ECE700.07: Game Theory with Engineering Applications

Lecture 1: Introduction

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K-Beauty Contest Game

- Let's start with playing game
- Everyone writes down a number between 0 and 100
- Person closest to k = 2/3 of the average wins
- Example:
  - A says 50 - B says 10 - C says 90
  - 2/3 of average(50, 10, 90) = 2/3 * 50 = 33.33
  - A is closest (|50-33.33| = 16.67), so A wins

Overview

- Course mechanics
- Outline and topics
- What is game theory?
- What is mechanism design?
- Examples

Course Mechanics

- Course website
  - https://ece.uwaterloo.ca/~smzahedi/crs/ece700t7
  - All class information, lecture notes, assignments, etc.
- Office hour
  - W 16:00 to 17:00, or catch me after class, or send me email to setup meeting
- Prerequisites
  - Basic knowledge of algorithms, probability, and optimization would be helpful

Course Requirements

- Participation and pop quizzes 10%
- Assignments 20%
  - Should be done individually, no group discussions
- Midterm 30% (date TBD)
- Project 40%
  - Could be done individually or in groups of 2
  - Should be on applications of game theory to engineering research problem
    - Experimental study via simulation of game-theoretic mechanisms
    - Theoretical analysis of game-theoretic models

Text and References

- There is no required textbook, here are useful references
  - Multi-agent Systems by Shoham and Leyton-Brown (freely available online)
  - Game Theory by Fudenberg and Tirole,
  - A Course in Game Theory by Osborne and Rubinstein (freely available onliene)
  - Microeconomic Theory by Mas-Colell, Whinston, and Green
  - Algorithmic Game Theory by Nisan, Roughgarden, Tardos, and Vazirani

Course Information

- Introduce fundamentals of game theory and mechanism design
- Emphasize on theory, mathematical models, and equilibrium notions
- Study examples from engineered systems
  - E.g., routing games, resource allocation, strategies in electricity markets, etc.

Tentative Topics

- Strategic form games
- Extensive games with perfect information
- Repeated games
- Games with incomplete information
- Mechanism design
- Learning in games

Game Theory

- Study of mathematical models of conflict and cooperation between intelligent rational decision-makers

[Roger Myerson, Game Theory: Analysis of Conflict]

John Forbes Nash Jr.
1928-2015

Fig. A Beautiful Mind, from s.hdnux.com

Game Theory

- Optimization theory: optimize single objective

$$\begin{aligned} min. \quad & f(x) \\ s.t. \quad & x \in X \subseteq \mathbb{R}^n \end{aligned}$$

- Game theory: study multi-agent decision making to understand
  - Competition, coordination, and cooperation among self-interested agents

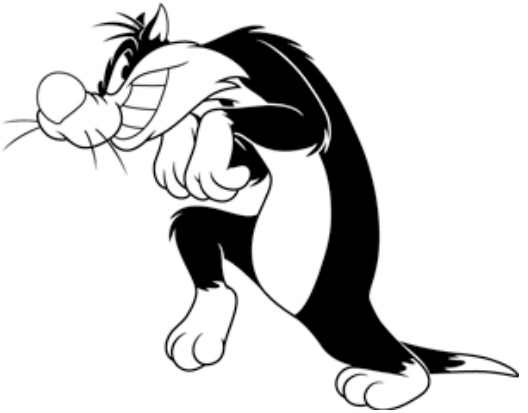
Mechanism Design

- Mechanism design is a field in economics and game theory that takes an engineering approach to designing economic mechanisms or incentives, toward desired objectives, in strategic settings, where players act rationally

[Wikipedia Aug. 2018]

Example I: Resource Allocation

- Design resource management systems robust to strategic behavior
- Agents manipulate management systems
- Real-life Examples
  - Yahoo! MapReduce datacenter [A. Ghodsi et al. 2011]
    Map slots were congested, users ran long reduce tasks
  - Google Borg [A. Verma et al. 2015]
    Users inflated demands to avoid colocated tasks
    Users deflated demands to fit in on any machine



Example II: Electricity Markets

- Generators supply energy into grid
- Operator balances demand/supply
- Generators can strategically curtail generation to manipulate prices
- Electricity markets should be carefully studied, designed and regulated

www.euneighbours.eu

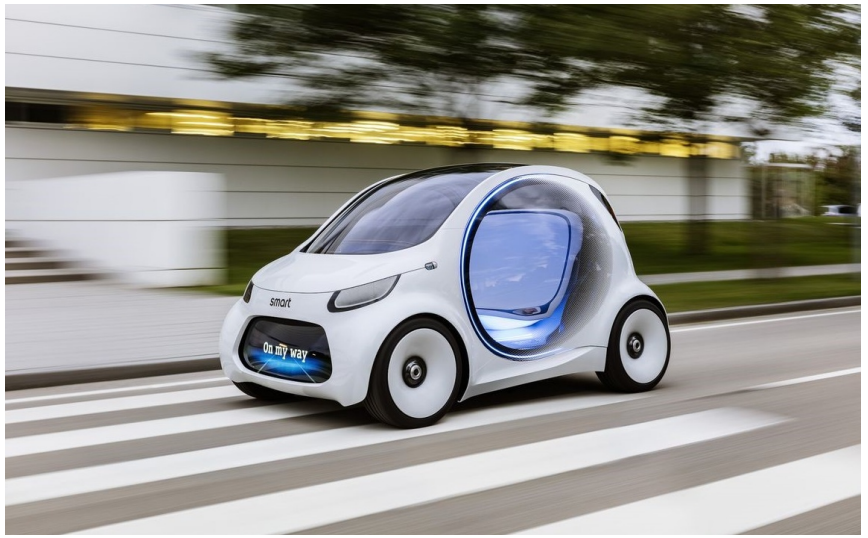
Example III: Blockchains

www.blockchains-expert.com

- Design protocols that guarantee
  - No coalition has incentives to deviate
  - If some coalition deviates, then no participating agent is worse of

Example IV: Autonomous Cars

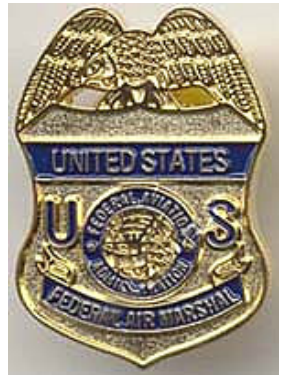
- Autonomous cars constantly interact with other drivers
- Different drivers deploy different decision making policies
- Safety needs to be verified
  - Requires 275 million miles of driving
- Game-theoretic traffic models could be used to test, compare, and calibrate control systems

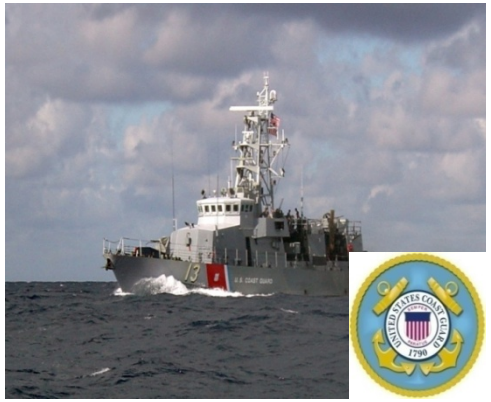


assets.aspeninstitute.org

Example V: Real-world Security [TEAMCORE group (USC)]

- Airport security: where to put checkpoints?
  - Deployed at LAX
- Federal Air Marshals: which flights get FAM?
- USA Coast Guard: which routs should be followed?
  - Deployed in Boston Harbor





Questions?

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