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Content Optimization with Multi-Arm Bandits & How to Title Presentations

Guest Talk
CSCI 4830
Special Topics in Computer Science
Data Driven Design
2021-03-18

Brad Weiner
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CU Boulder

Me

- Call me Brad
- Director of Data Science at CU Boulder
- I use institutional data to inform decision-making
- Excited to chat with you today and beyond
- First time teaching on Zoom, if you have questions, please just interrupt.



Today's Discussion

- Quick Introduction
- Apartment Hunting in Springfield
- Learning vs. Earning in User Experience
- Frequentists and Bayesians
- Questions
- Open Ended Data Science Questions



Finding an Apartment in Springfield

Buy Rent Sell Home Loans Agent finder



Manage Rentals Advertise Help Sign in

Boulder, CO For Rent \$400-\$1.4k 1+ bd, 1+ ba Apartments More Save search Schools Draw

\$1.4K
1 bd, 1 ba
590 sqft

Updated today

\$1,345+/mo
4 bds 3 ba 950 sqft - Apartment for rent
2995 Colorado Ave #72DKGFFN1, Boulder, CO 80303

Updated today

\$745+/mo
Sterling Boulder Apartments | 2985 Aurora Ave, Boulder, CO 80303

Updated yesterday

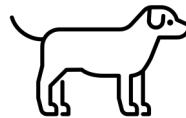
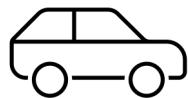
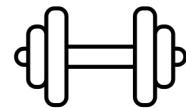
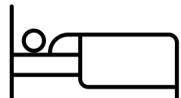
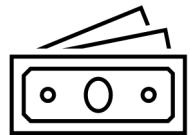
\$1,200+/mo
1 bd 1 ba 660 sqft - Apartment for rent
505 27th Way #35569508, Boulder, CO 80305

\$1,335/mo
1 bd 1 ba 640 sqft - Apartment for rent
4977 Moorhead Ave #W210, Boulder, CO 80305

