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
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online decision-making, markets and optimization
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
  $\sum_j x_{ij} = 1 \ \forall i \in V_L, \sum_i x_{ij} = 1 \ \forall i \in V_R, \ x_{ij} \in \{0, 1\}$
overture: bipartite matching

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

now suppose $V_L \equiv \text{‘buyers’}$, $V_R \equiv \text{‘items’}$; some variants we will look at:

- $V_L$ arrives dynamically, known distribution over weights $w_{ij}$
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- $V_L$ arrives online in arbitrary manner
  (online algorithms, competitive analysis)
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- $V_R$ 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
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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lectures, assignments, scribing, and a project

caveat emptor

- 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

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
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some of my favorite markets

http://www.lyft.com/
(SP’16 project) pricing and optimization in shared-vehicle systems
some of my favorite markets

http://www.feedingamerica.org/

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