Course Description:
Analytics and e-commerce have drastically increased the sophistication both in how goods are sold to customers, and how these goods are fulfilled. Examples of the former include dynamic pricing, recommending product assortments, and personalized coupons, and are studied in the area of Revenue Management; examples of the latter include flexible products and dynamic warehouse selection, and are studied in the area of Supply Chain Management.

This research-oriented course will review recent developments in both of these areas and discuss open directions; there will also be a slant toward learning how to apply the techniques of linear and integer programming, analysis of online algorithms, and mechanism design. This course is meant for Ph.D. students in operations research, industrial engineering, computer science, or related departments who are familiar with optimization and probability at the introductory graduate level.

Course Type: PhD elective (1 section), full-term, weekly 3-hour session

Optional Textbooks: Talluri and Van Ryzin (2006); Simchi-Levi et al. (2014); Gallego and Topaloglu (2019).

Grade Distribution:
- Attendance and Participation 10%
- Homework Exercises 30%
- Final Project 60%

Course Policies:
This course proceeds in a “bottom-up” fashion, with all sessions building upon previous ones. Therefore, students are expected to stay on top of course material from week to week, doing the homework exercises. These homework exercises will also suggest open problems or future readings/directions based on material from that week. By the end, students are expected to complete a research-oriented course project based on one of these suggestions or one of your own ideas.

The course project should represent a serious effort to push an open direction. While success is random and certainly cannot be guaranteed, the attempt must be serious including a clear problem formulation, understanding of what was known before, and clarity on what approaches you tried and (if applicable) why they didn’t work.
Course Outline

We will focus on models where the parameters are either already given or adversarially chosen; statistical estimation or learning of these parameters will generally not be covered.

The exact topics and reading list, especially for the second half, are still being finalized and subject to change.

Outline for First Half (01/14/2021–02/18/2021)

1. Introduction
   - fully-specified vs. partially-specified problems
   - fully-specified problems: dynamic programming and computational complexity
   - partially-specified problems: hedging for the worst case and Yao’s minimax principle
   - ratio vs. regret
   - warm-up: hiring a single secretary

References: Ball and Queyranne (2009), “Why do we use this Competitive Ratio thing anyways?” (Presentation)

2. Hiring a Single Agent, under different Arrival Models
   - basic arrival models: IID, independent non-identical, random-order with known distributions, random-order with unknown distributions, adversarial
   - basic techniques: prophet thresholds, $\gamma$-conservative Magician, approximate dynamic programming
   - generalizations: hiring $k$ agents, knapsack constraints, matroid constraints, reusable resources, network revenue management

References: Krengel and Sucheston (1977); Hill and Kertz (1982); Samuel-Cahn (1984); Kleinberg and Weinberg (2012); Alaei (2014); Correa et al. (2017); Ehsani et al. (2018); Stein et al. (2020); Correa et al. (2020); Rusmevichientong et al. (2020); Ma et al. (2020b)

3. Selling a Single Item to a Single Agent
   - welfare vs. revenue maximization
   - introduction to Bayesian mechanism design
   - optimality of posted prices for a single item

References: Myerson (1981); Chawla and Sivan (2014)

4. Offering an Assortment of Items to a Single Agent
   - multi-nominal logit (MNL) choice model
   - ranking-based models vs. random-utility models

References: Talluri and Van Ryzin (2004); Rusmevichientong et al. (2010); Gallego and Topaloglu (2014); Li et al. (2015); Blanchet et al. (2016); Aouad et al. (2018); Désir et al. (2020)
5. Matching Adversarially-arriving Agents

- classical online bipartite matching model of Karp, Vazirani, and Vazirani
- Adwords problem and the large budgets regime
- primal-dual analysis technique

References: Karp et al. (1990); Mehta et al. (2005); Buchbinder et al. (2007); Devanur et al. (2013)

6. Online Personalized Assortment Optimization, under different Arrival Models

- unification of hiring, pricing, assortment, and matching
- choice-based deterministic linear program (CDLP) and probabilistic rounding
- adaptivity; static vs. dynamic customer substitution
- understanding the LP correlation gap

References: Gallego et al. (2004); Liu and Van Ryzin (2008); Chawla et al. (2010); Golrezaei et al. (2014); Ma and Simchi-Levi (2020); Rusmevichientong et al. (2020); Ma et al. (2020a)

Outline for Second Half (03/11/2021–04/15/2021)

Some topics are still TBD.

7. New Models in Online Matching and Assortment Optimization

- hybrid arrival models (Hwang et al., 2020)
- two-sided arrivals and departures (Huang et al., 2018; Ashlagi et al., 2019; Aouad and Saritaç, 2020)
- product display and framing (Gallego et al., 2020)
- search and Pandora’s boxes (Derakhshan et al., 2018)
- multi-stage assortment optimization (Liu et al., 2020)
- supply-side choice (Aouad and Saban, 2020)

8. Flexible Fulfillment in Supply Chains

References: Elmachtoub et al. (2015); Lei et al. (2018); Asadpour et al. (2020); DeValve et al. (2020)

9. Inventory Pooling and Service Levels in Supply Chains

References: Zhong et al. (2018); Lyu et al. (2019); Jiang et al. (2019)

10. Asymptotic Regret in Network Revenue Management

References: Reiman and Wang (2008); Jasin and Kumar (2012); Bumpensanti and Wang (2020); Vera and Banerjee (2020); Cheung et al. (2020)

11. New Topics in Revenue and Supply Chain Management

- value of personalization in RM (Elmachtoub et al., 2020)
• privacy in personalized RM (Lei et al., 2020)
• fairness in pricing (Cohen et al., 2019)
• is RM good for customers (Chen and Gallego, 2019)
• strategic customers (Chen et al., 2019)
• RM in gaming industry (Chen et al., 2020)
• supply chain on blockchain (Iyengar et al., 2020)

12. Student Presentations

References