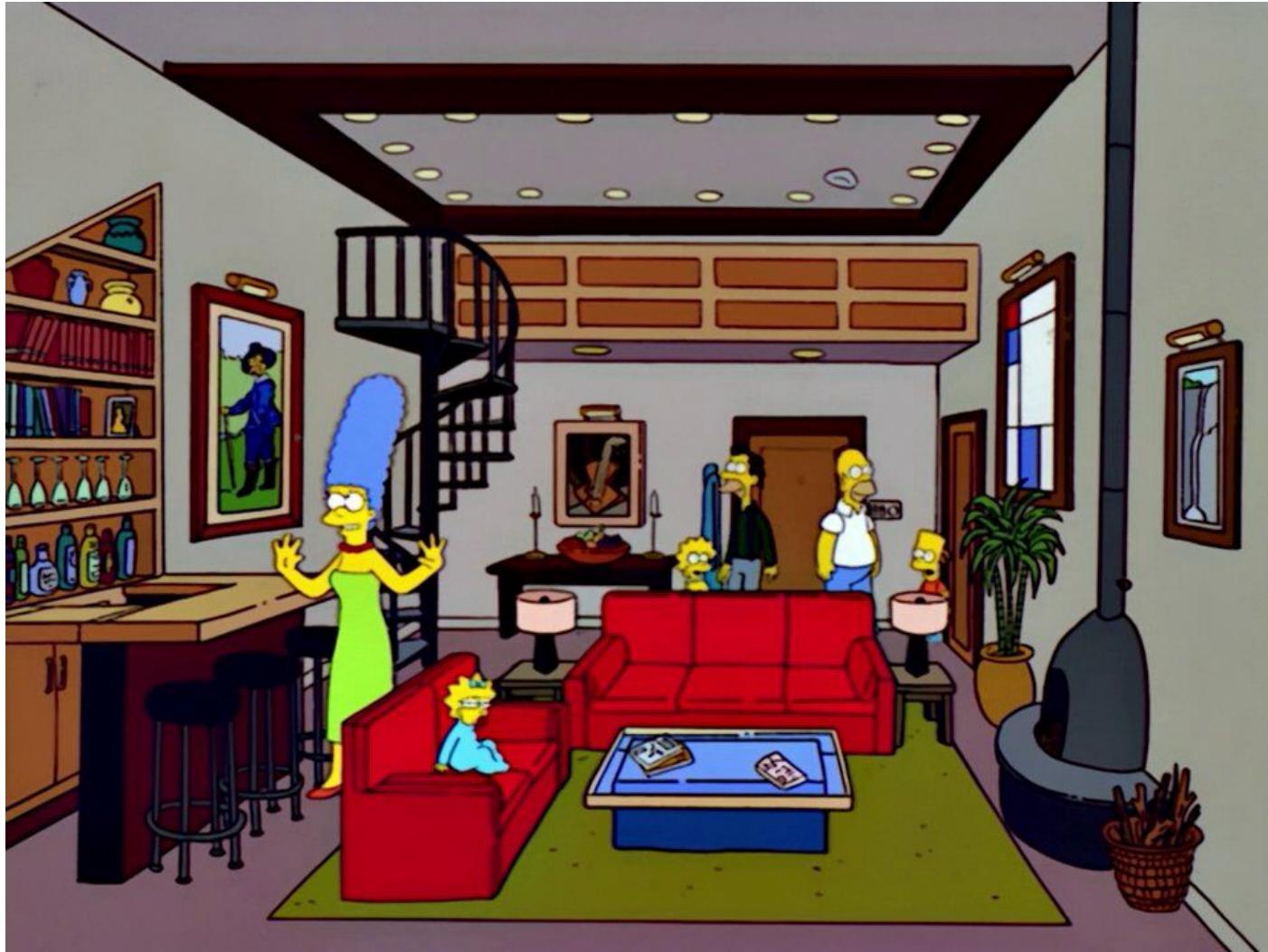


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Constraints



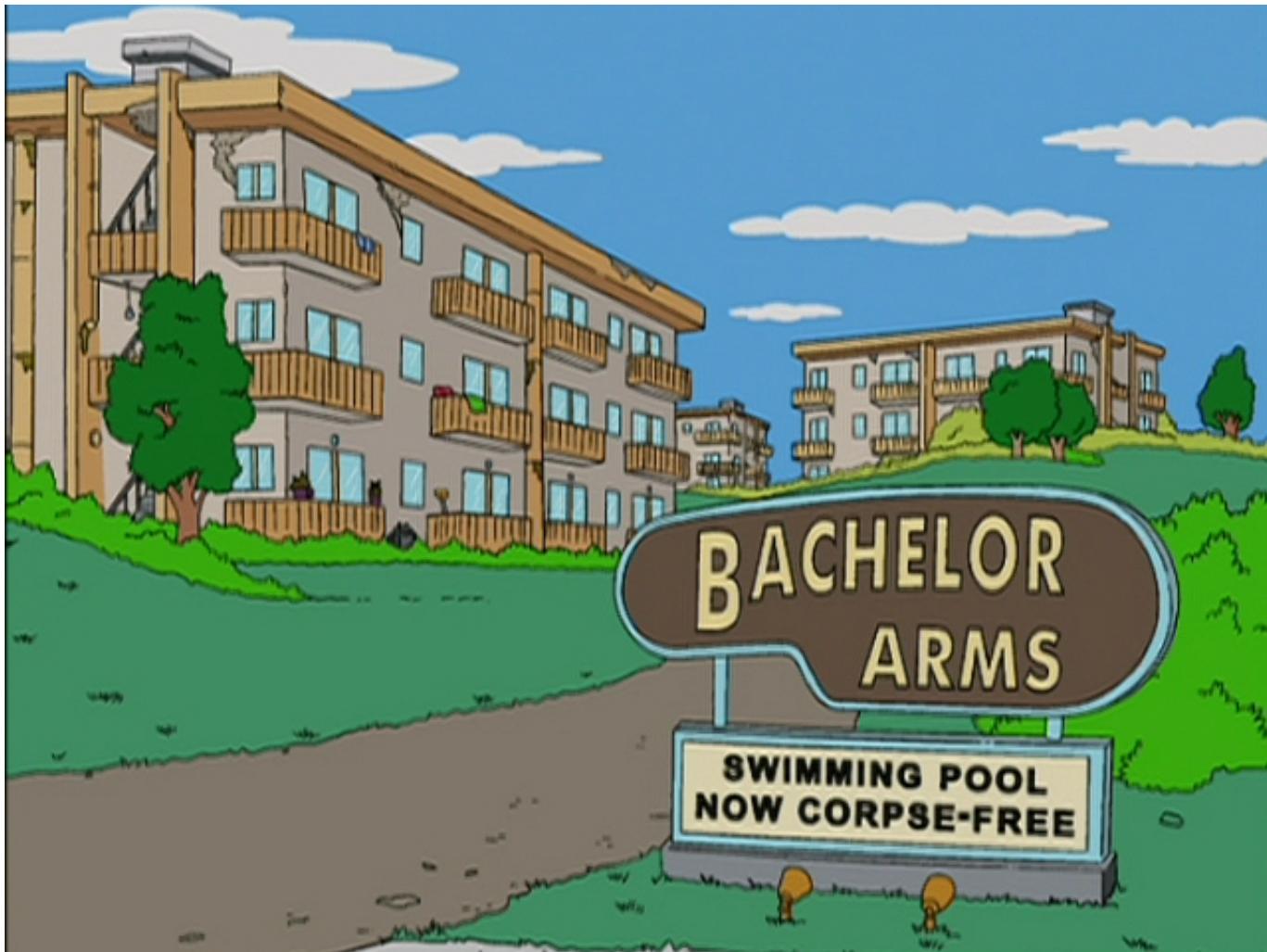
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Question: When Do You Stop Looking and Put Down a Deposit?

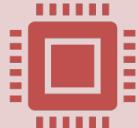


The challenge:

- If you deposit too early, you may miss out on a better apartment
- If you keep looking, you'll never find an apartment



Some Knowledge Here:



This is a well-known computer science problem called the **explore-exploit tradeoff**



Computers can scan through nearly limitless choices. How do we maximize the expected value from a selection?



Multi-Arm Bandits (MAB)



- Multi-arm bandits are algorithms that seek to maximize an expected payout
- They are intended for the most rapid move toward the “exploit” decision
- There are a variety of strategies for algorithms to switch from explore to exploit





Which machine
has highest
expected reward?



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THIS IS EPSILON(ϵ)



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Let's exploit that
knowledge and
win some money!



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SIMULATION

Source Code:

https://gist.github.com/robinvanemden/30969b48a44c2742a18ae14861793741#file-epsilon_greedy_animation-r



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Are there other
ways I could
explore then
exploit?



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Multi-Arm Bandit Solutions

- Changes to Explore/Exploit Ratio (Epsilon)
 - Do all exploring first
 - Gradually reduce the explore (Epsilon) rate over time
- Changes to Bandit Selection
 - Contextual bandits that choose the “correct” machine based on gambler’s information
- Different Algorithmic Approach
 - Thompson Sampling (Bayesian)



An Oversimplified Description of Statistical Approaches

Frequentist

- Assumes that with a large enough sample size, the point estimate (usually mean) gives the best guess at the whole population

Bayesian

- Assumes that the “right” answer is actually a range of probabilities from a distribution which can change and be updated



SIMULATION

Source Code:

https://gist.github.com/robinvanemden/30969b48a44c2742a18ae14861793741#file-thompson_sampling_animation-r



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Experiments in Web Design



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Which content
has highest
expected
engagement?



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A/B Split Test vs. Multi-Arm Bandit



Develop a randomized statistical test to understand which among multiple options is “significantly” better

Pro: You get a definitive answer and your organization learns

Con: It takes time and requires a robust sample size



Deploy an algorithm that programmatically selects the current “winner”

Pro: Your users are getting the benefit of the current, “best” version and the highest engagement rate

Con: The results might not provide a clear organizational answer



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Key Takeaways



Randomized experimentation is critical. You should deploy as many *useful* experiments as your organization can effectively absorb



There are multiple approaches, and the main question is “Are you trying to *understand* or to *maximize*?”



Understanding the mechanics of these methods is helpful, but you don't need to be a statistician to use Google or Optimizely





Questions



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Data Science Questions



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Sources

Zillow

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Interactive Bandits:

<https://pavlov.tech/2019/03/02/animated-multi-armed-bandit-policies/>

Original R Code for Interactive Bandits:

<https://gist.github.com/robinvanemden/30969b48a44c2742a18ae14861793741>

Updated R Code for Interactive Bandits:

<https://gist.github.com/bradweiner/96593a8e7a34c03c0a92db33fdc64f75>

Algorithms to Live By

Christian, B., & Griffiths, T. (2016). Algorithms to live by: The computer science of human decisions.

* Note that the interactive bandits in lecture were slightly repurposed, but otherwise copied from Github gist from Robin van Emden



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Stable Location

This presentation can be found at:

https://bradweiner.info/files/mab_presentation.pdf

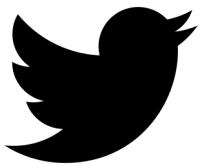


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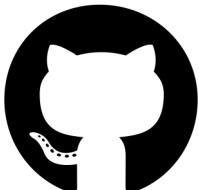
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