

Restaurant Recommendation on **yelp**

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Businesses

Background

Users


yelp 🌟 Restaurants Las Vegas, NV

Restaurants ▾ Home Services ▾ Auto Services ▾ More ▾

All Price ▾ Open Now Offers Delivery Offers Takeout Reservations Breakfast & Brunch Seafood

Sponsored Results ⓘ

All "restaurants" results in Las Vegas, Nevada



1. Bacchanal Buffet


★★★★☆ 13555

Buffets • \$\$\$ • The Strip

Closed until 3:30 PM

☞ "Despite increasing costs, we return again and again for special occasions like birthdays, anniversary, and holidays. This is our go-to place when we're willing..." [more](#)

✕ Outdoor seating ✕ Delivery ✕ Takeout



2. Mon Ami Gabi


★★★★☆ 11492

French • Steakhouses • Breakfast & Brunch • \$\$\$ • The Strip

Open until 10:00 PM

☞ "To start, the food was great it was very good quality beef and the fries were nice and crispy. The soup tasted very good, it was thick. The caesar..." [more](#)

✓ Outdoor seating ✓ Delivery ✓ Takeout



3. Gordon Ramsay Hell's Kitchen - Las Vegas


★★★★★ 9317




American (New) • Seafood • \$\$\$ • The Strip






Closed until 11:00 AM

☞ "Ate there with my group of 5 from Vancouver Canada on March 18, 2023. Been on my bucket list for a while. Got to our table and there were so many crumbs on the..." [more](#)

✕ Outdoor seating








Da D.
 SoMa, San Francisco, CA
   0

[Start your review of Las Vegas Brewing Company.](#)

Overall rating

234 reviews

5 stars

4 stars

3 stars


2 stars


1 star




Newest First ▾






English (233) ▾

Filter by rating ▾






Kyle M.
 NV, NV
   3








4/9/2023


What a wonderful atmosphere! We came in for our first time today. Chose the brewery because it's kid friendly right around the corner, has a diverse menu, plus bottomless Mimosas with brunch that's a no brainer. Food was immaculate, very friendly staff and on top of it, as soon as one Mimosa was finish the replacement was there right away. Oh don't let me forget happy Easter!!!! Thanks for the amazing service




