

A6 Python ver

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2021-01-25

Contents

page 4 Implementation-basic	2
page 5 “The first-time would write”	3
page 10 convergence trajectory	4
page 10 Graph	6

page 4 Implementation-basic

```
import numpy as np

np.random.seed(1234) # fix the random seed
N = 10**3
x = np.random.rand(N,1)*2 - 1
y = np.random.rand(N,1)*2 - 1
t = np.sqrt(x**2+y**2)

pi_hat = 4*np.sum(t<=1) / N
pi_hat

## 3.06
```

page 5 “The first-time would write”

```
np.random.seed(1234) # fix the random seed

MC_N = 10**6
count = 0

for MC_i in range(MC_N):
    x_i = np.random.uniform(0,1)*2 - 1
    y_i = np.random.uniform(0,1)*2 - 1
    t_i = np.sqrt(x_i**2+y_i**2)

    if t_i <= 1:
        count= count + 1

pi_hat = 4*count / MC_N
pi_hat

## 3.140204
```

page 10 convergence trajectory

```
import time

np.random.seed(1234) # fix the random seed
beg_time = time.time()
old_est = 0
n = 1
MC_N = 10**6

while True:
    x_i=np.random.uniform(0,1)*2-1
    y_i=np.random.uniform(0,1)*2-1
    t_i=np.sqrt(x_i**2+y_i**2)

    A_n=4*(t_i<=1)

    new_est=((n-1)/n)*old_est + (1/n)*A_n

    if n > MC_N:
        break

    n+=1
    old_est=new_est

print(new_est)

## 3.1402048597951002

end_time=time.time()
print('Time difference of ',end_time-beg_time,' secs')

## Time difference of 11.347616910934448 secs
```

page 10 convergence trajectory

```
import matplotlib.pyplot as plt

np.random.seed(1234) # fix the random seed
beg_time = time.time()
old_est = 0
n = 1
MC_N = 10**6
results = []

while True:
    x_i=np.random.uniform(0,1)*2-1
    y_i=np.random.uniform(0,1)*2-1
    t_i=np.sqrt(x_i**2+y_i**2)

    A_n=4*(t_i<=1)

    new_est=((n-1)/n)*old_est + (1/n)*A_n
    results.append(new_est)

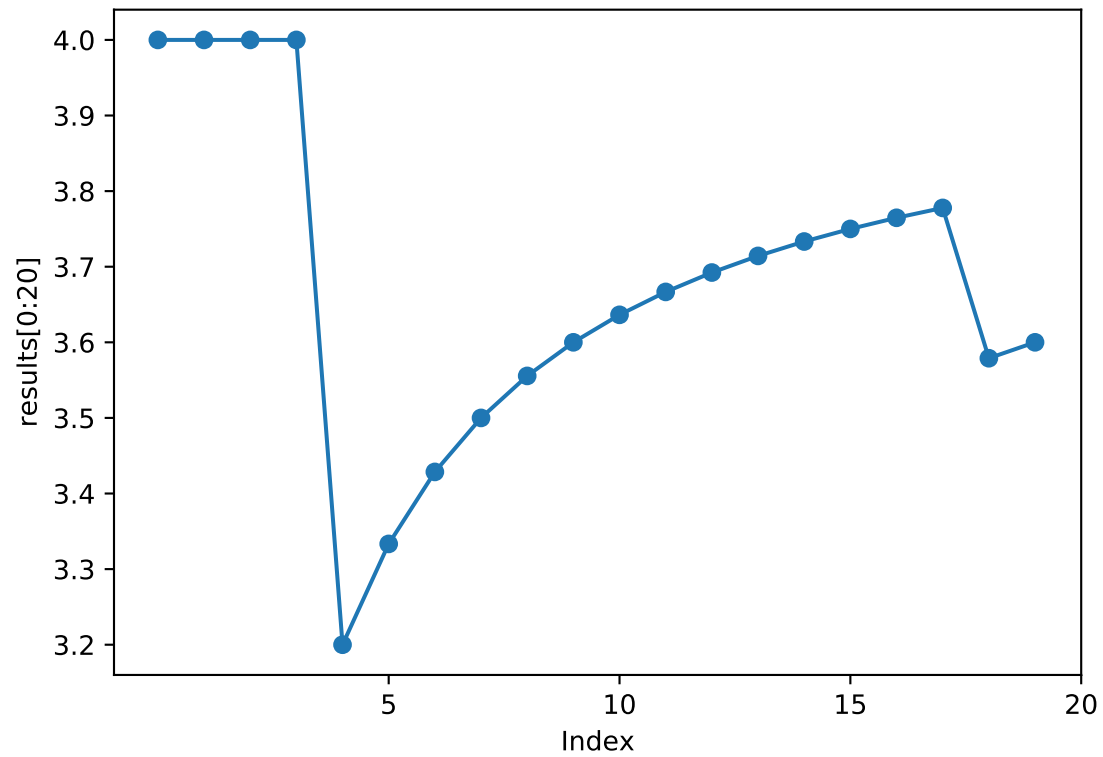
    if n > MC_N:
        break

    n+=1
    old_est=new_est

plt.plot(results[0:20],marker='o')
plt.xlabel('Index')
plt.ylabel('results[0:20]')
plt.xticks([5,10,15,20])

## ([<matplotlib.axis.XTick object at 0x000000002D358278>, <matplotlib.axis.XTick object at 0x000000002D358278>])

plt.show()
```

