bayesian-bandits-code

March 15, 2020

[55]:

```python
import matplotlib.pyplot as plt
import numpy as np
from scipy.stats import beta, uniform
import seaborn as sns
```

0.1 Example 1

[36]:

```python
NUM_TRIALS = 2000
BANDIT_PROBABILITIES = [0.2, 0.5, 0.75]
```

[30]:

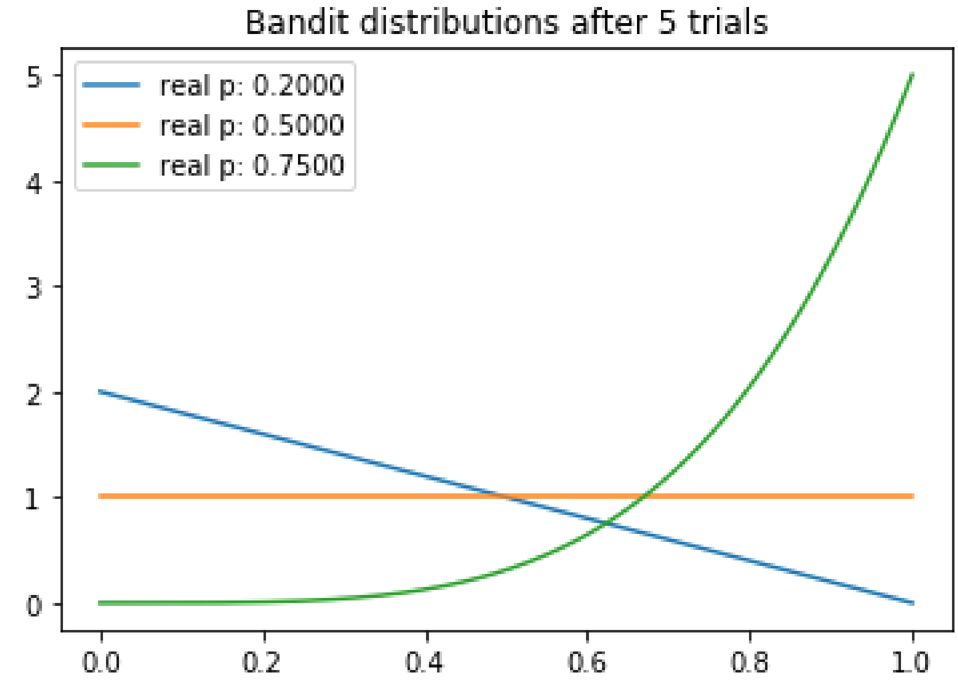
```python
class Bandit(object):
  def __init__(self, p):
    self.p = p
    self.a = 1
    self.b = 1

  def pull(self):
    return np.random.random() < self.p

  def sample(self):
    return np.random.beta(self.a, self.b)

  def update(self, x):
    self.a += x
    self.b += 1 - x


def plot(bandits, trial):
  x = np.linspace(0, 1, 200)
  for b in bandits:
    y = beta.pdf(x, b.a, b.b)
    plt.plot(x, y, label='real p: %.4f' % b.p)
  plt.title('Bandit distributions after %s trials' % trial)
  plt.legend()
  plt.show()
```

```
def experiment():
  bandits = [Bandit(p) for p in BANDIT_PROBABILITIES]

  sample_points = [5, 10, 20, 50, 100, 200, 500, 1000, 1500, 1999]

  for i in range(NUM_TRIALS):
    bestb = None
    maxsample = -1
    allsamples = []
    for b in bandits:
      sample = b.sample()
      allsamples.append('%.4f' % sample)
      if sample > maxsample:
        maxsample = sample
        bestb = b
    if i in sample_points:
      print('current samples: %s' % allsamples)
      plot(bandits, i)

    x = bestb.pull()
    bestb.update(x)
```