Helpful 0




Thanks 0











Love this 0



On no 0



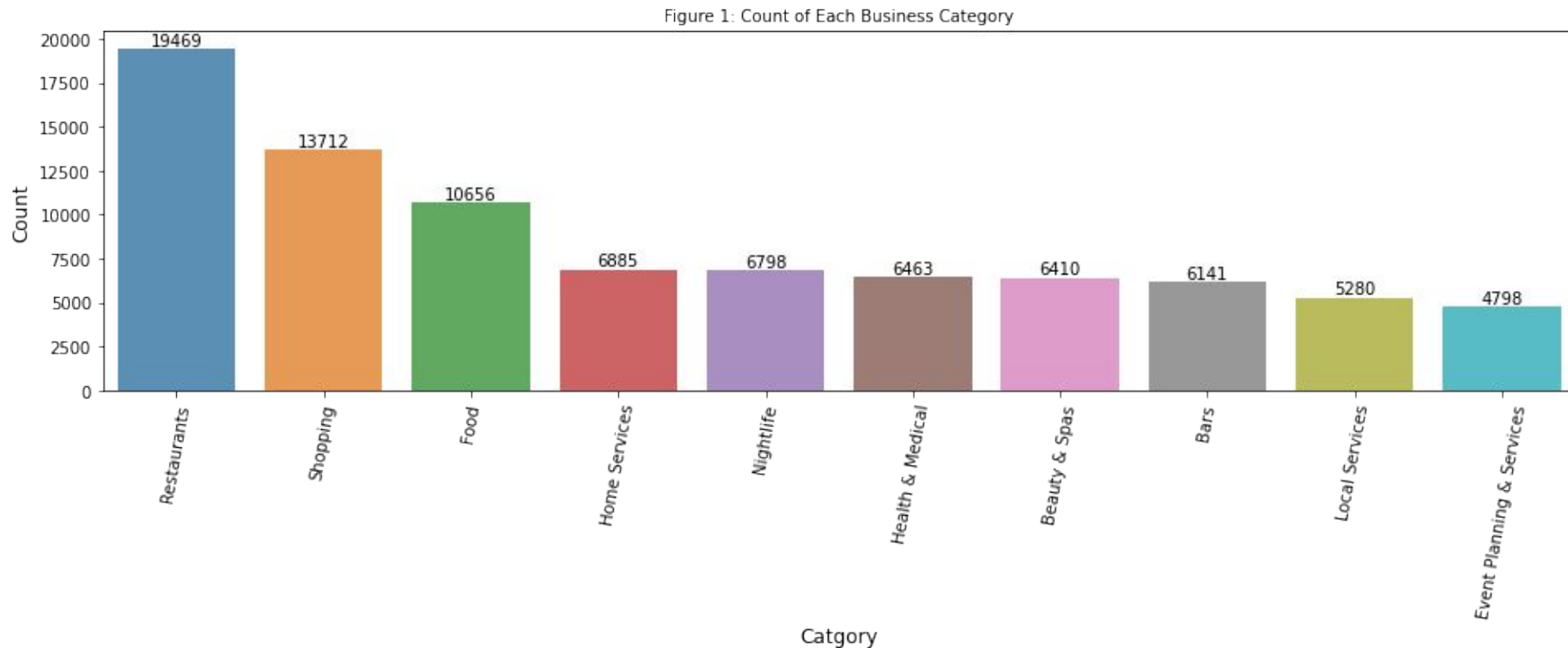
Suzanne S.
 Las Vegas, NV
 43  30  22

4/8/2023

Background

Restaurants on Yelp



Motivation

How do recommendations on Yelp work?

Las Vegas, NV > Restaurants > Mexican

Best Mexican near me in Las Vegas, Nevada

Sort: **Recommended** ▾ ⓘ



Current recommendation system is:

A

Rigid

Safe but monotonous

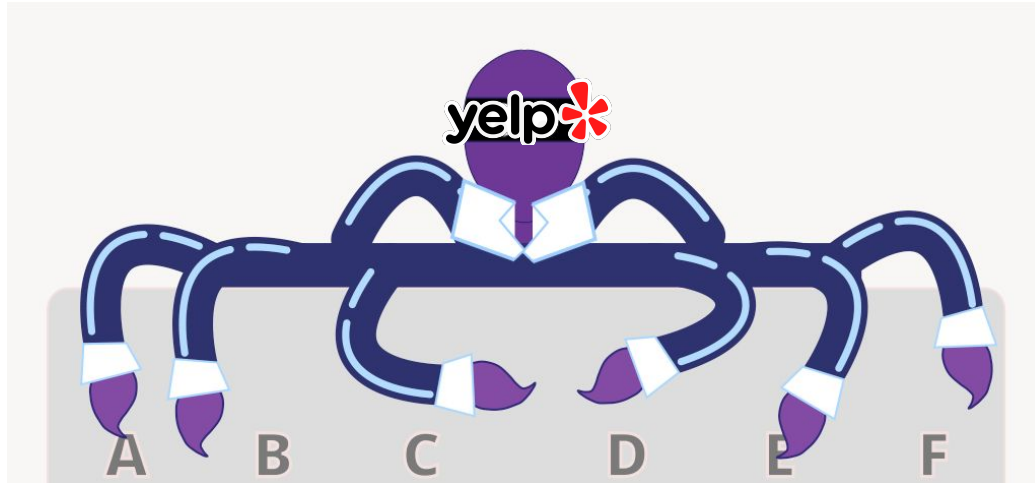
B

Lacks Exploration

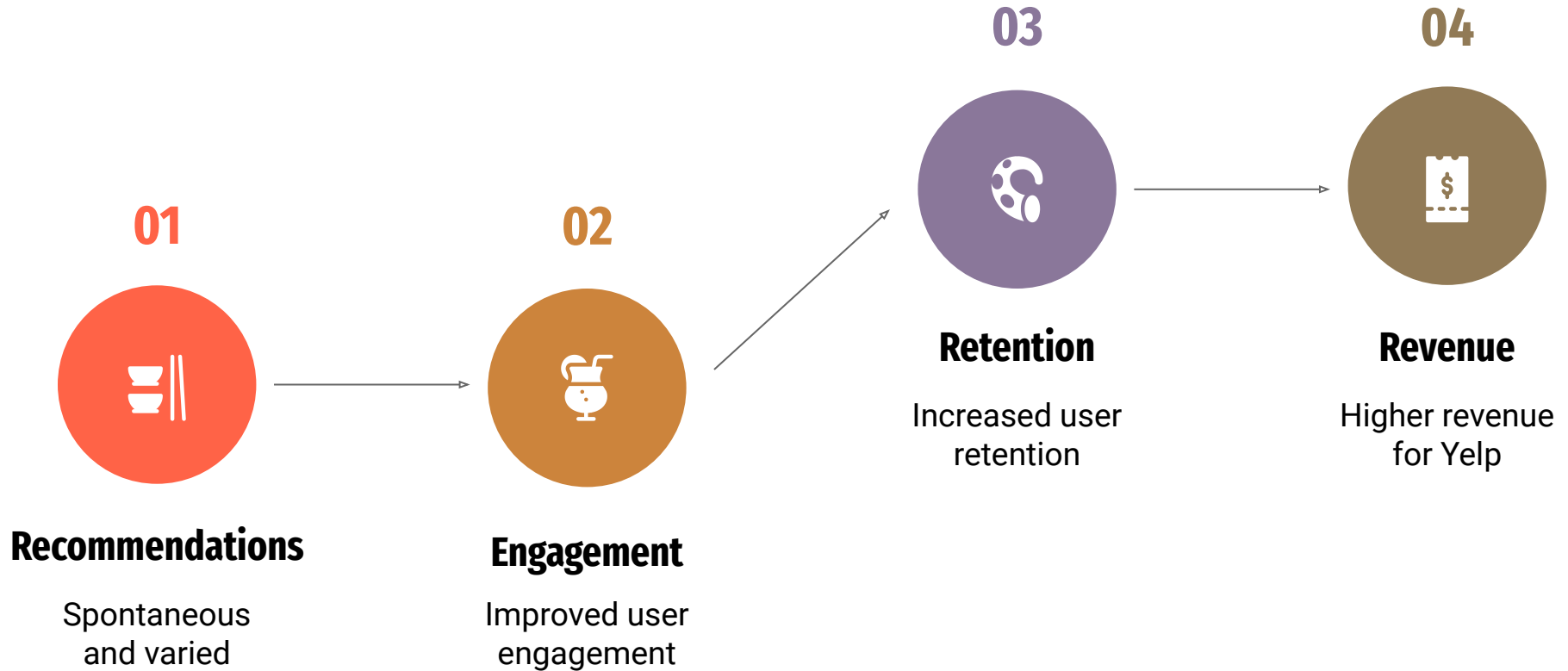
Into lesser known
businesses

Motivation

Bandit Algorithms



Motivation



Problem

Overwhelming number of restaurant options on Yelp and rigidity of recommendations for users

Solution

Using bandit algorithms to provide personalized restaurant recommendations to users

Highlights of Key Findings and Implications

Epsilon-Greedy

Epsilon-Decay

Softmax

Annealing Softmax

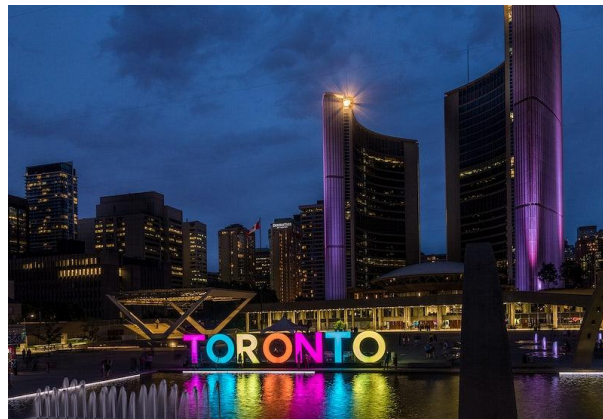
Upper Confidence Bound(UCB)

