```
# Thompson Sampling for Slot Machines

# Importing the libraries
#(Harris et. al., 2020)
import numpy as np


# Setting conversion rates and the number of samples
conversionRates = [0.15, 0.04, 0.13, 0.11, 0.05]
N = 10000
d = len(conversionRates)

# Creating the dataset
X = np.zeros((N, d))
for i in range(N):
    for j in range(d):
        if np.random.rand() < conversionRates[j]:
            X[i][j] = 1



# Making arrays to count our losses and wins
#np.zeros will "return a new array of given shape and type, filled with zeros"
nPosReward = np.zeros(d)
nNegReward = np.zeros(d)


# Taking our best slot machine through beta distibution and updating its losses and wins
for i in range(N):
    selected = 0
    maxRandom = 0
    for j in range(d):
        randomBeta = np.random.beta(nPosReward[j] + 1, nNegReward[j] + 1)
        if randomBeta > maxRandom:
            maxRandom = randomBeta
            selected = j
    if X[i][selected] == 1:
        nPosReward[selected] += 1
    else:
        nNegReward[selected] += 1


# Showing which slot machine is considered the best
nSelected = nPosReward + nNegReward
for i in range(d):
    print('Machine number ' + str(i + 1) + ' was selected ' + str(nSelected[i]) + ' times')
print('Conclusion: Best machine is machine number ' + str(np.argmax(nSelected) + 1))
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Machine number 1 was selected 8277.0 times
Machine number 2 was selected 58.0 times
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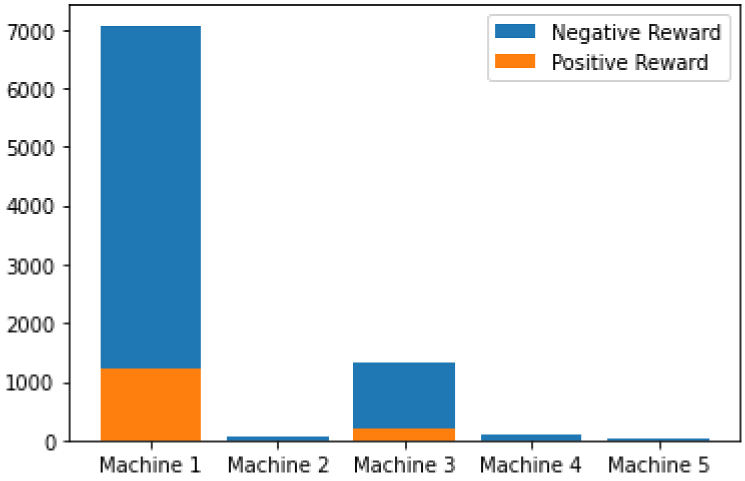
    Machine number 3 was selected 1516.0 times
    Machine number 4 was selected 107.0 times
    Machine number 5 was selected 42.0 times
    Conclusion: Best machine is machine number 1
```

```
# create plot
# The number of times the slot machine number i returned a 1 reward up to round n
# The number of times the slot machine number i returned a 0 reward up to round n
#(Hunter, 2007)
import matplotlib.pyplot as plt

labels = ["Machine 1", "Machine 2", "Machine 3", "Machine 4", "Machine 5"]
fig, ax·=·plt.subplots()
ax.bar(labels, nNegReward, label="Negative Reward")
ax.bar(labels, nPosReward, label="Positive Reward")
ax.legend()
plt.show()
```



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# Models comparison

import numpy as np
import pandas as pd

N = [200, 1000, 5000]
D = 20
convRanges = [(0., 0.1), (0., 0.3), (0., 0.5)]
```

```
from google.colab import drive

drive.mount('/content/gdrive')
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```
    Drive already mounted at /content/gdrive; to attempt to forcibly remount, call drive.mou
    results = list()
    for n in N:
        for ranges in convRanges:
            results.append([])
            for d  in range(3, D + 1):
                p1 = 0
                p2 = 0

                for rounds in range(1000):

                    conversionRates = list()
                    for i in range(d):
                        conversionRates.append(np.random.uniform(low = ranges[0], high = ranges[1

                    X = np.zeros((n,d))
                    for i in range(n):
                        for j in range(d):
                            if np.random.rand() < conversionRates[j]:
                                X[i][j] = 1

                    nPosReward = np.zeros(d)
                    nNegReward = np.zeros(d)

                    for i in range(n):
                        selected = 0
                        maxRandom = 0

                        for j in range(d):
                            randomBeta = np.random.beta(nPosReward[j] + 1, nNegReward[j] + 1)
                            if randomBeta > maxRandom:
                                maxRandom = randomBeta
                                selected = j

                        if X[i][selected] == 1:
                            nPosReward[selected] += 1
                        else:
                            nNegReward[selected] += 1

                    nSelected = nPosReward + nNegReward

                    left = n - max(nSelected)

                    countStandard = np.zeros(d)

                    x = int(left / d)
                    for i in range(x):
                        for j in range(d):
                            if X[i][j] == 1:
                                countStandard[j] += 1

                    bestStandard = np.argmax(countStandard)
                    bestReal = np.argmax(conversionRates)
                    bestTS = np.argmax(nSelected)

                    if bestTS == bestReal:
                        p1 += 1
                    if bestStandard == bestReal:
                        p2 += 1

                print('N = ' + str(n) + ' d = ' + str(d) + ' range = ' + str(ranges) + ' | result
                results.append([n, ranges, d, p1, p2])

    df = pd.DataFrame(results)
```

```
N = 1000 d = 16 range = (0.0, 0.5) | result Thompson Sampling = 588 result Standard s
N = 1000 d = 17 range = (0.0, 0.5) | result Thompson Sampling = 574 result Standard s
N = 1000 d = 18 range = (0.0, 0.5) | result Thompson Sampling = 533 result Standard s
N = 1000 d = 19 range = (0.0, 0.5) | result Thompson Sampling = 537 result Standard s
N = 1000 d = 20 range = (0.0, 0.5) | result Thompson Sampling = 502 result Standard s
N = 5000 d = 3 range = (0.0, 0.1) | result Thompson Sampling = 907 result Standard so
N = 5000 d = 4 range = (0.0, 0.1) | result Thompson Sampling = 873 result Standard so
N = 5000 d = 5 range = (0.0, 0.1) | result Thompson Sampling = 817 result Standard so
N = 5000 d = 6 range = (0.0, 0.1) | result Thompson Sampling = 787 result Standard so
N = 5000 d = 7 range = (0.0, 0.1) | result Thompson Sampling = 745 result Standard so
N = 5000 d = 8 range = (0.0, 0.1) | result Thompson Sampling = 700 result Standard so
N = 5000 d = 9 range = (0.0, 0.1) | result Thompson Sampling = 663 result Standard so
N = 5000 d = 10 range = (0.0, 0.1) | result Thompson Sampling = 648 result Standard s
N = 5000 d = 11 range = (0.0, 0.1) | result Thompson Sampling = 609 result Standard s
N = 5000 d = 12 range = (0.0, 0.1) | result Thompson Sampling = 584 result Standard s
N = 5000 d = 13 range = (0.0, 0.1) | result Thompson Sampling = 567 result Standard s
N = 5000 d = 14 range = (0.0, 0.1) | result Thompson Sampling = 551 result Standard s
N = 5000 d = 15 range = (0.0, 0.1) | result Thompson Sampling = 525 result Standard s
N = 5000 d = 16 range = (0.0, 0.1) | result Thompson Sampling = 486 result Standard s
N = 5000 d = 17 range = (0.0, 0.1) | result Thompson Sampling = 474 result Standard s
N = 5000 d = 18 range = (0.0, 0.1) | result Thompson Sampling = 498 result Standard s
N = 5000 d = 19 range = (0.0, 0.1) | result Thompson Sampling = 484 result Standard s
N = 5000 d = 20 range = (0.0, 0.1) | result Thompson Sampling = 421 result Standard s
N = 5000 d = 3 range = (0.0, 0.3) | result Thompson Sampling = 945 result Standard so
N = 5000 d = 4 range = (0.0, 0.3) | result Thompson Sampling = 928 result Standard so
N = 5000 d = 5 range = (0.0, 0.3) | result Thompson Sampling = 897 result Standard so
N = 5000 d = 6 range = (0.0, 0.3) | result Thompson Sampling = 869 result Standard so
N = 5000 d = 7 range = (0.0, 0.3) | result Thompson Sampling = 867 result Standard so
N = 5000 d = 8 range = (0.0, 0.3) | result Thompson Sampling = 830 result Standard so
N = 5000 d = 9 range = (0.0, 0.3) | result Thompson Sampling = 828 result Standard so
N = 5000 d = 10 range = (0.0, 0.3) | result Thompson Sampling = 803 result Standard s
N = 5000 d = 11 range = (0.0, 0.3) | result Thompson Sampling = 756 result Standard s
N = 5000 d = 12 range = (0.0, 0.3) | result Thompson Sampling = 742 result Standard s
N = 5000 d = 13 range = (0.0, 0.3) | result Thompson Sampling = 726 result Standard s
N = 5000 d = 14 range = (0.0, 0.3) | result Thompson Sampling = 728 result Standard s
N = 5000 d = 15 range = (0.0, 0.3) | result Thompson Sampling = 686 result Standard s
N = 5000 d = 16 range = (0.0, 0.3) | result Thompson Sampling = 692 result Standard s
N = 5000 d = 17 range = (0.0, 0.3) | result Thompson Sampling = 667 result Standard s
N = 5000 d = 18 range = (0.0, 0.3) | result Thompson Sampling = 642 result Standard s
N = 5000 d = 19 range = (0.0, 0.3) | result Thompson Sampling = 653 result Standard s
N = 5000 d = 20 range = (0.0, 0.3) | result Thompson Sampling = 627 result Standard s
```

```
N = 5000 d = 3 range = (0.0, 0.5) | result Thompson Sampling = 957 result Standard so
N = 5000 d = 4 range = (0.0, 0.5) | result Thompson Sampling = 941 result Standard so
N = 5000 d = 5 range = (0.0, 0.5) | result Thompson Sampling = 924 result Standard so
N = 5000 d = 6 range = (0.0, 0.5) | result Thompson Sampling = 905 result Standard so
N = 5000 d = 7 range = (0.0, 0.5) | result Thompson Sampling = 889 result Standard so
N = 5000 d = 8 range = (0.0, 0.5) | result Thompson Sampling = 866 result Standard so
N = 5000 d = 9 range = (0.0, 0.5) | result Thompson Sampling = 853 result Standard so
N = 5000 d = 10 range = (0.0, 0.5) | result Thompson Sampling = 859 result Standard s
N = 5000 d = 11 range = (0.0, 0.5) | result Thompson Sampling = 845 result Standard s
N = 5000 d = 12 range = (0.0, 0.5) | result Thompson Sampling = 836 result Standard s
N = 5000 d = 13 range = (0.0, 0.5) | result Thompson Sampling = 815 result Standard s
N = 5000 d = 14 range = (0.0, 0.5) | result Thompson Sampling = 792 result Standard s
N = 5000 d = 15 range = (0.0, 0.5) | result Thompson Sampling = 772 result Standard s
N = 5000 d = 16 range = (0.0, 0.5) | result Thompson Sampling = 770 result Standard s
N = 5000 d = 17 range = (0.0, 0.5) | result Thompson Sampling = 754 result Standard s
N = 5000 d = 18 range = (0.0, 0.5) | result Thompson Sampling = 765 result Standard s
N = 5000 d = 19 range = (0.0, 0.5) | result Thompson Sampling = 726 result Standard s
```

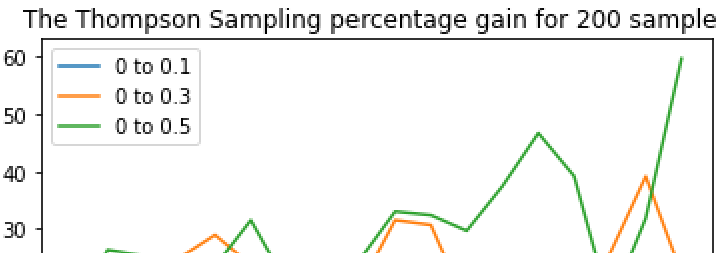
```
df.to_excel('/content/gdrive/MyDrive/results.xlsx', sheet_name = 'Result', index = False)
```

```
import pandas as pd
list_200 = df[df[0] == 200]
list_1000 = df[df[0] == 1000]
list_5000 = df[df[0] == 5000]
```

```
ranges = list(range(3,21))
list_200_01 = list_200[list_200[1] == (0.0, 0.1)]
list_200_03 = list_200[list_200[1] == (0.0, 0.3)]
list_200_05 = list_200[list_200[1] == (0.0, 0.5)]

pg_200_01 = ((list_200_01[3] - list_200_01[4]) / list_200_01[4]) * 100
pg_200_03 = ((list_200_03[3] - list_200_03[4]) / list_200_03[4]) * 100
pg_200_05 = ((list_200_05[3] - list_200_05[4]) / list_200_05[4]) * 100
```

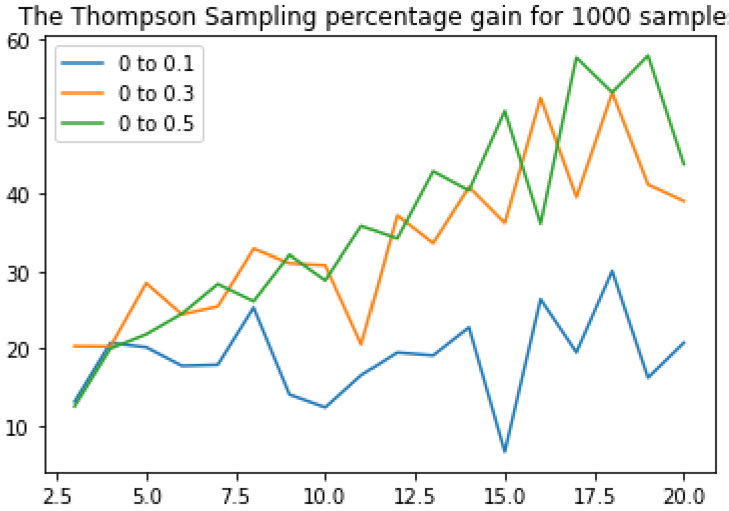
```
plt.plot(ranges,·pg_200_01,·label·=·"0·to·0.1")
plt.plot(ranges,·pg_200_03,·label·=·"0·to·0.3")
plt.plot(ranges,·pg_200_05,·label·=·"0·to·0.5")·
plt.legend()
plt.title("The·Thompson·Sampling·percentage·gain·for·200·samples")
plt.show()
```



```
list_1000_01 = list_1000[list_1000[1] == (0.0, 0.1)]
list_1000_03 = list_1000[list_1000[1] == (0.0, 0.3)]
list_1000_05 = list_1000[list_1000[1] == (0.0, 0.5)]

pg_1000_01 = ((list_1000_01[3] - list_1000_01[4]) / list_1000_01[4]) * 100
pg_1000_03 = ((list_1000_03[3] - list_1000_03[4]) / list_1000_03[4]) * 100
pg_1000_05 = ((list_1000_05[3] - list_1000_05[4]) / list_1000_05[4]) * 100

plt.plot(ranges, pg_1000_01, label = "0 to 0.1")
plt.plot(ranges, pg_1000_03, label = "0 to 0.3")
plt.plot(ranges, pg_1000_05, label = "0 to 0.5")
plt.legend()
plt.title("The Thompson Sampling percentage gain for 1000 samples")
plt.show()
```



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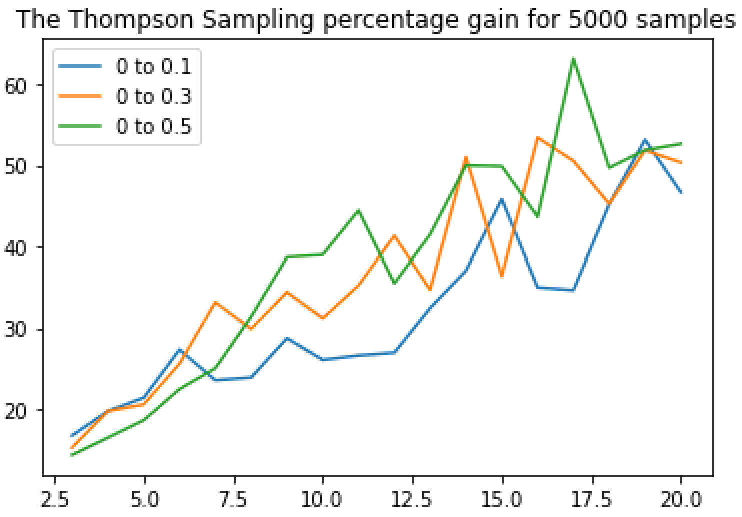
list_5000_01 = list_5000[list_5000[1] == (0.0, 0.1)]
list_5000_03 = list_5000[list_5000[1] == (0.0, 0.3)]
list_5000_05 = list_5000[list_5000[1] == (0.0, 0.5)]

pg_5000_01 = ((list_5000_01[3] - list_5000_01[4]) / list_5000_01[4]) * 100
pg_5000_03 = ((list_5000_03[3] - list_5000_03[4]) / list_5000_03[4]) * 100
pg_5000_05 = ((list_5000_05[3] - list_5000_05[4]) / list_5000_05[4]) * 100

plt.plot(ranges, pg_5000_01, label = "0 to 0.1")
plt.plot(ranges, pg_5000_03, label = "0 to 0.3")
plt.plot(ranges, pg_5000_05, label = "0 to 0.5")
plt.legend()
plt.title("The Thompson Sampling percentage gain for 5000 samples")
plt.show()
```

```
    plt.show()
```



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