Upper-Confidence-Bound

January 17, 2025

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'''
    Upper Confidence Bound (UCB) -->

    The Upper Confidence Bound (UCB) is a popular approach in multi-armed
    bandit problems where an agent must balance exploration (trying different
    options to gather information) and exploitation (choosing the best-known␣
 ↪option).
    It is used to optimize the selection of actions based on observed rewards.
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    Problem Context -->

    Imagine you have n slot machines (or "arms") with unknown probabilities
    of reward. The goal is to maximize your total reward over time by
    pulling the arms intelligently.

    How It Works -->

    Initialization:
    Pull each arm once to get initial reward estimates.

    Iterate:
    For each arm, compute the UCB score.
    Select the arm with the highest UCB score.
    Update the reward estimate and pull count for the chosen arm.
    Repeat until a stopping condition (e.g., time limit) is met.

    Key Features -->

    Exploration:
    Arms with fewer pulls are favored because of the ln t/Ni(t) term.

    Exploitation:
    Arms with higher average rewards ( i) are preferred over time.
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    Applications -->

    Recommender Systems: Selecting items or advertisements to display.
    Clinical Trials: Choosing treatments to test on patients.
    Online Learning: Optimizing decisions in real-time scenarios.
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#   Importing Libraries -->

import pandas as pd
import numpy as np
import math
import matplotlib.pyplot as plt
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#   Importing Dataset -->

data = pd.read_csv('Data/Ads_CTR_Optimisation.csv')
data.head(10)
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   Ad 1  Ad 2  Ad 3  Ad 4  Ad 5  Ad 6  Ad 7  Ad 8  Ad 9  Ad 10
0     1     0     0     0     1     0     0     0     1      0
1     0     0     0     0     0     0     0     0     1      0
2     0     0     0     0     0     0     0     0     0      0
3     0     1     0     0     0     0     0     1     0      0
4     0     0     0     0     0     0     0     0     0      0
5     1     1     0     0     0     0     0     0     0      0
6     0     0     0     1     0     0     0     0     0      0
7     1     1     0     0     1     0     0     0     0      0
8     0     0     0     0     0     0     0     0     0      0
9     0     0     1     0     0     0     0     0     0      0
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#   Implementing UCB -->

num_users = 10000
num_ads = 10
ads_selected = []
num_selections = [0] * num_ads
sum_reward = [0] * num_ads
total_reward = 0

for rounds in range(0,num_users):
    ad = 0
    max_upper_bound = 0

    for ads in range(0,num_ads):
        if (num_selections[ads] > 0):
            avg_reward = sum_reward[ads] / num_selections[ads]
            delta = math.sqrt(3/2 * math.log(rounds+1)/num_selections[ads])
            upper_bound = avg_reward + delta

        else:
            upper_bound = 1e400 # Super high value

        if (upper_bound > max_upper_bound):
            max_upper_bound = upper_bound
            ad = ads

    ads_selected.append(ad)
    num_selections[ad] += 1
    reward = data.values[rounds, ad]
    sum_reward[ad] += reward
    total_reward += reward
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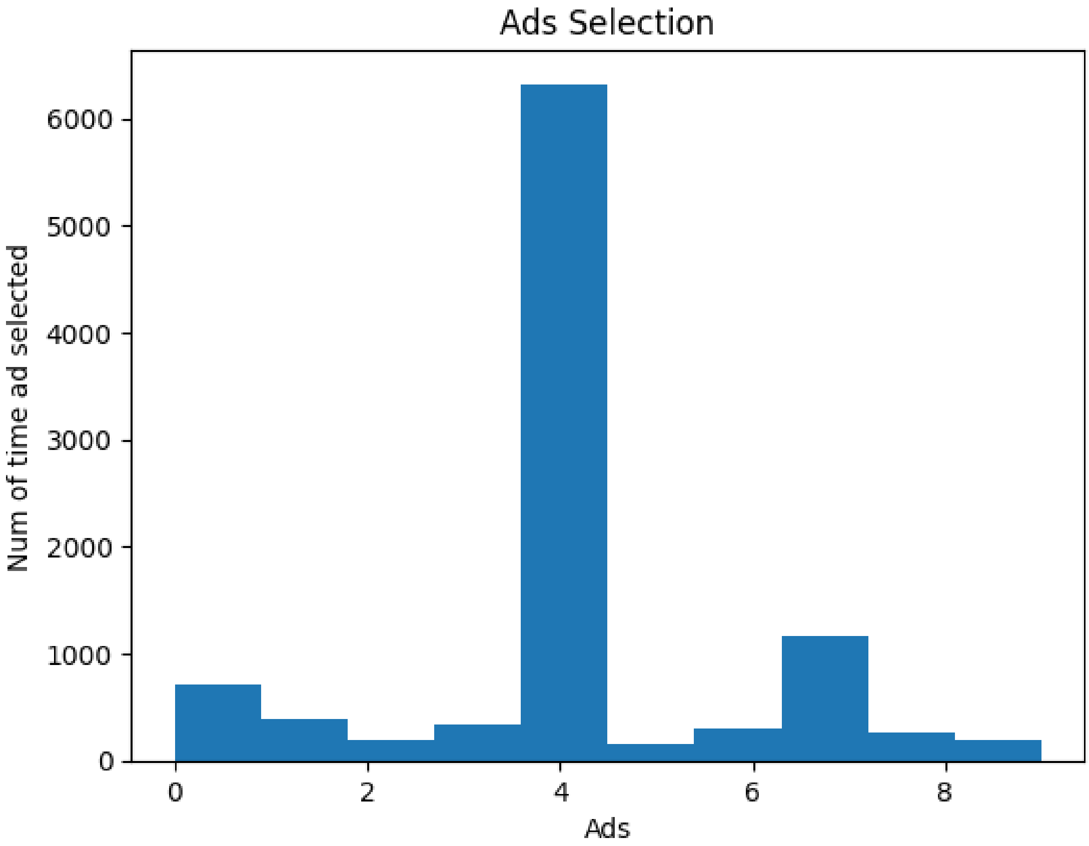
#   Visualizing The Results -->

plt.hist(ads_selected)
plt.title('Ads Selection')
plt.xlabel('Ads')
plt.ylabel('Num of time ad selected')
plt.show()
```



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#   Ad 5 is selected the most !
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#   Let's see how quickly it can identify -->

#   Changing num_users to 1000 to reduce number of rounds !

num_users = 1000
num_ads = 10
ads_selected = []
num_selections = [0] * num_ads
sum_reward = [0] * num_ads
total_reward = 0

for rounds in range(0,num_users):
    ad = 0
    max_upper_bound = 0

    for ads in range(0,num_ads):

        if (num_selections[ads] > 0):
            avg_reward = sum_reward[ads] / num_selections[ads]
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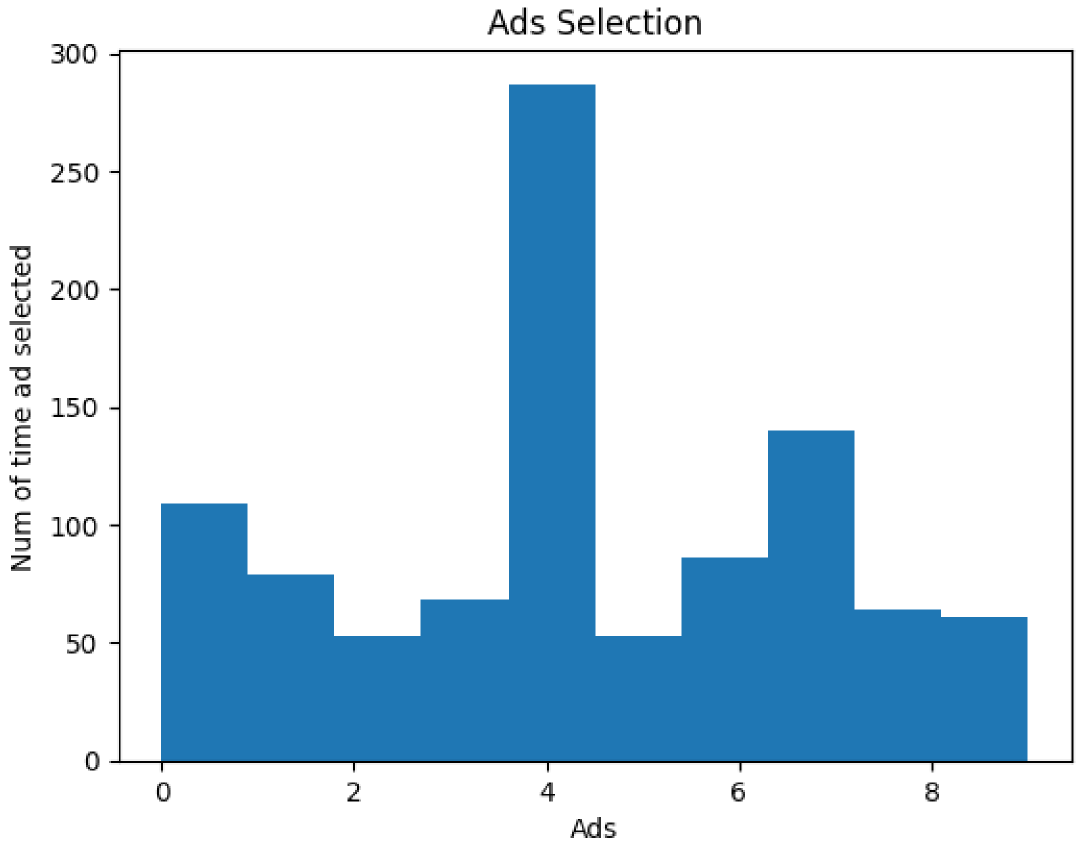

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#   It is still identifying the ad which is most selected !
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#   Let's make it 500 -->

num_users = 500
num_ads = 10
ads_selected = []
num_selections = [0] * num_ads
sum_reward = [0] * num_ads
total_reward = 0

for rounds in range(0,num_users):
    ad = 0
    max_upper_bound = 0

    for ads in range(0,num_ads):

        if (num_selections[ads] > 0):
            avg_reward = sum_reward[ads] / num_selections[ads]
            delta = math.sqrt(3/2 * math.log(rounds+1)/num_selections[ads])
            upper_bound = avg_reward + delta

        else:
            upper_bound = 1e400 # Super high value

        if (upper_bound > max_upper_bound):
            max_upper_bound = upper_bound
            ad = ads

    ads_selected.append(ad)
    num_selections[ad] += 1
    reward = data.values[rounds, ad]
    sum_reward[ad] += reward
    total_reward += reward
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#   Visualizing The Results -->

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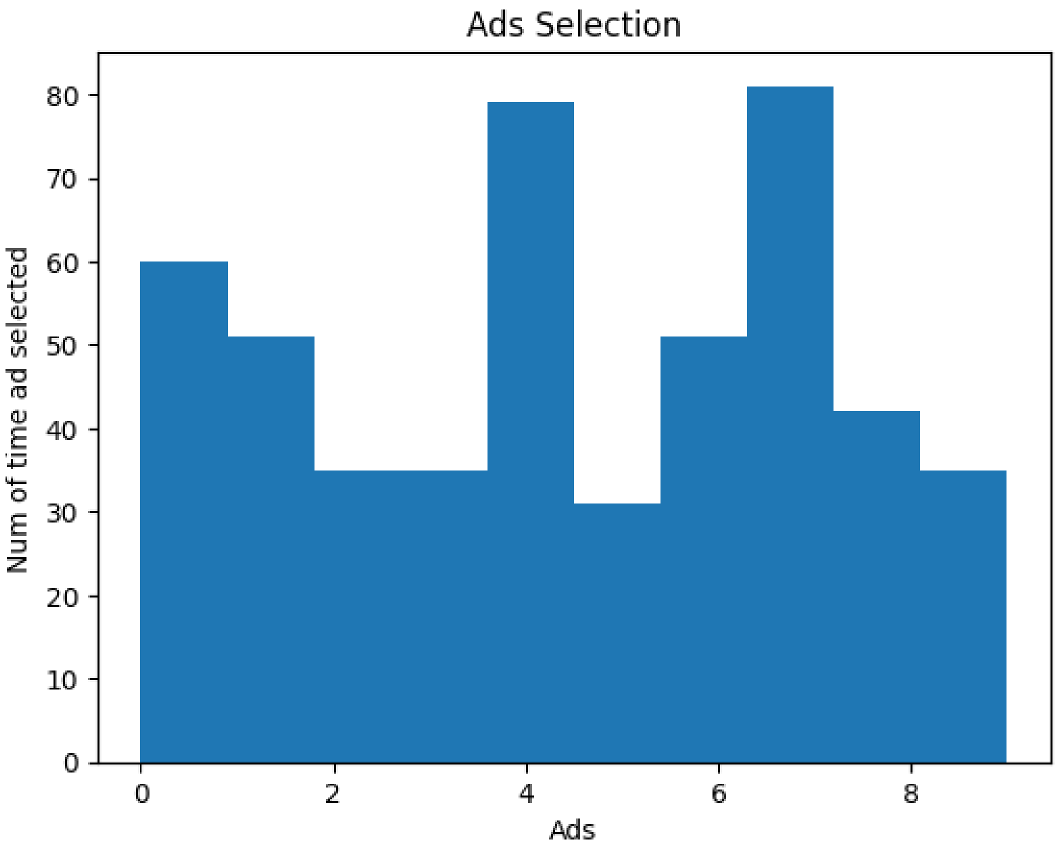

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#   You can see it is unable to identify the ad in 500 rounds !
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