Bayesian UCB

Thompson Sampling

Linear UCB

Contextual Thompson Sampling



Data

Yelp Open Dataset

An all-purpose dataset for learning



Data - files

01 **users.json**

Business data with business attributes

02 **business.json**

User data including metadata

03 **reviews.json**

Full review text data including user and business id

checkin.json

04

Check Ins on a business

tip.json

05

Tips written by a user on a business

photo.json

06

Contains photo data including caption

Data - size



150,346



1,987,897



6,990,280

Businesses

Users

Reviews

Data - filtering

Location



Restaurants Only



Data - filtering

Number of restaurants after filtering

5899



7148



Benchmark number to reduce complexity

20 - 40

Data - filtering

Average Stars per Restaurant



Las Vegas Minimum reviews

2000

Toronto Minimum reviews

500

Data - Final size



38

Restaurants



88854

Reviews

Data - Final size



24

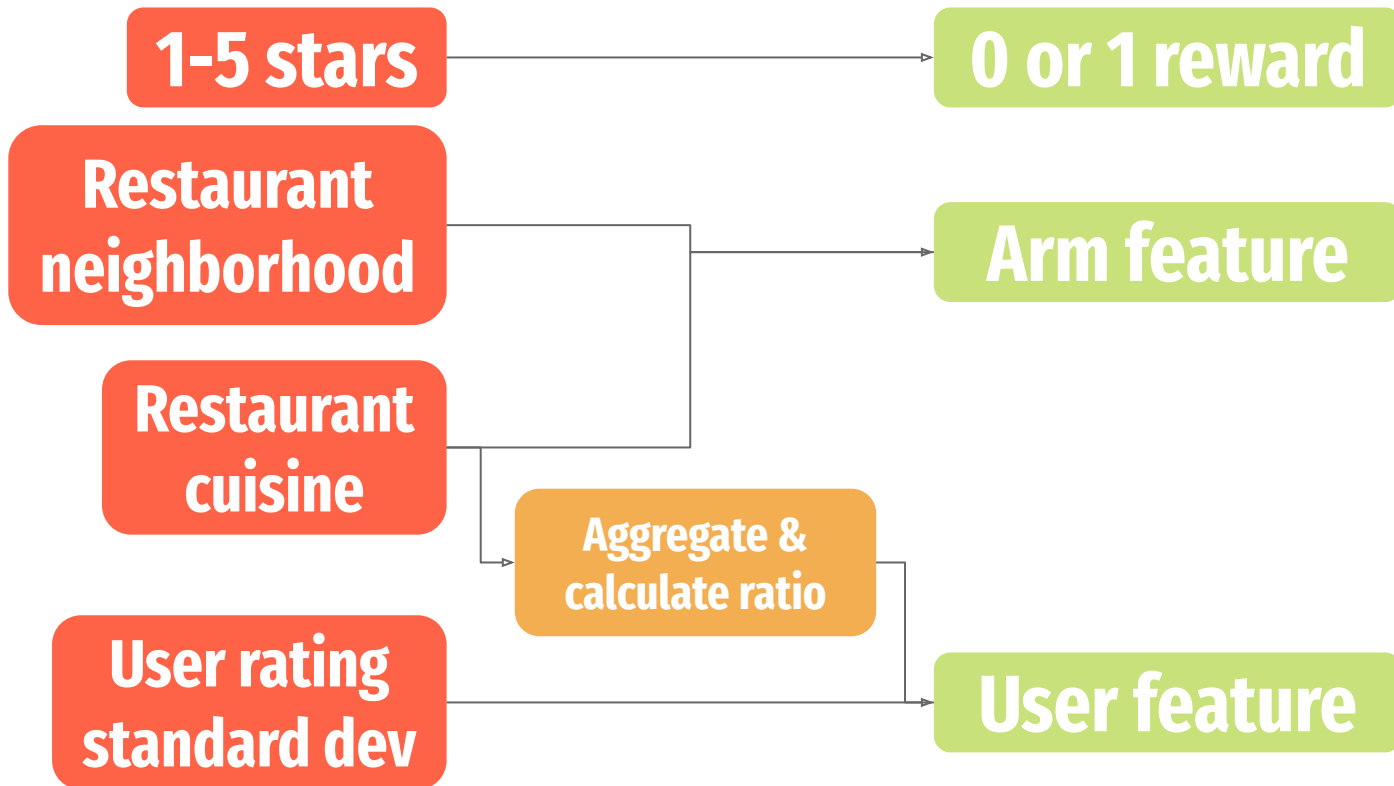


15573

Restaurants

Reviews

Feature Engineering



Methodology - Evaluation Replay

Step 01



Set-up

Each restaurant is one arm, at each time step, a review (including features) is shown to the bandit algorithm

Step 02



Select arm

Bandit algorithm will recommend a restaurant, contextual bandits will use features in their recommendations

Step 03



Update

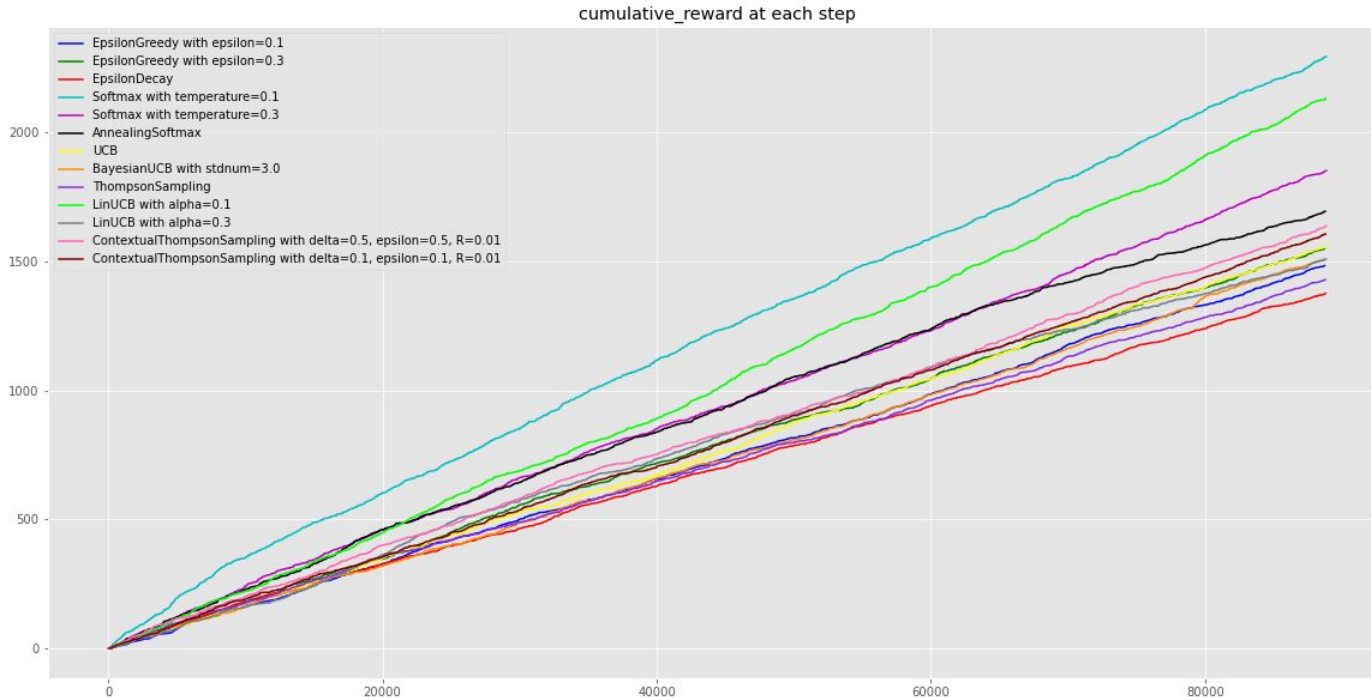
If recommended restaurant matches actual restaurant of review, bandit algorithm will update itself based on the reward of that review

Methodology

Model Name	Parameters Used
Non-contextual Bandit Algorithms	
Epsilon-greedy	epsilon=0.1 epsilon=0.3
Softmax	temperature=0.1 temperature=0.3
Annealing Softmax	
Upper Confidence Bound (UCB)	
Bayesian UCB	stdnum=3
Thompson Sampling	
Contextual Bandit Algorithms	
Linear UCB (LinUCB)	alpha = 0.1 alpha = 0.3
Contextual Thompson Sampling	delta=0.1, epsilon=0.1, R=0.01 delta=0.5, epsilon=0.5, R=0.01

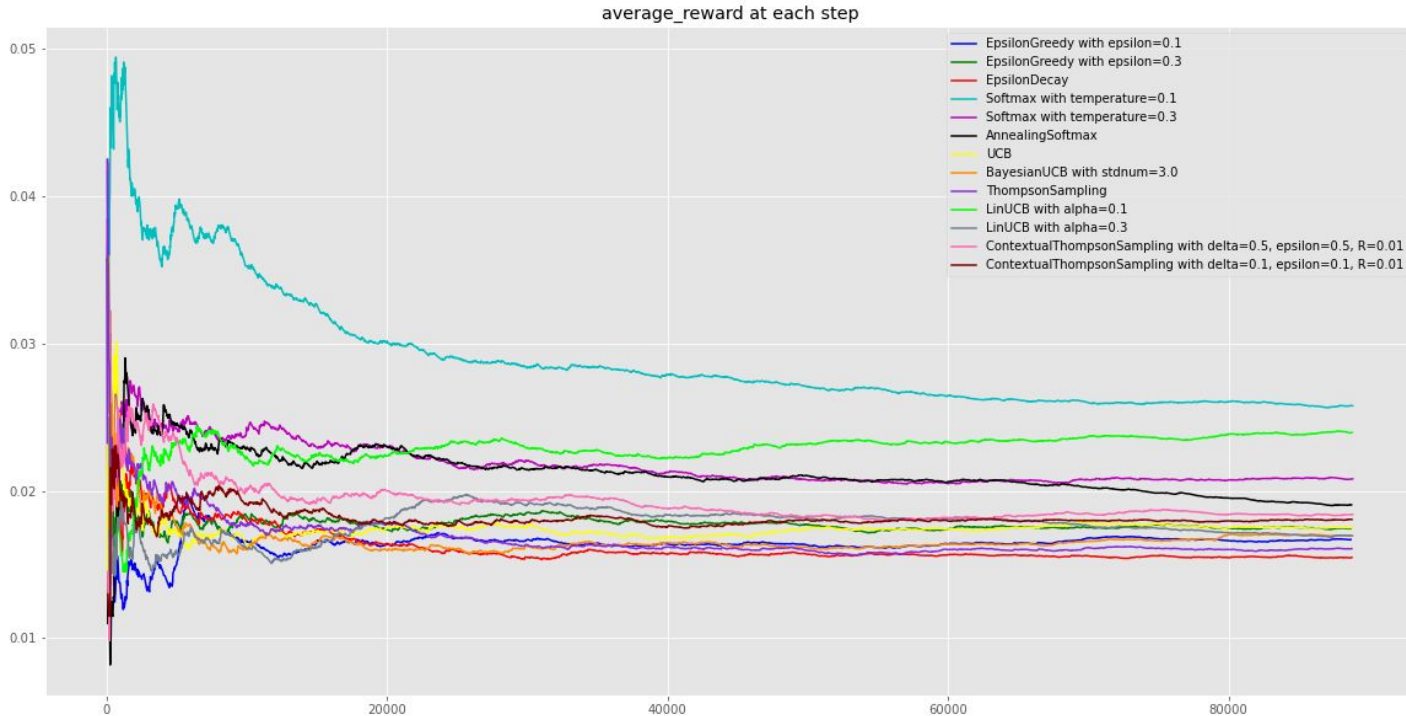
- For Bayesian UCB & Thompson Sampling, reward assumed to follow Bernoulli, Beta distribution as conjugate prior, prior alpha and beta set to 1
- For contextual bandits, model parameters will be disjoint

Las Vegas - Cumulative Reward



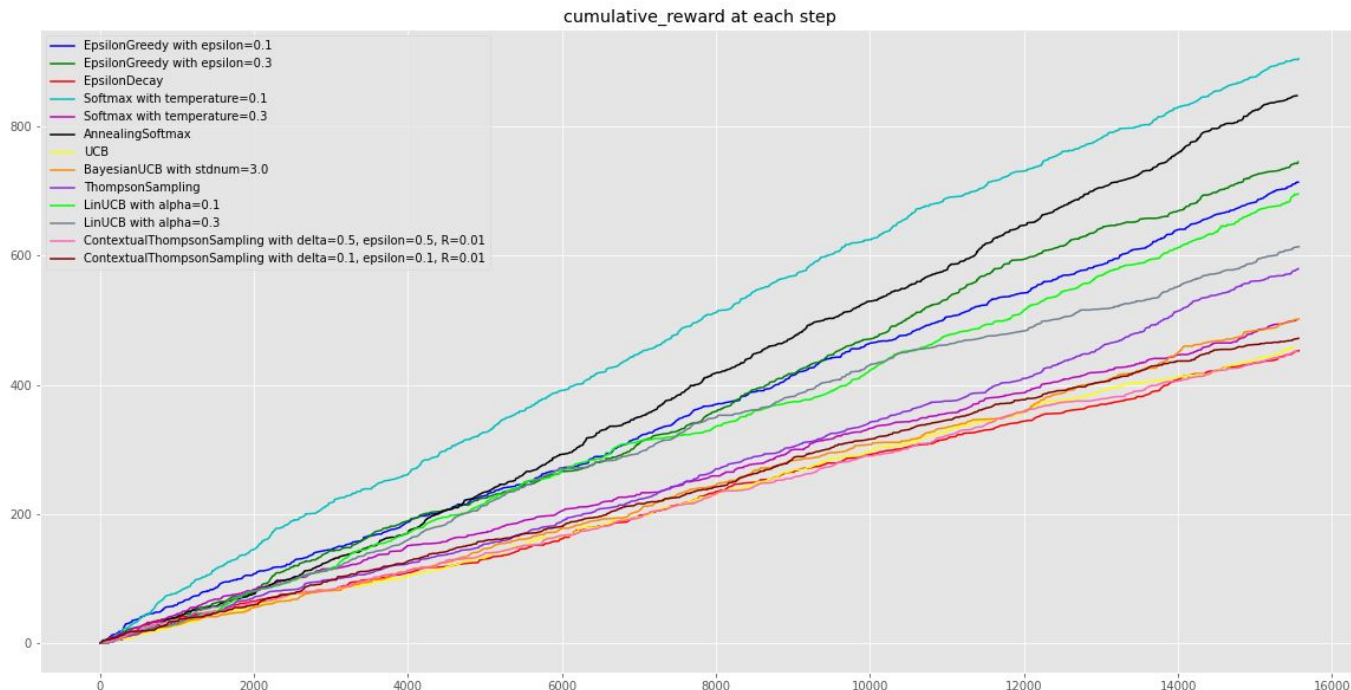
- Softmax (temperature=0.1) was the best performing algorithm, followed by LinUCB($\alpha=0.1$)
- Epsilon-decay and Thompson Sampling had the lowest cumulative reward
- All 3 Softmax variants did well, outside these 3, the contextual bandits had the highest cumulative reward
- Features were useful in understanding distribution of rewards