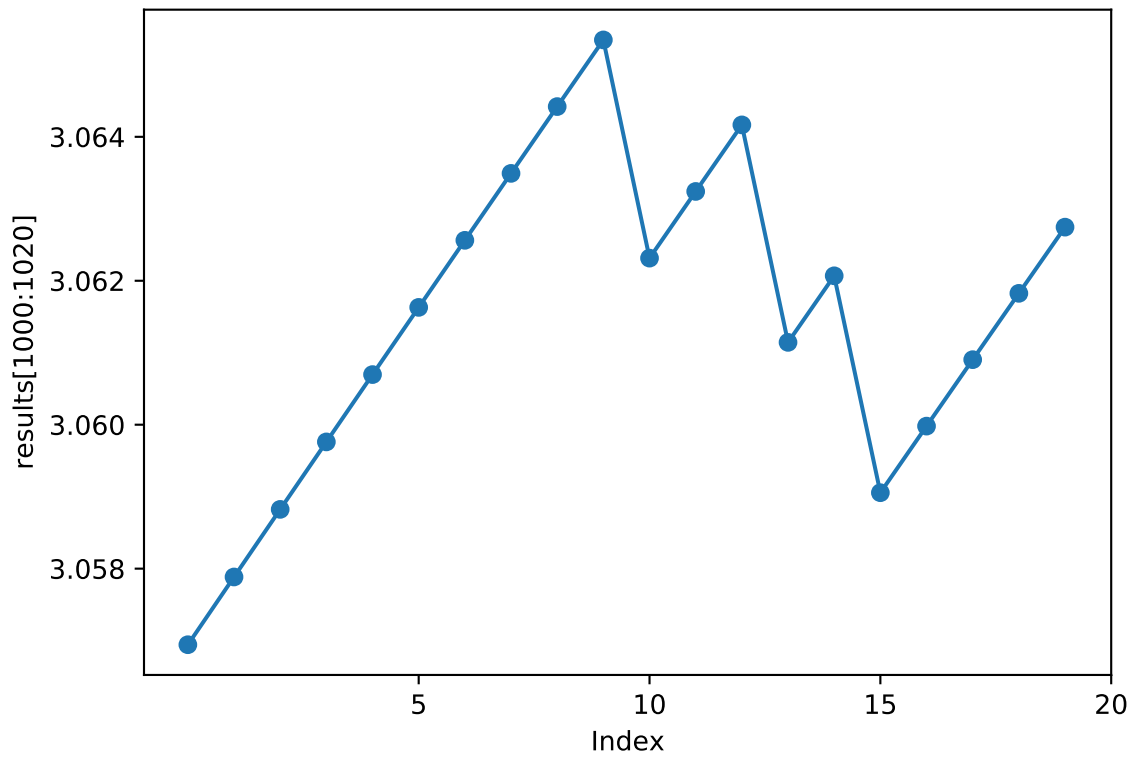


page 10 Graph

```
plt.plot(results[1000:1020],marker='o')
plt.xlabel('Index')
plt.ylabel('results[1000:1020]')
plt.xticks([5,10,15,20])
```

```
## ([<matplotlib.axis.XTick object at 0x000000002D430898>, <matplotlib.axis.XTick object at 0x000000002D430898>],
```

```
plt.show())
```



page 10 Graph

```
plt.plot(results[100000:100020],marker='o')
plt.xlabel('Index')
plt.ylabel('results[100000:100020]')
plt.xticks([5,10,15,20])
```

```
## ([<matplotlib.axis.XTick object at 0x000000002D5D5828>, <matplotlib.axis.XTick object at 0x0000000002D5D5828>])
```

```
plt.show()
```