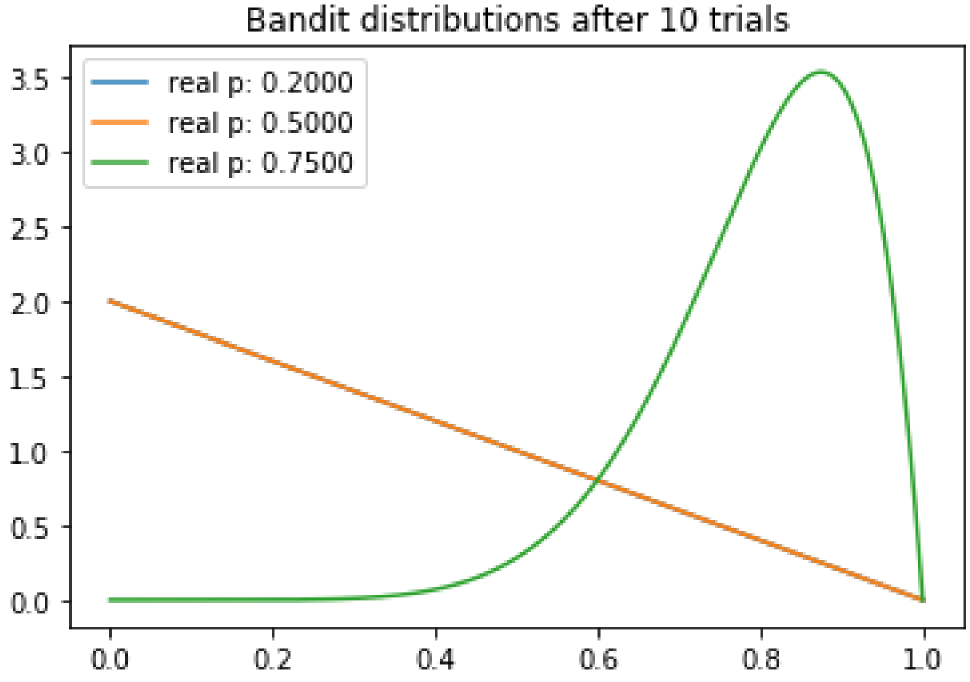
[31]:

```
experiment();
```

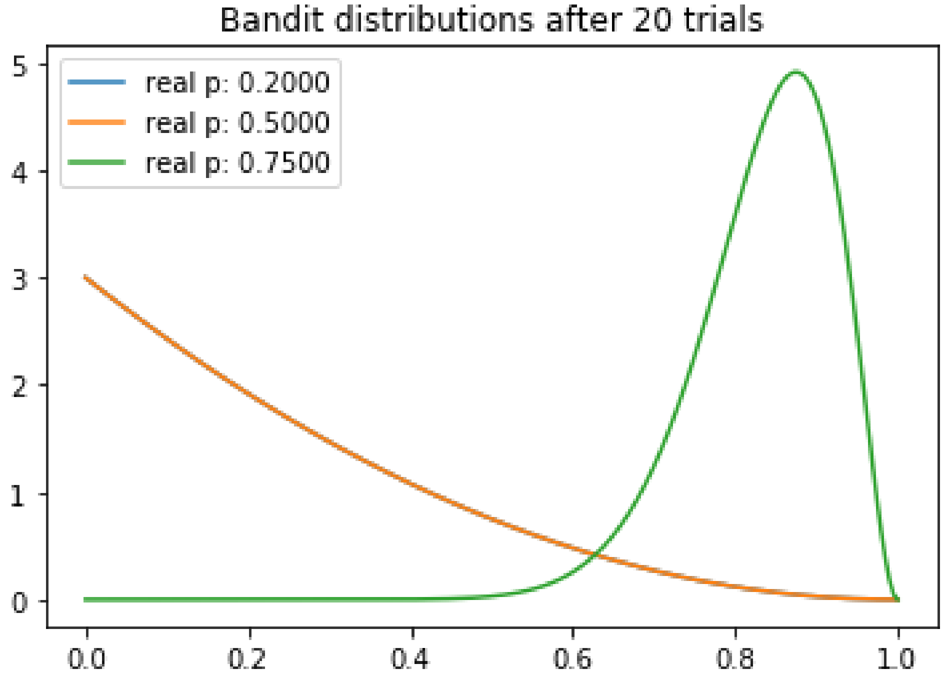
```
current samples: ['0.7618', '0.4567', '0.8549']
```



