code02

September 9, 2021

0.0.1 Lab02

0.0.2 2021-09-09

0.0.3 Moments: Examples: Functions for Mean and Variance in Python

```
In [1]: import numpy as np
```

```
In [2]: def fn_mean_var(data):

            if len(data) == 0:
                return (None, None)

            mean = sum(data) / len(data)
            var = sum((data - mean)** 2) / len(data)

            return (mean, var)



        data = np.array((range(10)))
        print(data)
        print(fn_mean_var(data))
```

```
[0 1 2 3 4 5 6 7 8 9]
(4.5, 8.25)
```

```
In [3]: def fn_mean_var_second(data):

            if len(data) == 0:
                return (None, None)

            mean = sum(data) / len(data)
            var = sum((data - mean) ** 2) / len(data)

            # return a dictionary object
            # so we have control of the output
            return {
```

```
            "mean": mean,
            "var": var,
        }


    data = np.array((range(10)))
    print(data)
    print(fn_mean_var_second(data))
```

```
[0 1 2 3 4 5 6 7 8 9]
{'mean': 4.5, 'var': 8.25}
```

```
In [4]: # Always use a "standard" implementation if exists

        def fn_mean_var_third(data):
            # the function translates data into a numpy array
            # and applies the methods for mean and var
            return {"mean": np.array(data).mean(), "var": np.array(data).var()}


        data = list(range(10))
        print(data)
        print(fn_mean_var_third(data))
```

```
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
{'mean': 4.5, 'var': 8.25}
```

0.0.4 Functions to calculate first 10 moments:

Recall from lecture:

$$M_k := E(X - E(X))^k$$

```
In [5]: def fn_moments(data, number_of_moments=10):

            if len(data) == 0:
                return None

            data = np.array(data)
            mean = data.mean()

            # return a dictionary: where k points to k-th moment
            return {k: np.array((data - mean) ** k).mean() for k in range(number_of_moments)}


        data = list(range(10))
        print("date: ", data)
        print("momdents:", fn_moments(data))
```

```
date:  [0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
momdents: {0: 1.0, 1: 0.0, 2: 8.25, 3: 0.0, 4: 120.8625, 5: 0.0, 6: 2079.515625, 7: 0.0, 8: 384
```

Examine the 0th moment;
Examine the odd moments: What values do they take? Does it makes sense?

0.0.5 Generate random variables

```
In [6]: ### generate 1000 i.i.d. random variables X_i's:


        ### X_i follows unif[0, 1]
        number_of_samples = 1000
        sample_uniform = np.random.uniform(0, 1, number_of_samples)

        # display first 10
        sample_uniform[ :10]
```

```
Out[6]: array([0.39832695, 0.18521393, 0.46254488, 0.73017618, 0.9121479 ,
               0.04953912, 0.94611426, 0.21311086, 0.24772881, 0.3451323 ])
```

```
In [7]: # examine our function
        fn_mean_var_third(sample_uniform)
```

```
Out[7]: {'mean': 0.5116874546484749, 'var': 0.08434051651951975}
```

```
In [8]: ### generate 1000 i.i.d. random variables X_i's:

        ### X_i follows normal N(0, 1)
        number_of_samples = 1000
        mu, sigma = 0, 1
        sample_normal = np.random.normal(mu, sigma, number_of_samples)

        # display first 10
        sample_normal[ :10]
```

```
Out[8]: array([-0.30349567,  0.22718967, -1.5435742 , -0.42098806,  0.31968847,
               -0.07634775,  0.27441126, -1.14210872, -1.19705341,  0.00924654])
```

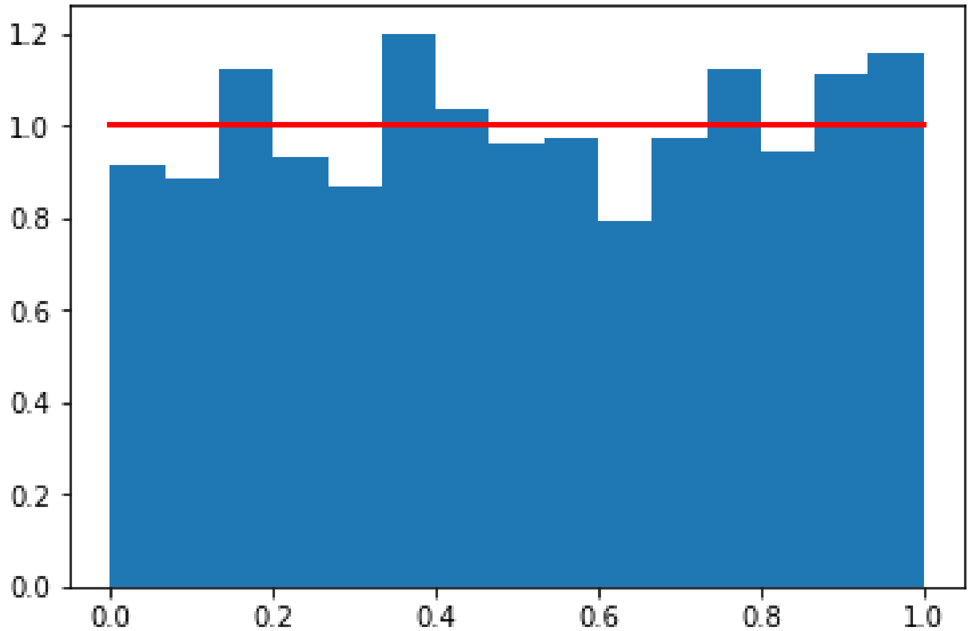
```
In [9]: # examine our function
        fn_mean_var_third(sample_normal)
```

```
Out[9]: {'mean': 0.008323789932932467, 'var': 0.9264862706851009}
```

