ORIE 5355

Project description, game theory/competition

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Plan for rest of the semester

Almost there!

Rest of semester

- Class project
- Miscellaneous lectures, guest lectures
  - Quiz 5
  - Attendance

Project Overview

Deadlines

Official deadlines

- Part 1 – November 21
- Part 2 – December 8 [BUT DO NOT WAIT TO START]
- Report – December 14

Can submit edits to Part 1 + Part 2 at report deadline if absolutely needed (substantial points deduction)

Earlier “deadlines”

Starting this week, will post “leaderboard” for Part 1

Will start running preliminary Part 2 tournaments immediately after Thanksgiving break

Part 1 overview

- You are selling one an item
- A customer walks in and you observe their covariates
- You post a price for the item
- The customer buys from you if price is below their (secret) valuation
  - If price < v, and only if you have any inventory left
- Repeat for many more customers
- **You only have 12 copies of the item for every 20 timesteps → dynamic programming!**
  - How does this affect strategy?
- At beginning of timestep 0, 20, 40, etc… your inventory resets to 12
- Objective: maximize revenue over an extended time period

Deliverable:

- Code for agent, via GitHub
- Non capacity constrained demand estimation + price optimization:
  - For a set of test customers, what prices would you set for each customer for each item to maximize revenue, *if you didn't have to worry about capacity constraints or competition?*

Part 2 overview

Changes from Part 1:

- Now you have a competitor (another team in the class)
- You and your competitor post prices for each item
- The customer buys from one of you, or neither
  - If minimum price < v, buys from minimum price seller

Deliverables

- Code for competitive pricing

Grading

Project report	0-6 points	How clearly + well did you *discuss* your strategy and evaluation techniques? How thoughtful was your reflection?
Project Part 1	0-6 points	How thoughtful and effective was your strategy? Does it reflect substantial effort? This will be influenced by objective performance, description in your report, and looking at your code.
Project Part 2	0-6 points	Same as Part 1 above
Overall subjective	0-2 points	

For grades: performance matters, but *strategy/analysis* matters more

Code Submission information

- Via GitHub classroom!
- Github classroom has an autograder that checks file structure and packages!

Summary

- Fill out the google form with your team's information. At least 1 team member needs GitHub username
- Have 1 team member click on github classroom invite link and "create" the team (use same team name as form)
  - This creates a repository
  - Everyone else can click on same link and join the team via team name.
- Rename "yourteamname.py" agent file
  - And rename "yourteamname/" folder. Allowed to put data/pickled machine learning models/etc into this folder
- Submission of code is just via pushing to the repository

How to avoid common submission mistakes

- Do **not** edit files other “yourteamname.py” or “yourteamname/” (or at least, do not rely on those edits for your code to work)
- Do **not** edit **function names** inside “yourteamname.py” file
- **Yes:** Edit above **file names** “yourteamname.py”, “yourteamname/” with your team name
- Only put your required data or machine learning models in the folder “yourteamname/” inside the agents folder
- **Yes:** Use *relative* paths when loading data in your agent

  CORRECT: `filename = 'agents/yourteamname/trained_model’`

  NOT CORRECT: `filename = ‘c:/Users/Nikhil/documents/ORIE5355bestclassever/project/agents/yourteamname/trained_model’`

Suggestions + brief intro to game theory

More broadly: game theory, pricing competition

Part 1

- Very similar to HW3 components
  - Demand estimation – what is estimated value distribution (demand at each price) for a customer with the given covariates?
  - Dynamic programming – pricing with capacity constraints
    - Bonus question – pricing with multiple copies over time period
- Putting things together: what should your dynamic pricing learn?
  - If you have fewer copies left, should have “higher bar” to sell it
  - If have many copies left compared to inventory reset, then “lower bar”
  - Want to compare (estimated) revenue for today’s customer to revenue from future customers
    - So have to learn general demand distribution as well