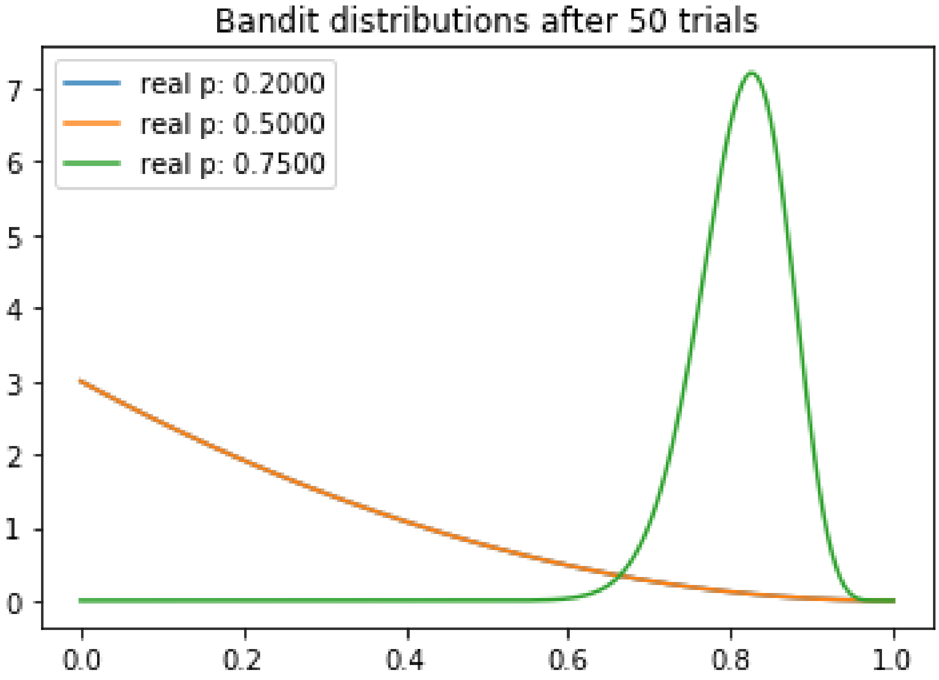
```
current samples: ['0.1935', '0.0163', '0.7698']
```



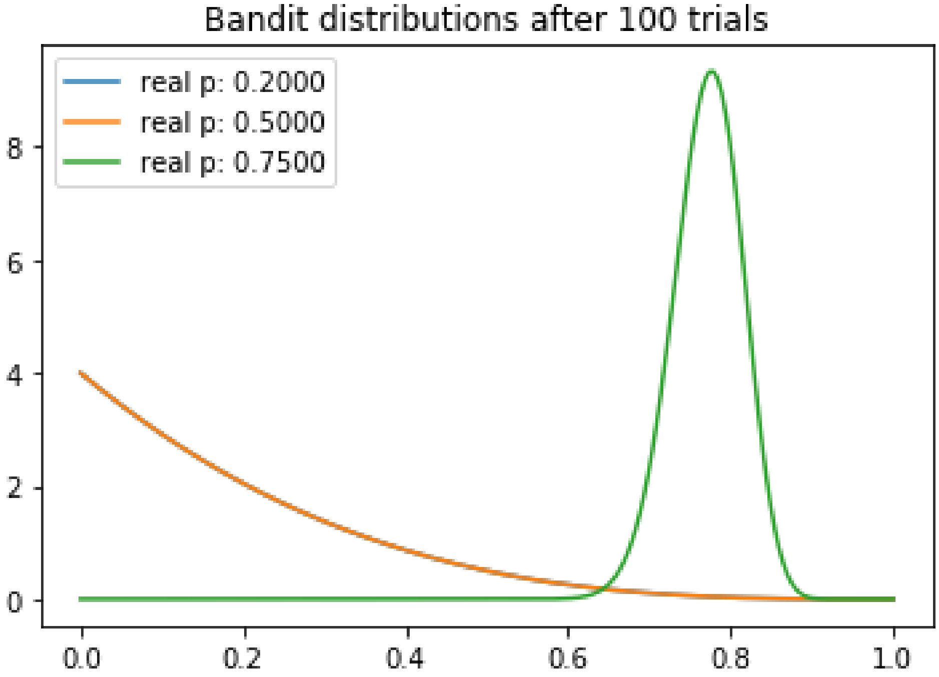
```
current samples: ['0.0806', '0.5004', '0.9161']
```



