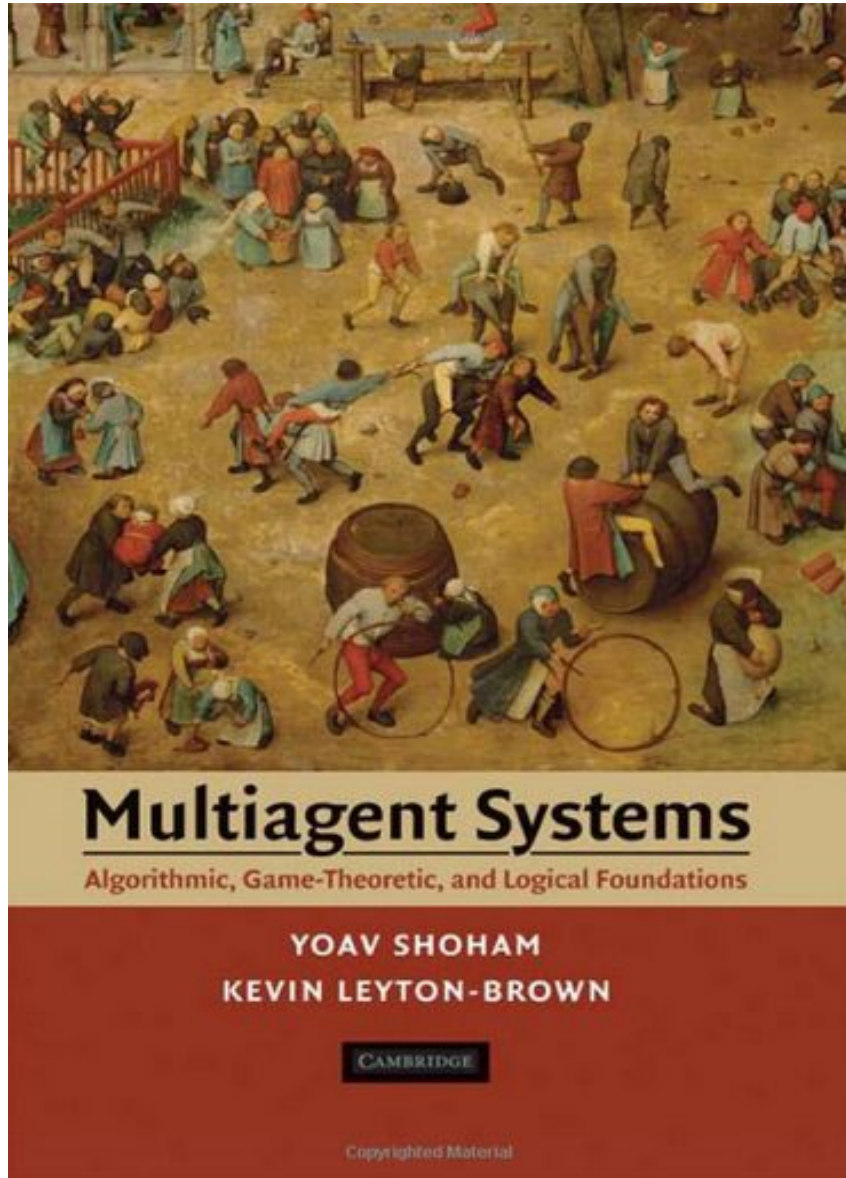
Slides

- I will post all the slides on Moodle
- The slides may contain material different from the books

Books



Books



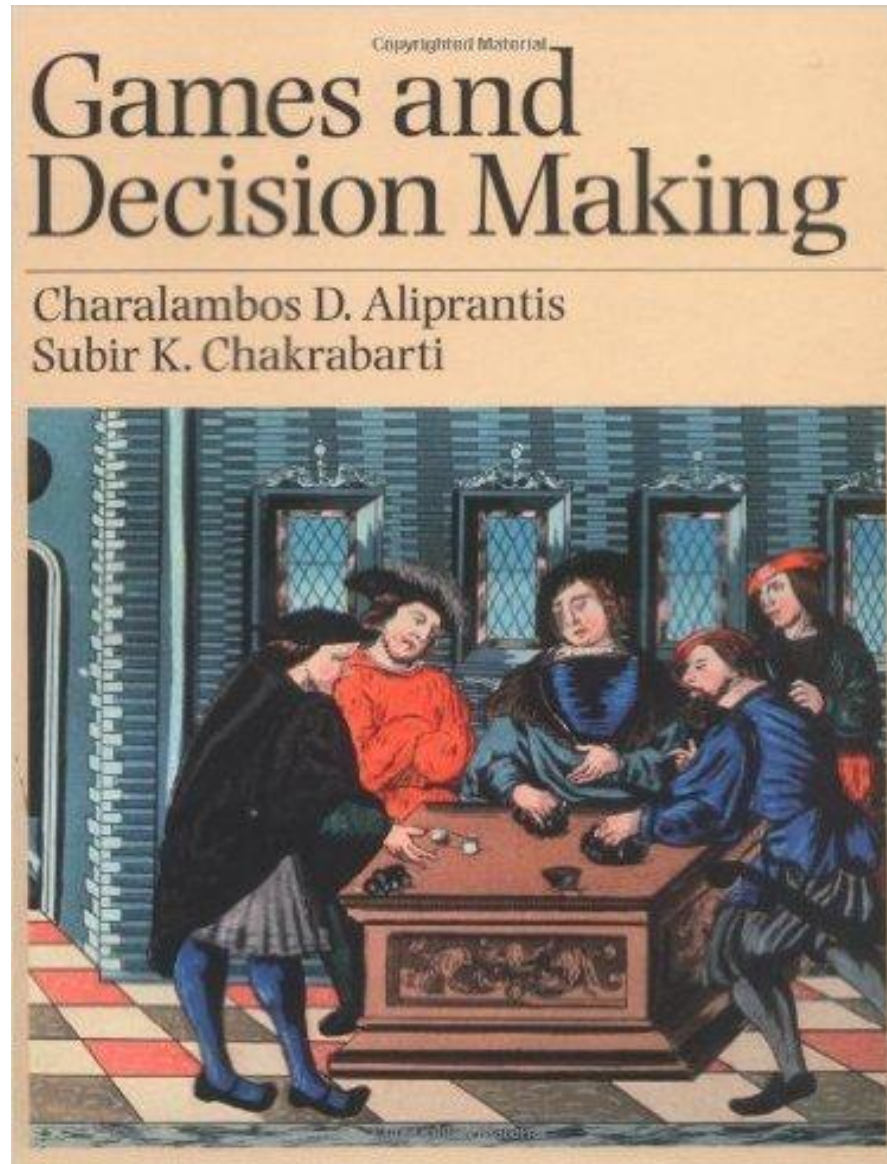
Books

A COURSE IN GAME THEORY

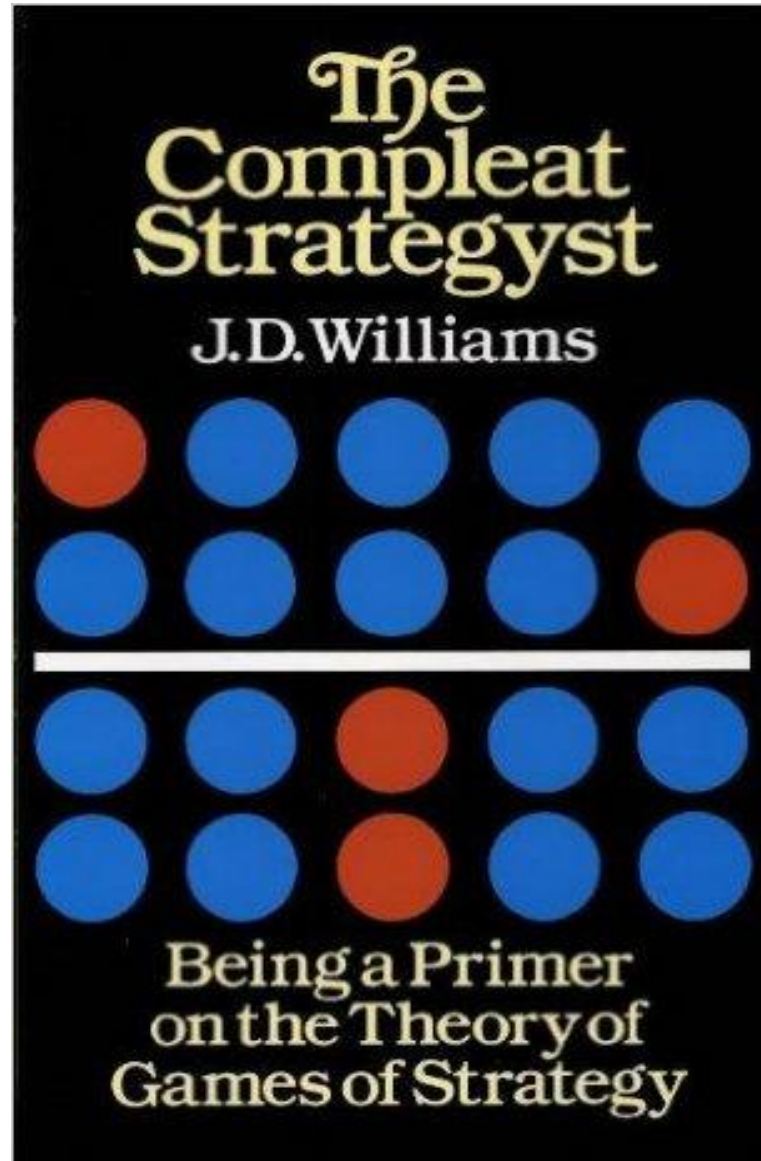


MARTIN J. OSBORNE
ARIEL RUBINSTEIN

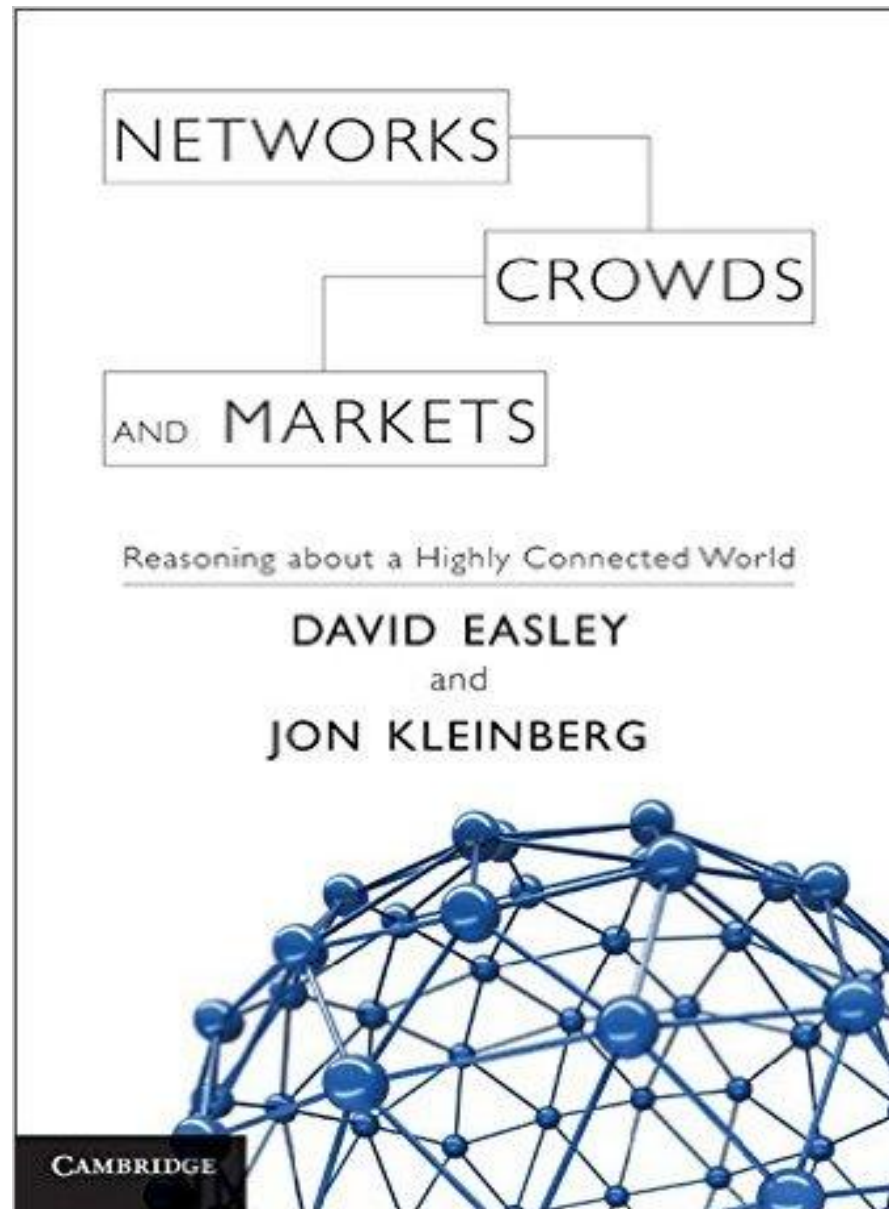
Books



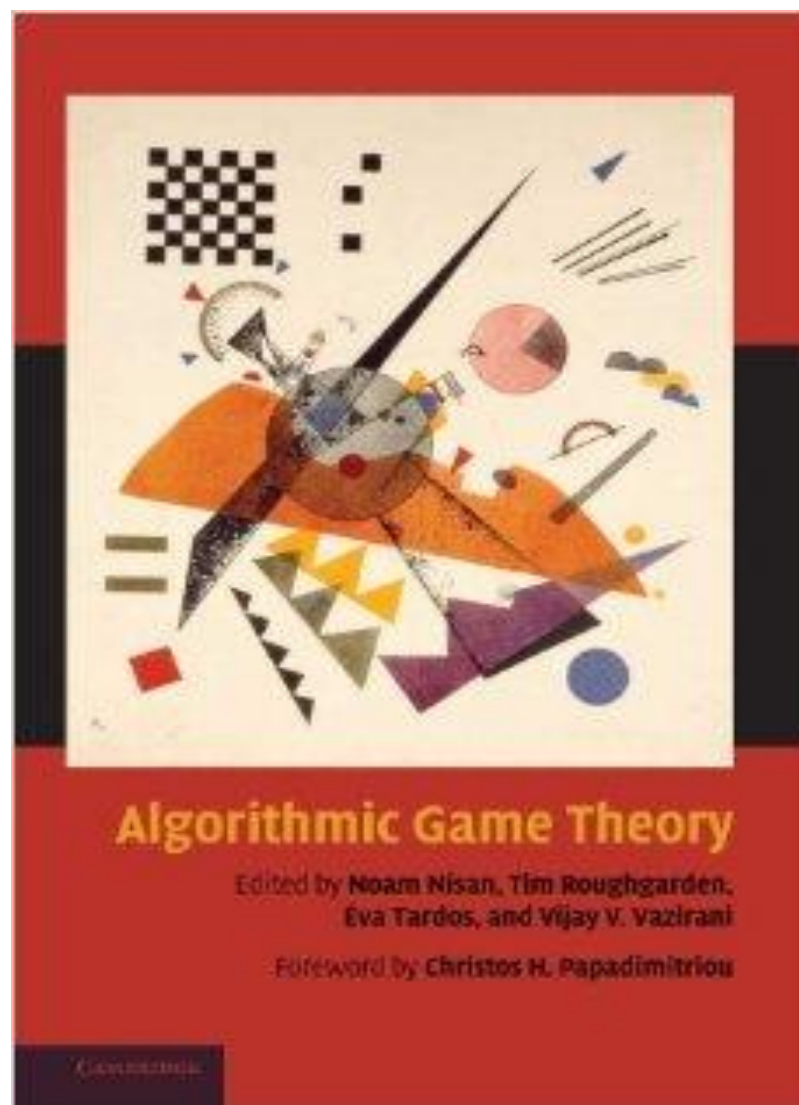
Books



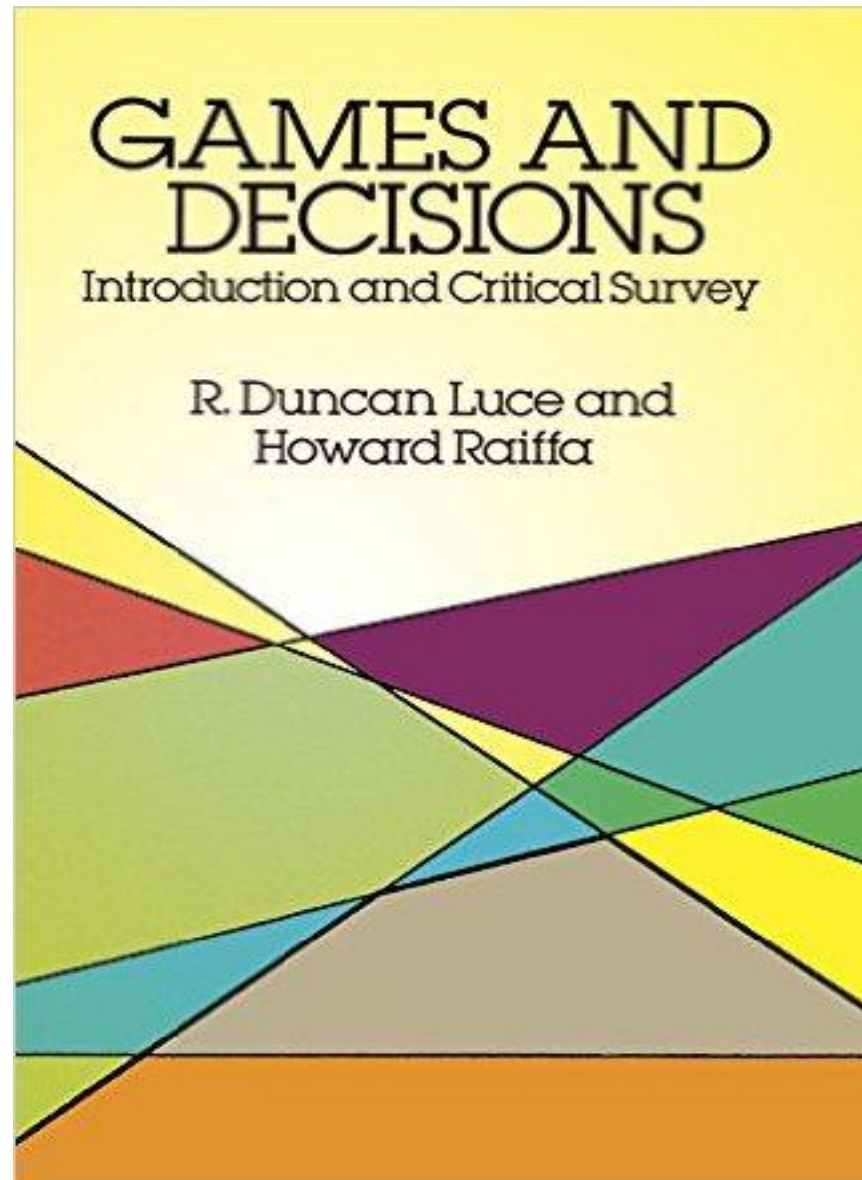
Books



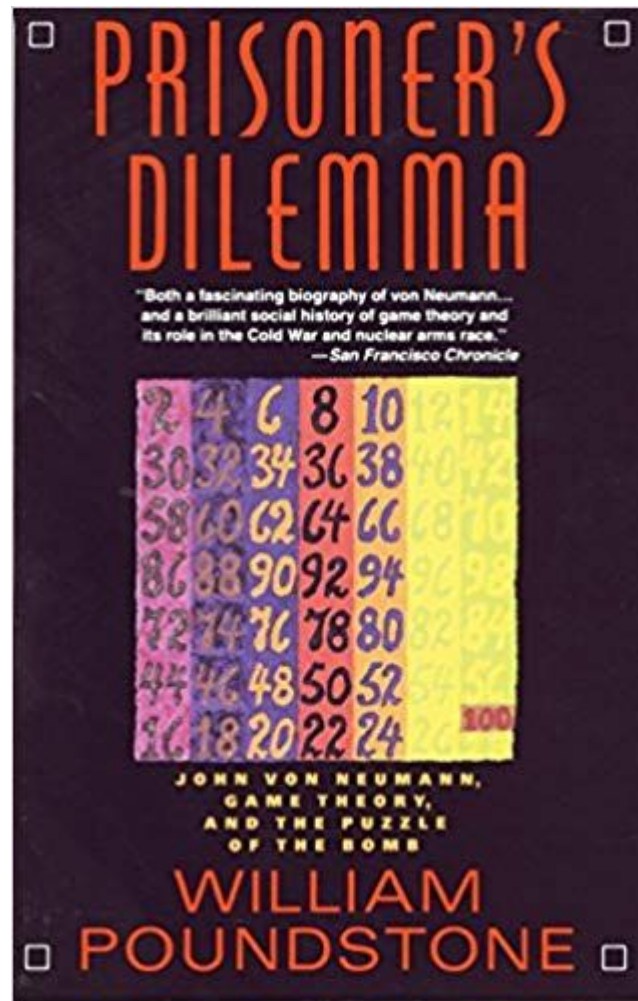
Books



Books



Books



Books

- Good news!
 - All books (except the last two) are publicly available online

Courses

- Coursera
 - Game Theory and Advanced Game Theory
 - M. Jackson, Y. Shoham, K. Leyton-Brown
 - Stanford University and UBC
- Computational Game Theory and Mechanism Design
 - Vincent Conitzer, Duke
 - <http://www.cs.duke.edu/courses/fall06/cps296.2/>
- Topics in Decision and Control: Static and Dynamic Game Theory
 - Bruce Hajek, University of Illinois
 - <https://courses.engr.illinois.edu/ece586/sp2013/>

Papers

- I will recommend papers to be read together with the classes
- I will also post a list of technical papers that link with computer science

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Goals

- Learn how to model conflict scenarios using game theory
- Be able to read and understand computer science papers that use game theory as a framework
- Be able to conduct your own research using game theory

Calendar

- Show calendar

Task due to Sunday!

- Details will arrive by e-mail
 - If you are enrolled to the course on Moodle