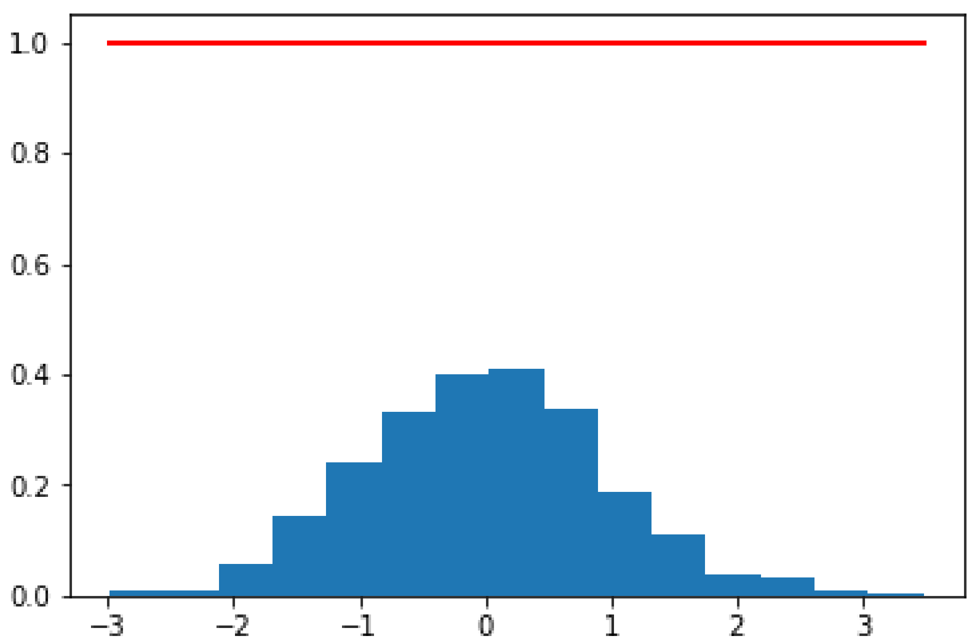
0.0.6 plot histograms:

```
In [10]: import matplotlib.pyplot as plt
```

```
In [11]: count, bins, ignored = plt.hist(sample_uniform, 15, density=True)
         plt.plot(bins, np.ones_like(bins), linewidth=2, color='r')
         plt.show()
```




```
In [12]: count, bins, ignored = plt.hist(sample_normal, 15, density=True)
         plt.plot(bins, np.ones_like(bins), linewidth=2, color='r')
         plt.show()
```