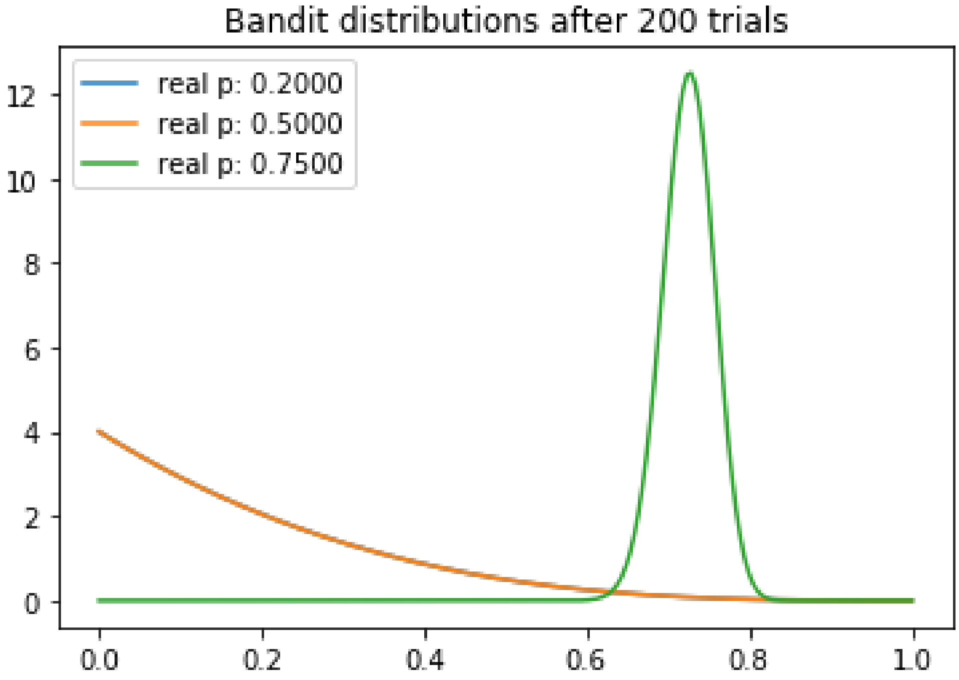
```
current samples: ['0.2050', '0.1388', '0.8971']
```



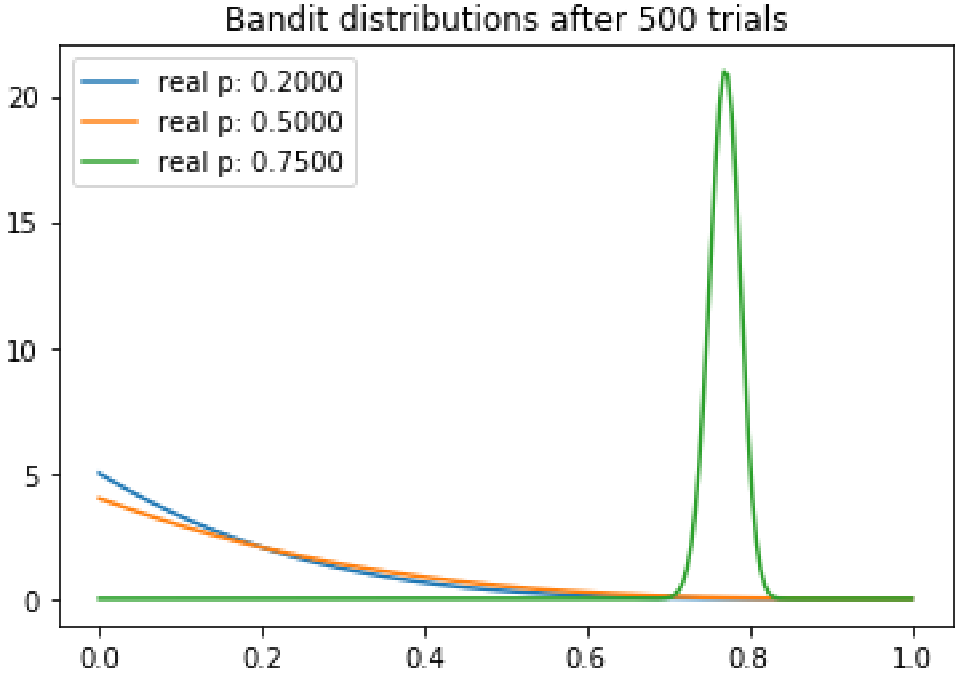
```
current samples: ['0.0555', '0.0838', '0.8012']
```



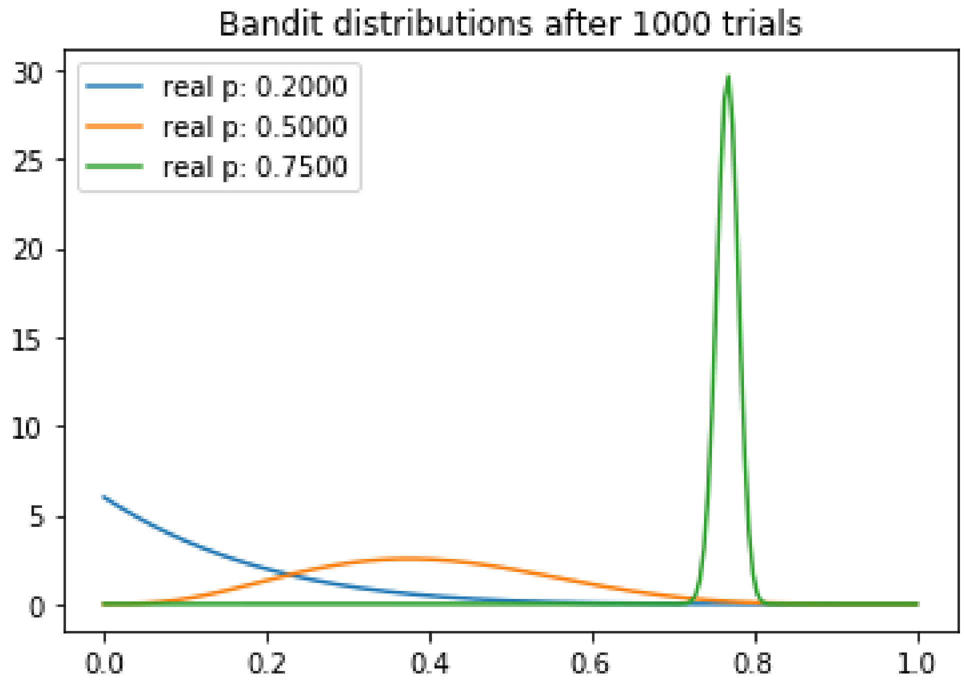
```
current samples: ['0.4525', '0.0752', '0.7951']
```



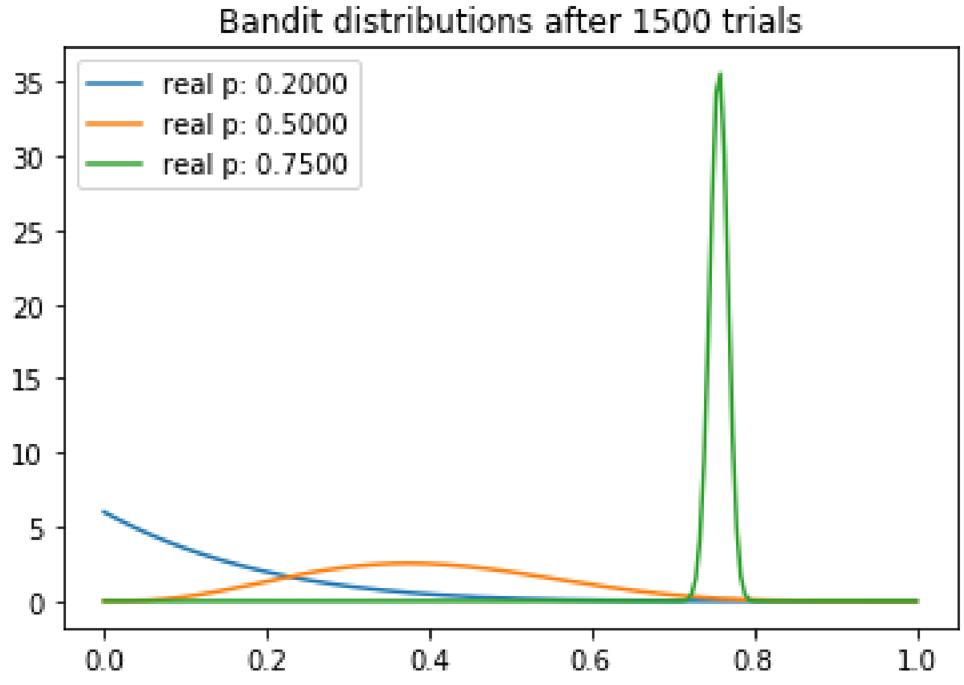
```
current samples: ['0.0559', '0.0381', '0.7579']
```



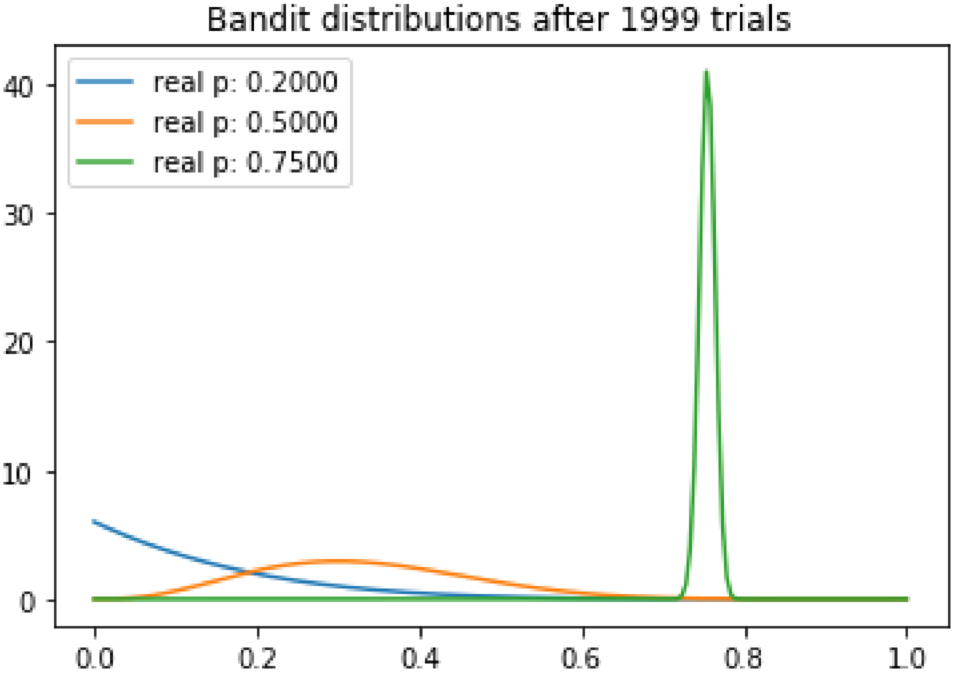
```
current samples: ['0.1711', '0.3887', '0.7536']
```



```
current samples: ['0.1885', '0.3112', '0.7767']
```



```
current samples: ['0.1058', '0.1914', '0.7520']
```



0.2 Example 2

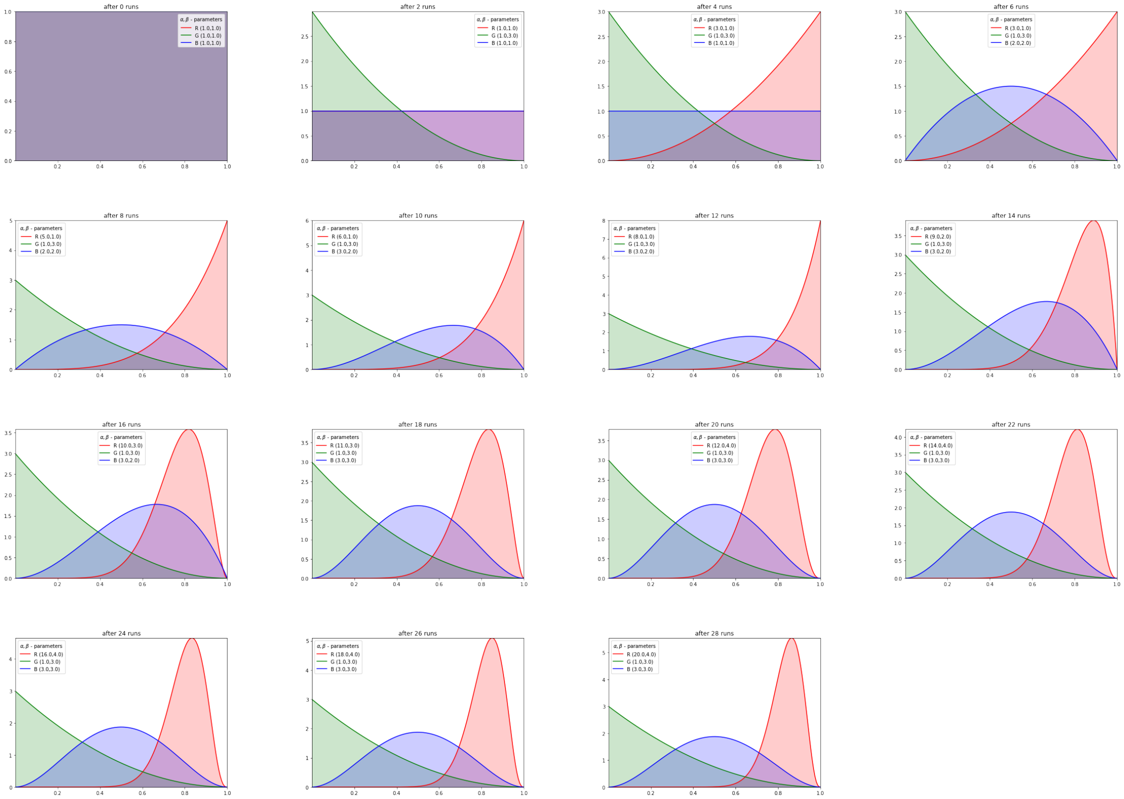
[59]:
```
'''
This function takes as input three tuples for alpha,beta that specify␣
 ↪priorR,priorG,priorB
And returns R,G,B along with the maximum value sampled from these three␣
 ↪distributions.
We can sample from a beta distribution using scipy.
'''
def find_asset(priorR,priorG,priorB):
    red_rv = beta.rvs(priorR[0],priorR[1])
    green_rv = beta.rvs(priorG[0],priorG[1])
    blue_rv = beta.rvs(priorB[0],priorB[1])
    return assets[np.argmax([red_rv,green_rv,blue_rv])]


'''
This is a helper function that simulates the real world using the actual␣
 ↪probability value of the assets.
```

```
In real life we won't have this function and our user click input will be the␣
 ↪proxy for this function.
'''
def simulate_real_website(asset, real_probs_dict):
    #simulate a coin toss with probability. Asset clicked or not.
    if real_probs_dict[asset]> uniform.rvs(0,1):
        return 1
    else:
        return 0

'''
This function takes as input the selected asset and returns the posteriors for␣
 ↪the selected asset.
'''
def update_posterior(asset,priorR,priorG,priorB,outcome):
    if asset=='R':
        priorR=(priorR[0]+outcome,priorR[1]+1-outcome)
    elif asset=='G':
        priorG=(priorG[0]+outcome,priorG[1]+1-outcome)
    elif asset=='B':
        priorB=(priorB[0]+outcome,priorB[1]+1-outcome)
    return priorR,priorG,priorB


'''
This function runs the strategy once.
'''
def run_strategy_once(priorR,priorG,priorB):
    # 1. get the asset
    asset = find_asset(priorR,priorG,priorB)
    # 2. get the outcome from the website/users
    outcome = simulate_real_website(asset, real_probs_dict)
    # 3. update prior based on outcome
    priorR,priorG,priorB = update_posterior(asset,priorR,priorG,priorB,outcome)
    return asset,priorR,priorG,priorB

def plot_posteriors(priorR,priorG,priorB,ax=None,title=None):
    #fig = plt.figure(figsize=(12.5, 10))
    parameters = [priorR,priorG,priorB]
    x = np.linspace(0.001, 1, 150)
    for i, (_alpha, _beta) in enumerate(parameters):
        color = assets[i]
        y = beta.pdf(x, _alpha, _beta)
        lines = sns.lineplot(x, y, label="%s (%.1f,%.1f)" % (color, _alpha,␣
 ↪_beta), color = color,ax=ax)
        plt.fill_between(x, 0, y, alpha=0.2, color=color)
        if title:
            plt.title(title)
        plt.autoscale(tight=True)
    plt.legend(title=r"$\alpha, \beta$ - parameters")
    return plt
```

[60]:
```
real_probs_dict = {'R':0.8,'G':0.4,'B':0.3}
assets = ['R','G','B']

priorR,priorG,priorB = (1,1),(1,1),(1,1)

data = [("_",priorR,priorG,priorB)]

for i in range(50):
    asset,priorR,priorG,priorB = run_strategy_once(priorR,priorG,priorB)
    data.append((asset,priorR,priorG,priorB))
```

[61]:
```
fig = plt.figure(figsize=(40, 60))
fig.subplots_adjust(hspace=0.4, wspace=0.4)
cnt=1
for i in range(0,30,2):
    ax = fig.add_subplot(8, 4, cnt)
    g = plot_posteriors(*data[i][1:],ax,"after "+str(i)+" runs")
    cnt+=1
plt.show()
```

```
/Users/jujohnson/anaconda3/envs/tf.latest/lib/python3.6/site-
packages/ipykernel_launcher.py:57: MatplotlibDeprecationWarning: Support for
uppercase single-letter colors is deprecated since Matplotlib 3.1 and will be
removed in 3.3; please use lowercase instead.
/Users/jujohnson/anaconda3/envs/tf.latest/lib/python3.6/site-
packages/IPython/core/pylabtools.py:128: MatplotlibDeprecationWarning: Support
for uppercase single-letter colors is deprecated since Matplotlib 3.1 and will
be removed in 3.3; please use lowercase instead.
  fig.canvas.print_figure(bytes_io, **kw)
```


after 0 runs
α, β - parameters
R (1.0,1.0)
G (1.0,1.0)
B (1.0,1.0)
after 2 runs
α, β - parameters
R (1.0,1.0)
G (1.0,3.0)
B (1.0,1.0)
after 4 runs
α, β - parameters
R (3.0,1.0)
G (1.0,3.0)
B (1.0,1.0)
after 6 runs
α, β - parameters
R (3.0,1.0)
G (1.0,3.0)
B (2.0,2.0)
after 8 runs
α, β - parameters
R (5.0,1.0)
G (1.0,3.0)
B (2.0,2.0)
after 10 runs
α, β - parameters
R (6.0,1.0)
G (1.0,3.0)
B (3.0,2.0)
after 12 runs
α, β - parameters
R (8.0,1.0)
G (1.0,3.0)
B (3.0,2.0)
after 14 runs
α, β - parameters
R (9.0,2.0)
G (1.0,3.0)
B (3.0,2.0)
after 16 runs
α, β - parameters
R (10.0,3.0)
G (1.0,3.0)
B (3.0,2.0)
after 18 runs
α, β - parameters
R (11.0,3.0)
G (1.0,3.0)
B (3.0,3.0)
after 20 runs
α, β - parameters
R (12.0,4.0)
G (1.0,3.0)
B (3.0,3.0)
after 22 runs
α, β - parameters
R (14.0,4.0)
G (1.0,3.0)
B (3.0,3.0)
after 24 runs
α, β - parameters
R (16.0,4.0)
G (1.0,3.0)
B (3.0,3.0)
after 26 runs
α, β - parameters
R (18.0,4.0)
G (1.0,3.0)
B (3.0,3.0)
after 28 runs
α, β - parameters
R (20.0,4.0)
G (1.0,3.0)
B (3.0,3.0)
0.2
0.4
0.6
0.8
1.0

[ ]:

[ ]: