ETC

February 11, 2018

```
In [1]: import numpy as np
        from math import ceil,log,log10,sqrt
        import matplotlib.pyplot as plt
        import pandas as pd
        import dill

In [2]: filename = 'globalsave3.pkl'
        # dill.dump_session(filename)
        # dill.load_session(filename)

In [3]: def ETC(horizon,replications,arms_prob,m):

            arm_means = [0]*len(arms_prob)
            arm_pulls = [0]*len(arms_prob)
            optimal_arm = 0

            optimal_arm_pulls_per_round = np.zeros([horizon,replications])
            regret_per_round = np.zeros([horizon,replications])

            gap = arms_prob[0] - arms_prob[1]
            print('Gap is :', gap)
            print('M is :', m)

            for r in range(replications):

                #Exploration
                t = 0
                for i in range(len(arms_prob)):
                    for j in range(m):
                        arm_pulls[i]+=1
                        temp = np.random.binomial(1,arms_prob[i])
                        arm_means[i] += (temp - arm_means[i])/arm_pulls[i]
                        if i == optimal_arm:
                            optimal_arm_pulls_per_round[t,r] += 1
                        regret_per_round[t,r] = (arms_prob[optimal_arm] - arms_prob[i])
                        t+=1

                        ''' # Incremental mean update
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                    if i == optimal_arm:
                       optimal_arm_pulls_per_round[t] += (1 - optimal_arm_pulls_per_roun
                    else:
                        optimal_arm_pulls_per_round[t] += (0 - optimal_arm_pulls_per_rou
                    regret_per_round[t] += (arms_prob[optimal_arm] - arms_prob[i] - regr
                '''

            #Exploitation
            best_arm = np.argmax(arm_means)
#           print("Best arm in round : ",replications,"is : ",best_arm)
            for h in range(horizon - m*len(arms_prob)):
                arm_pulls[best_arm] += 1
                temp = np.random.binomial(1, arms_prob[best_arm])
                arm_means[best_arm] += (temp - arm_means[best_arm]) /arm_pulls[best_arm]
                if best_arm == optimal_arm:
                    optimal_arm_pulls_per_round[t,r] += 1
                regret_per_round[t,r] = (arms_prob[optimal_arm] - arms_prob[best_arm])
                t+=1


        # Calculating Mean and Standard Error for % optimal arm pulls
        optimal_arm_means_stderr = np.zeros([horizon,2])
        optimal_arm_means_stderr[:,0] = np.mean(optimal_arm_pulls_per_round,axis=1)
        optimal_arm_means_stderr[:,1] = (np.std(optimal_arm_pulls_per_round, axis=1)/sqrt(re
        optimal_arm_percentage = sum(optimal_arm_means_stderr[:,0])/horizon*100
        optimal_arm_pulls_sum = np.cumsum(optimal_arm_means_stderr[:,0])/horizon*100
        print("Total Optimal arm pulls :",sum(optimal_arm_means_stderr[:,0]),'and percentage


        # Calculating Mean and Standard Error for commulative regret
        regret_means_stderr = np.zeros([horizon,2])
        regret_means_stderr[:,0] = np.mean(regret_per_round,axis=1)
        regret_means_stderr[:,1] = (np.std(regret_per_round, axis=1)/sqrt(replications))
        total_regret = sum(regret_means_stderr[:,0])
        regret_per_round_sum = np.cumsum(regret_means_stderr[:,0])
        print("Total Regret :",total_regret)

        theoretical_regret = gap + (4/gap)*(1+log(horizon*gap**2/4))
        print("Theoretical Regret : ",theoretical_regret,"\n")

        return regret_per_round_sum,regret_means_stderr, optimal_arm_pulls_sum,optimal_arm_m
```

In [4]:
```
horizon = 10000
replications = 100
arms_prob = [[0.9, 0.6], [0.9, 0.8], [0.55, 0.45]]
problem = 2
m_len = 5
optimal_arm_pulls_sum = np.zeros([m_len,horizon])
```

```
    regret_per_round_sum = np.zeros([m_len,horizon])
    optimal_arm_means_stderr = np.zeros([m_len,horizon,2])
    regret_means_stderr = np.zeros([m_len,horizon,2])
    optimal_arm_percentage = np.zeros([m_len])
    total_regret = np.zeros([m_len])
    theoretical_regret = np.zeros([m_len])



    for i in range(m_len):
        gap = arms_prob[problem][0] - arms_prob[problem][1]
        optimal_m = ceil(4*log(horizon*gap**2/4)/gap**2)
        m = [optimal_m,100,500,1000,3000]
        print("Executing problem :",problem,"with arms probability :",arms_prob[problem]," w
        regret_per_round_sum[i,:],regret_means_stderr[i,:,:], optimal_arm_pulls_sum[i,:],opt
```

```
Executing problem : 2 with arms probability : [0.55, 0.45]  with M =  1288
Gap is : 0.10000000000000003
M is : 1288
Total Optimal arm pulls : 8712.0 and percentage is : 87.12
Total Regret : 128.8
Theoretical Regret :  168.85503299472796

Executing problem : 2 with arms probability : [0.55, 0.45]  with M =  100
Gap is : 0.10000000000000003
M is : 100
Total Optimal arm pulls : 9900.0 and percentage is : 99.0
Total Regret : 10.0
Theoretical Regret :  168.85503299472796

Executing problem : 2 with arms probability : [0.55, 0.45]  with M =  500
Gap is : 0.10000000000000003
M is : 500
Total Optimal arm pulls : 9500.0 and percentage is : 95.0
Total Regret : 50.0
Theoretical Regret :  168.85503299472796

Executing problem : 2 with arms probability : [0.55, 0.45]  with M =  1000
Gap is : 0.10000000000000003
M is : 1000
Total Optimal arm pulls : 9000.0 and percentage is : 90.0
Total Regret : 100.0
Theoretical Regret :  168.85503299472796

Executing problem : 2 with arms probability : [0.55, 0.45]  with M =  3000
Gap is : 0.10000000000000003
M is : 3000
Total Optimal arm pulls : 7000.0 and percentage is : 70.0
```

```
Total Regret : 300.0
Theoretical Regret :  168.85503299472796
```

```
In [5]: from IPython.display import HTML, display

        def tableIt(data):
            print(pd.DataFrame(data))
```

```
In [6]: print("optimal_arm_percentage")
        tableIt(optimal_arm_percentage)

        print("total_regret")
        tableIt(total_regret)

        print("theoretical_regret")
        tableIt(theoretical_regret)
```

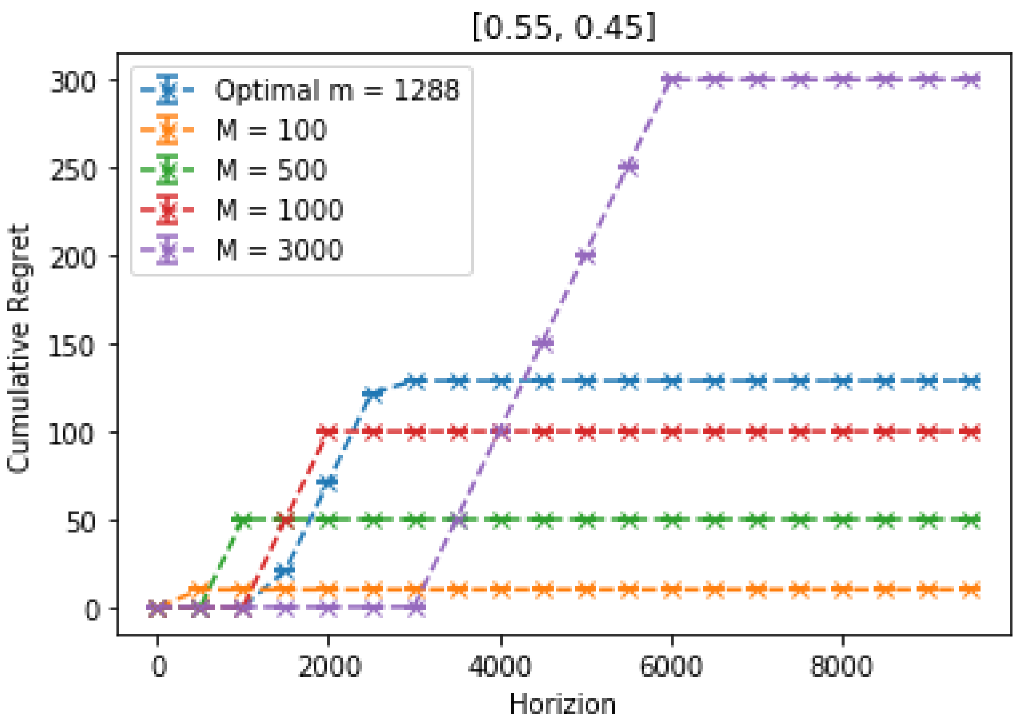
```
optimal_arm_percentage
       0
0  87.12
1  99.00
2  95.00
3  90.00
4  70.00
total_regret
       0
0  128.8
1   10.0
2   50.0
3  100.0
4  300.0
theoretical_regret
            0
0  168.855033
1  168.855033
2  168.855033
3  168.855033
4  168.855033
```

```
In [7]: x = np.arange(horizon)
        ind = [i for i in range(0,horizon,500)]

        for i in range(m_len):
            plt.errorbar(x[ind],regret_per_round_sum[i,ind], regret_means_stderr[i,ind,1],
                    linestyle='--', marker='x',capsize=4,capthick=1.5,elinewidth=1.5)
```

```
plt.xlabel('Horizion')
plt.ylabel('Cumulative Regret')
plt.legend(['Optimal m = '+str(optimal_m),'M = 100','M = 500','M = 1000','M = 3000','Err
plt.title(arms_prob[problem])
plt.savefig('CumulativeRegret_'+str(problem)+'.png',dpi=300)
plt.show()

print("regret_means_stderr")
print(regret_means_stderr[:,[500,2000,5000,8000,9500],1])
```

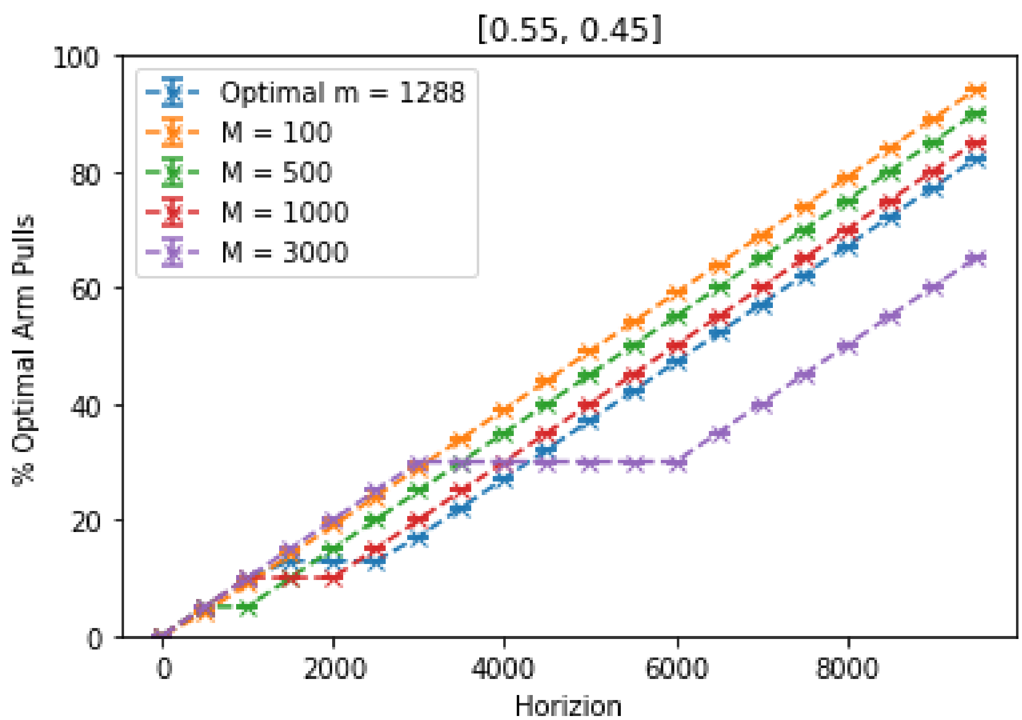



```
regret_means_stderr
[[  0.00000000e+00   1.38777878e-18   0.00000000e+00   0.00000000e+00
    0.00000000e+00]
 [  0.00000000e+00   0.00000000e+00   0.00000000e+00   0.00000000e+00
    0.00000000e+00]
 [  1.38777878e-18   0.00000000e+00   0.00000000e+00   0.00000000e+00
    0.00000000e+00]
 [  0.00000000e+00   0.00000000e+00   0.00000000e+00   0.00000000e+00
    0.00000000e+00]
 [  0.00000000e+00   0.00000000e+00   1.38777878e-18   0.00000000e+00
    0.00000000e+00]]
```

```
In [8]: for i in range(m_len):
            plt.errorbar(x[ind],optimal_arm_pulls_sum[i,ind], optimal_arm_means_stderr[i,ind,1],
```

```
                linestyle='--', marker='x',capsize=4,capthick=1.5,elinewidth=1.5)
plt.xlabel('Horizion')
plt.ylabel('% Optimal Arm Pulls')
plt.legend(['Optimal m = '+str(optimal_m),'M = 100','M = 500','M = 1000','M = 3000','Err
plt.title(arms_prob[problem])
plt.ylim((0,100))
plt.savefig('OptimalArmPulls_'+str(problem)+'.png',dpi=300)
plt.show()

print("optimal_arm_means_stderr")
print(optimal_arm_means_stderr[:,[500,2000,5000,8000,9500],1])
```




```
optimal_arm_means_stderr
[[ 0.  0.  0.  0.  0.]
 [ 0.  0.  0.  0.  0.]
 [ 0.  0.  0.  0.  0.]
 [ 0.  0.  0.  0.  0.]
 [ 0.  0.  0.  0.  0.]]
```