Las Vegas - Average Reward



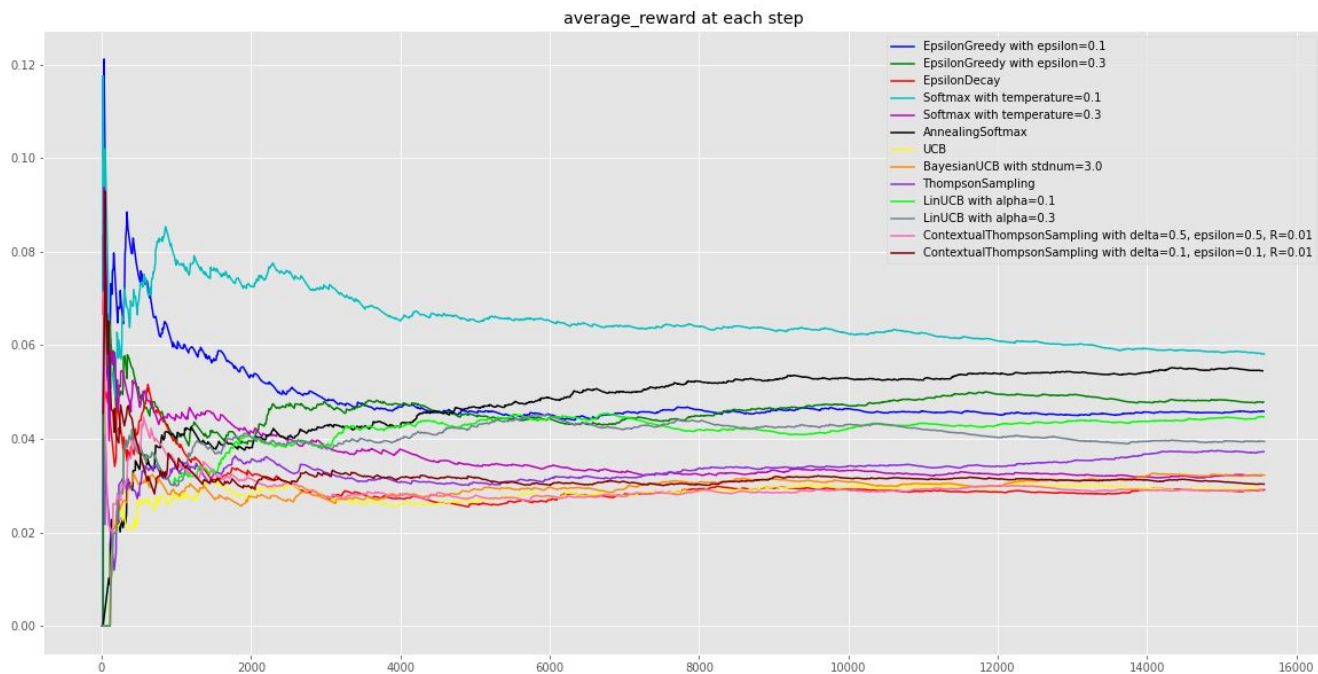
- Same order as cumulative reward
- Softmax (temperature=0.1) takes the longest to converge
- May have allowed it to achieve better long-term performance

Toronto - Cumulative Reward



- **Softmax (temperature = 0.1) still performs the best**
- Followed by Annealing Softmax and EpsilonGreedy algorithms
- Epsilon-decay, UCB and Contextual Thompson Sampling ($\delta=0.1$, $\epsilon=0.5$, $R=0.01$) have **lowest cumulative reward**
- Contextual bandit algorithms fell short on performance
- Smaller size of Toronto dataset may have played a role

Toronto - Average Reward



- Same order as cumulative reward as well
- Other algorithms apart from Softmax (temperature = 0.1) not seem to stabilize as quickly
- Likely due to the smaller dataset compared to Las Vegas

Summary of Results

Softmax - best performing algorithm

Non-zero probability for other arms, vs 'argmax' approach

Bayesian UCB & Thompson Sampling struggled

Assumption of Bernoulli distribution may not be appropriate

LinUCB outperformed Contextual Thompson Sampling

Usage of multivariate Gaussian may not be suitable

Personalized recommendations possible

LinUCB achieved strong performance, features useful in helping to choose best arm

Limitations

Limited features available

**Disjoint vs joint model
parameters**

Hyperparameter tuning

Conclusion

Softmax

Contextual Bandits

LinUCB

**Thank
You**