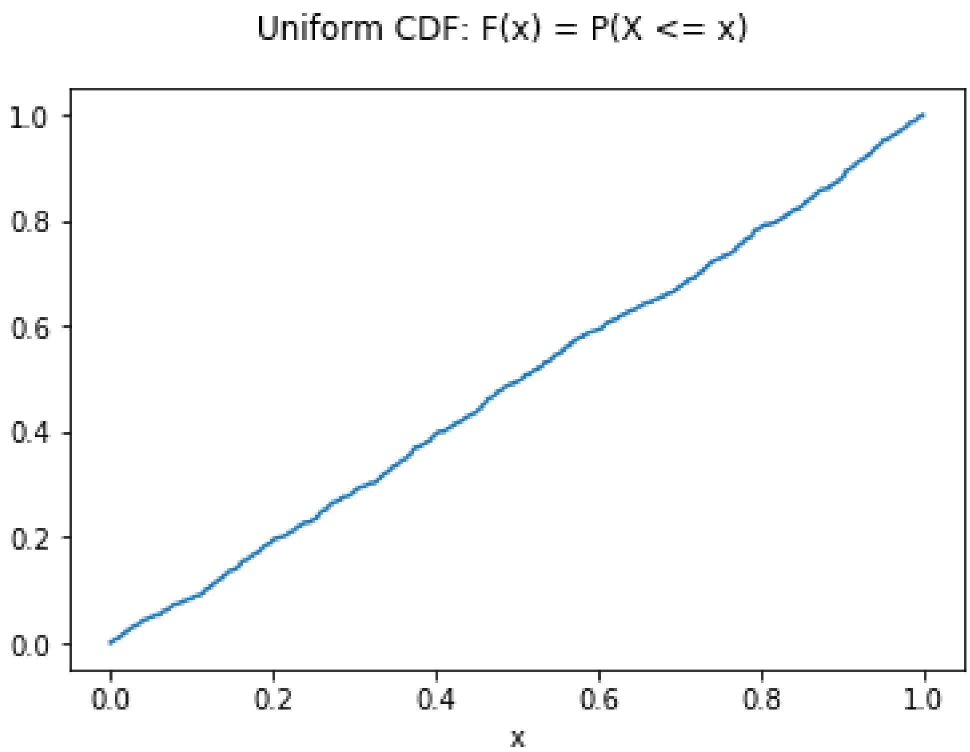
0.0.7 CDF for Uniform Distribution

```
In [13]: ### sample_uniform

         sorted_random_data = np.sort(sample_uniform)
         x = np.arange(len(sorted_random_data)) / float(len(sorted_random_data) - 1)

         fig = plt.figure()
         fig.suptitle('Uniform CDF: F(x) = P(X <= x)')
         ax = fig.add_subplot(111)
         ax.plot(sorted_random_data, x)
         ax.set_xlabel('x')
         ax.set_ylabel('')
```

```
Out[13]: Text(0, 0.5, '')
```



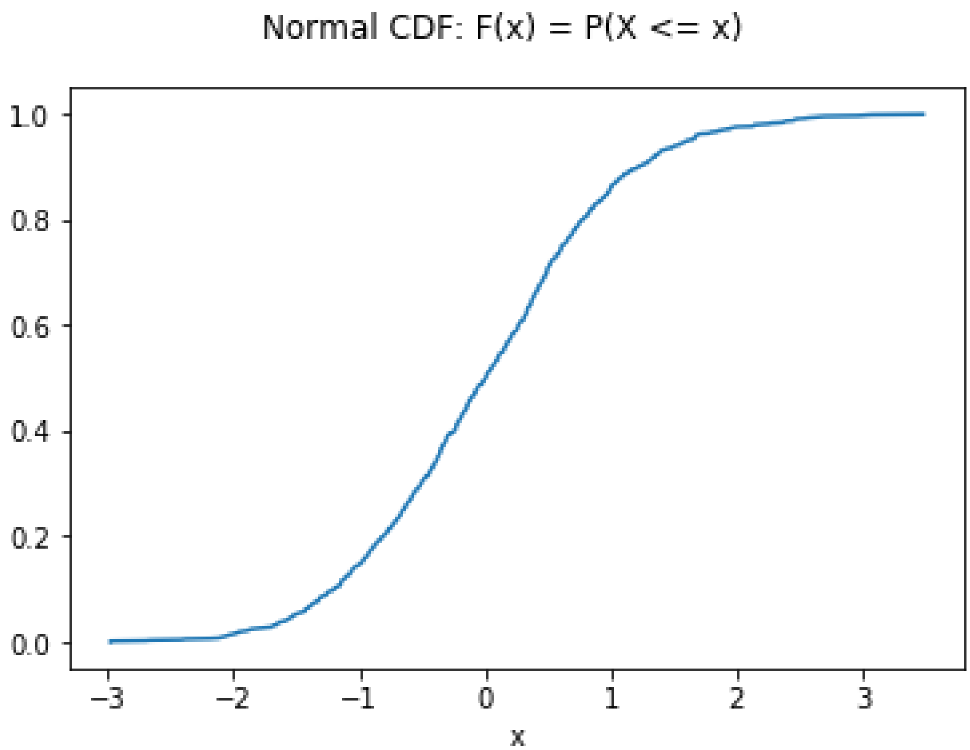
0.0.8 CDF for Normal Distribution

```
In [14]: ### sample_normal
```

```
sorted_random_data = np.sort(sample_normal)
x = np.arange(len(sorted_random_data)) / float(len(sorted_random_data) - 1)

fig = plt.figure()
fig.suptitle('Normal CDF: F(x) = P(X <= x)')
ax = fig.add_subplot(111)
ax.plot(sorted_random_data, x)
ax.set_xlabel('x')
ax.set_ylabel('')
```

Out[14]: Text(0, 0.5, '')



In [ ]: