ORIE 6180 - Online Decision-Making and Markets

August 26, 2021

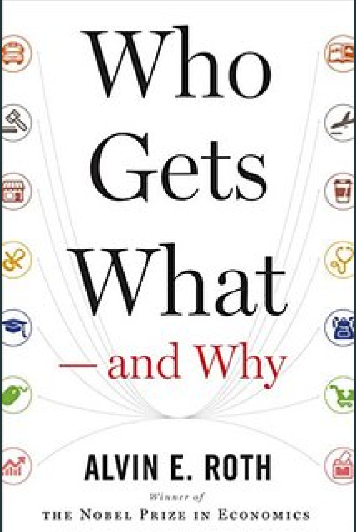
Semester: Fall 2021

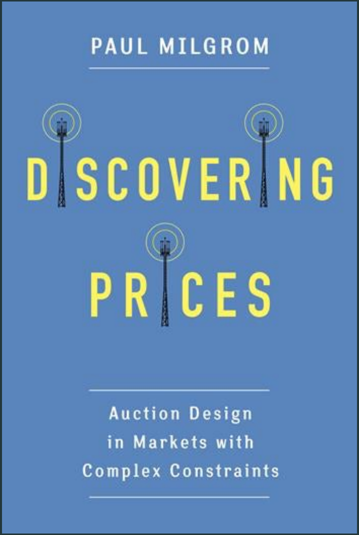
Essential Course Information

- *Instructor*
  Sid Banerjee, 229 Rhodes Hall
  sbanerjee@cornell.edu
- *Lectures*
  TR 9:40-10:55pm, Phillips 307
- *Website*
  http://people.orie.cornell.edu/sbanerjee/ORIE6180F21/orie6180f21.html

What is this course about?

online decision-making and markets





What is this course about?

online decision-making, markets and optimization

overture: bipartite matching

setting: graph $G(V_L, V_R, E)$, edge-weights $w_{ij}\,\forall\,(i,j) \in E$
aim: pick maximum weight matching

- $OPT = \max \sum_{(i,j)\in E} x_{ij} w_{ij}$
  subject to
  $\sum_j x_{ij} = 1\,\forall\, i \in V_L,\ \sum_i x_{ij} = 1\,\forall\, i \in V_R,\ x_{ij} \in \{0,1\}$

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- LP relaxation gives OPT matching
- greedy matching gives $\geq OPT/2$

overture: bipartite matching

now suppose $V_L \equiv$ 'buyers', $V_R \equiv$ 'items'; some variants we will look at:

- V_L arrives dynamically, known distribution over weights w_{ij} (MDPs, online stochastic packing)

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- V_L arrives online in arbitrary manner (online algorithms, competitive analysis)

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- V_L arrives online in arbitrary manner (online algorithms, competitive analysis)
- V_R have posted prices, V_L choose favorite option (Walrasian prices, prophet inequalities, large-market models)
- V_L are strategic buyers with private info about w_{ij} (mechanism design)

Course Aims

learn models, paradigms and tools

explore applications in complex systems, online marketplaces

find open questions, research problems

(tentative) list of topics

from online decision-making and markets to optimization

- Markov decision processes: value function, HJB, LP formulations
- non-Bayesian decision-making: zero-sum games and minimax theorem, Yao's lemma, Blackwell approachability
- mechanism design: IC & IR constraints, revelation principle

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Bayesian online decision-making (MDPs)

- exact solutions: threshold policies, index policies
- approximation techniques: LP and information relaxations, coupling
- 'stochastic' bandits: algorithms and lower bounds

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non-Bayesian online decision-making

- no-regret learning: multiplicative weights and FTPL, blackbox reductions
- online algorithms: LP approaches for competitive analysis
- reinforcement learning: regret bounds via optimistic algorithms

(tentative) list of topics (contnd)

mechanism design and markets

- basics of mechanism design: Myerson's lemma, impossibility theorems (bilateral trade, public goods)
- mechanisms for complex settings: VCG, correlated valuations
- approximate mechanism design

course methods

lectures, assignments, scribing, and a project

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- large scope and number of topics:

  focus on simpler settings, intuition

  suggested reading for details, additional topics
- requires active participation

  some reading for before/after class

  scribing for lectures as well as exercise solutions

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prerequisites:

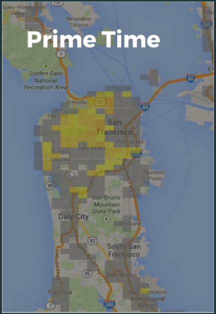
probability and stochastic processes (in particular, Markov chains, basic measure concentration): at the level of ORIE 6500

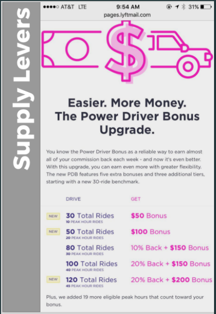
optimization: at the level of ORIE 6300

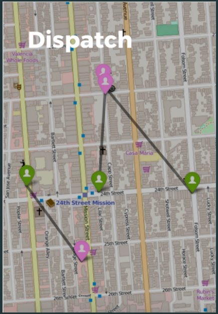
algorithms: ideally CS 6820 (at least CS 4820)

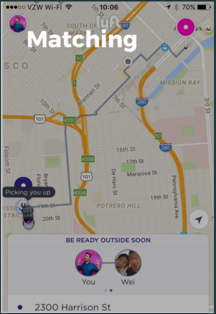
game theory, online learning: useful, but not required

some of my favorite markets









http://www.lyft.com/

(SP'16 project) pricing and optimization in shared-vehicle systems

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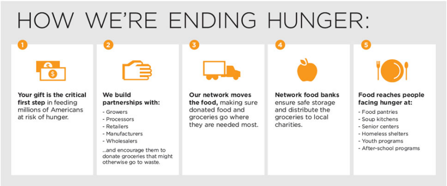

http://www.feedingamerica.org/

(SP'16 project) non-monetary mechanisms via artificial currencies