Part 2: Challenge with competition

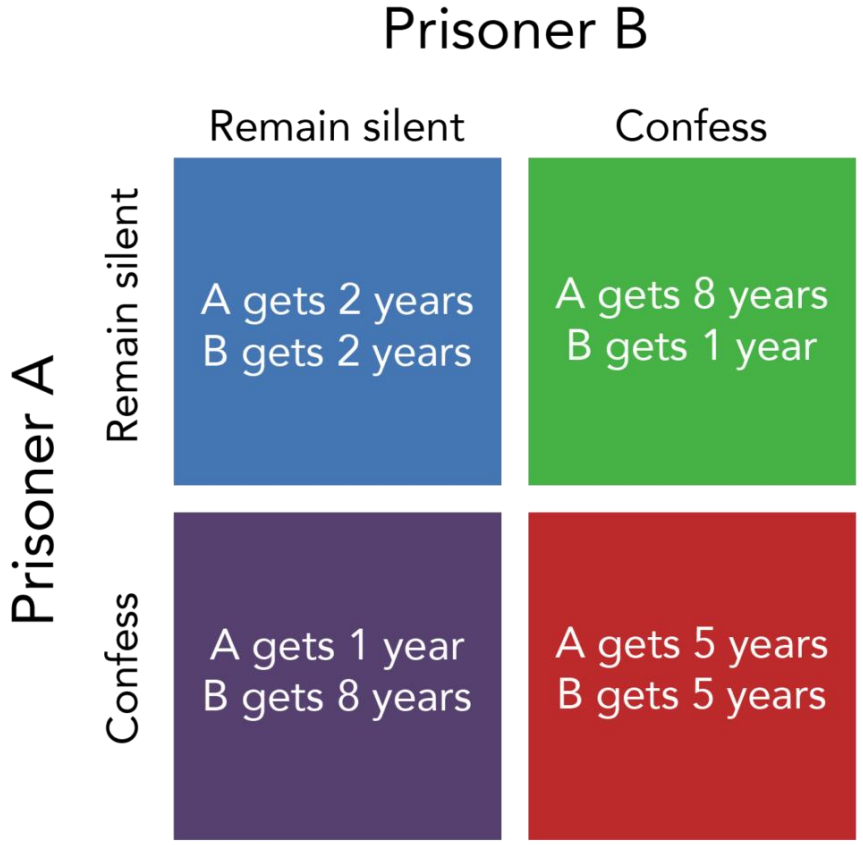
- There's now a game theory component: you need to anticipate what your opponent will do when setting prices
- You and your opponent both do the same thing, and calculate the exact same price p at the current time step
- Your opponent is clever, and so decides to *undercut* you slightly, and so sets price $p - \$0.01$
- …but you're cleverer, and know your opponent will do this, and so you set prices $p - \$0.02$
- … You keep doing this, and you're both setting prices $p = 0$
- You can't ignore your opponent, otherwise they'll undercut you and always win the customer

Aside: game theory

Game theory: "study of mathematical models of strategic interactions among rational agents"

Example: Prisoner's dilemma

- 2 players
- Each can take 1 of 2 actions
- Have to choose action without knowing what other person chose
- **No matter what other person does**, you're better off confessing



[Prisoner's Dilemma | Microeconomics (lumenlearning.com)]

What about *repeated* games?

- In many settings, you're playing a *repeated* game
- Sometimes, repeated games change optimal behavior:
  - If I betray you today, you can retaliate by betraying me tomorrow
  - If I remain cooperate today, you can reward me tomorrow
- …but, calculating optimal strategies in repeated settings can get complicated
- There are tournaments where people just play repeated prisoner's dilemma against each other. Person with most utility overall wins
  - "tit-for-tat" is often a top performing strategy

Pricing in repeated settings

- By the logic of a previous slide, setting prices $p = 0$ is only rational response if you want to win the customer
- BUT, your objective isn't to win the customer, it's to make the most money overall. (and you know your opponent's goal is the same)
- What you do should depend on your opponent's actions
  - If they tend to price low, you should also price low
  - If they tend to price high, you should also price high
- But – your actions affect your opponent's future actions!

  How do you avoid a price war?

Competition with inventory constraints

- You and your opponent each have 12 copies of the item every 20 time steps
- How does this affect your strategy?
- Conceptually, you want to win high value customers, at high prices

Questions?