EP20BTECH11015-Assignment-1

January 15, 2023

0.0.1 EP4130 - ASSIGNMENT 1

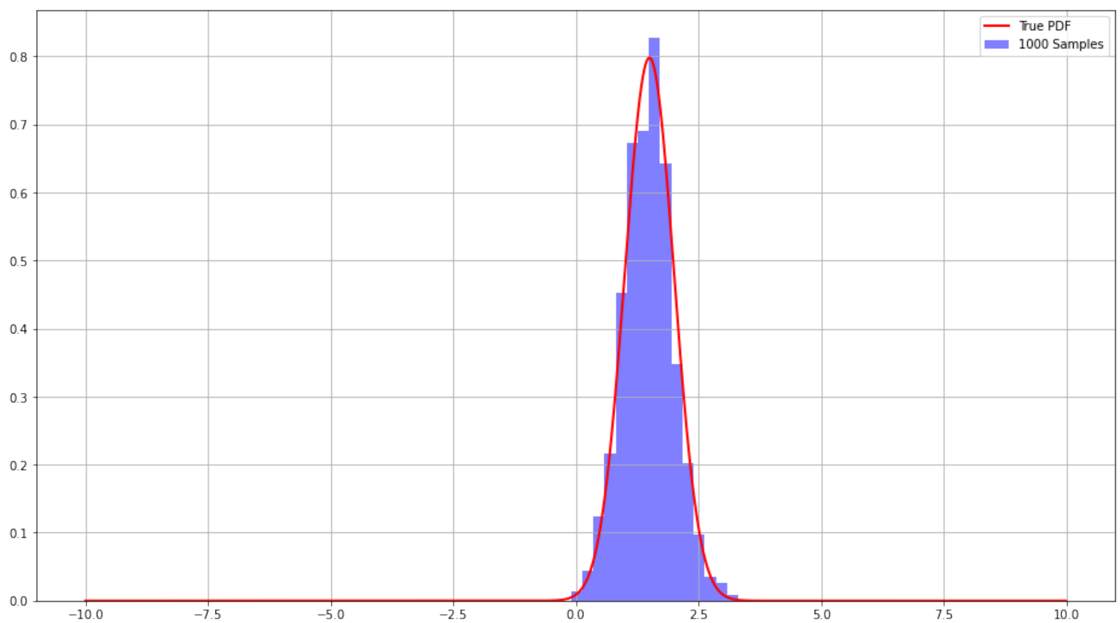
[ ]:
```python
import numpy as np
from scipy import stats as st
import astropy as ap
import astroML.stats as aml
import pandas as pd
import matplotlib.pyplot as plt
```

1. Create 1000 draws from a normal distribution of mean of 1.5 and standard deviation of 0.5. Plot the pdf. Calculate the sample mean, variance, skewness, kurtosis as well as standard deviation using MAD and G of these samples.

[ ]:
```python
#np.random.seed(42)
normal_dist_object = st.norm(1.5, 0.5)

draws1000 = normal_dist_object.rvs(size=1000)

print(f"Sample mean:    \t%.3f" % draws1000.mean())

print(f"Sample variance:    \t%.3f" % float(draws1000.var()*1000/999.0))

print(f"Kurtosis:       \t%.3f" % st.kurtosis(draws1000))

print(f"Skewness:   \t\t%.3f" % st.skew(draws1000))

print(f"MAD:    \t\t%.3f" % st.median_abs_deviation(draws1000))

print(f"sigma_G:    \t\t%.3f" % aml.sigmaG(draws1000))

print(f"sigma_G manual:    \t%.3f" % (0.7413 * (np.percentile(draws1000, 75) - 
 ↪np.percentile(draws1000, 25))))

plt.figure(figsize=(16, 9))

plt.plot(np.arange(-10, 10, 0.01), normal_dist_object.pdf(np.arange(-10, 10, 0.
 ↪01)), c='r', lw=2, label='True PDF')
```

```
plt.grid()
#plt.vlines(draws1000.mean(), 0, 0.8, linestyles='dashed')
plt.hist(draws1000, bins=15, density=True, alpha=0.5, color='b', label='1000␣
↪Samples')

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

```
Sample mean:            1.477
Sample variance:        0.260
Kurtosis:               0.247
Skewness:               0.123
MAD:                    0.337
sigma_G:                0.496
sigma_G manual:         0.496
```

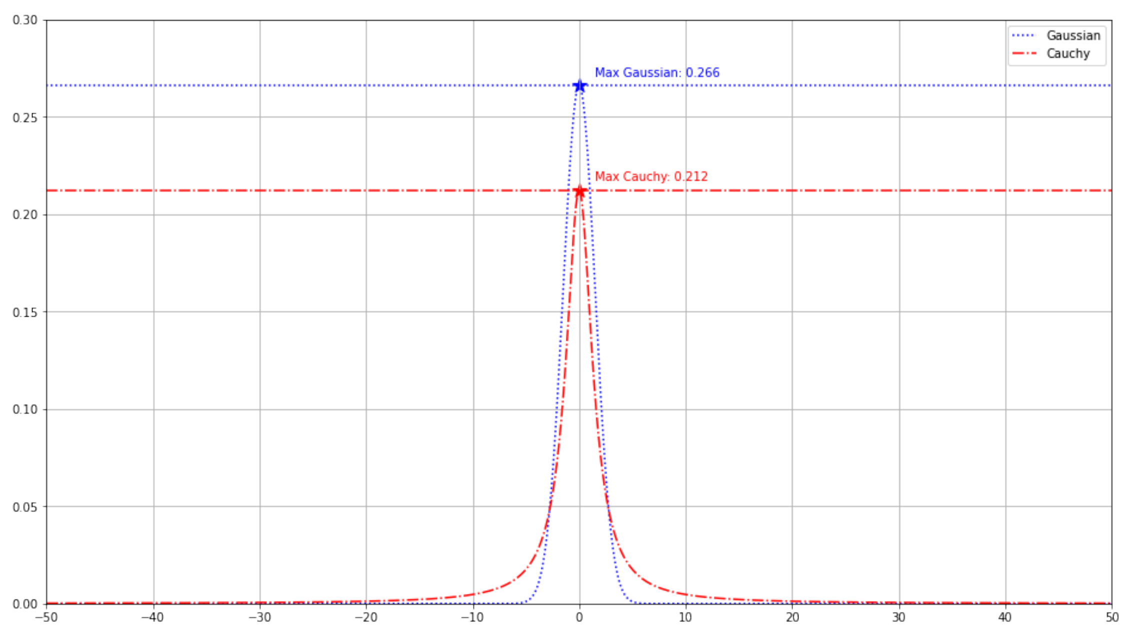


2. Plot a Cauchy distribution with =0 and =1.5 superposed on the top a Gaussian distribution with =0 and =1.5.

   Use two different line styles to distinguish between the Gaussan and Cauchy distribution on the plot and also indicate these in the legends.

[ ]:
```
q2_cauchy = st.cauchy(0, 1.5).pdf(np.arange(-50, 50, 0.1))  #Generating Cauchy␣
↪PDF for x in [-50, 50] with step size 0.1
q2_gaussian = st.norm(0, 1.5).pdf(np.arange(-50, 50, 0.1))  #Generating␣
↪Gaussian PDF for x in [-50, 50] with step size 0.1
```

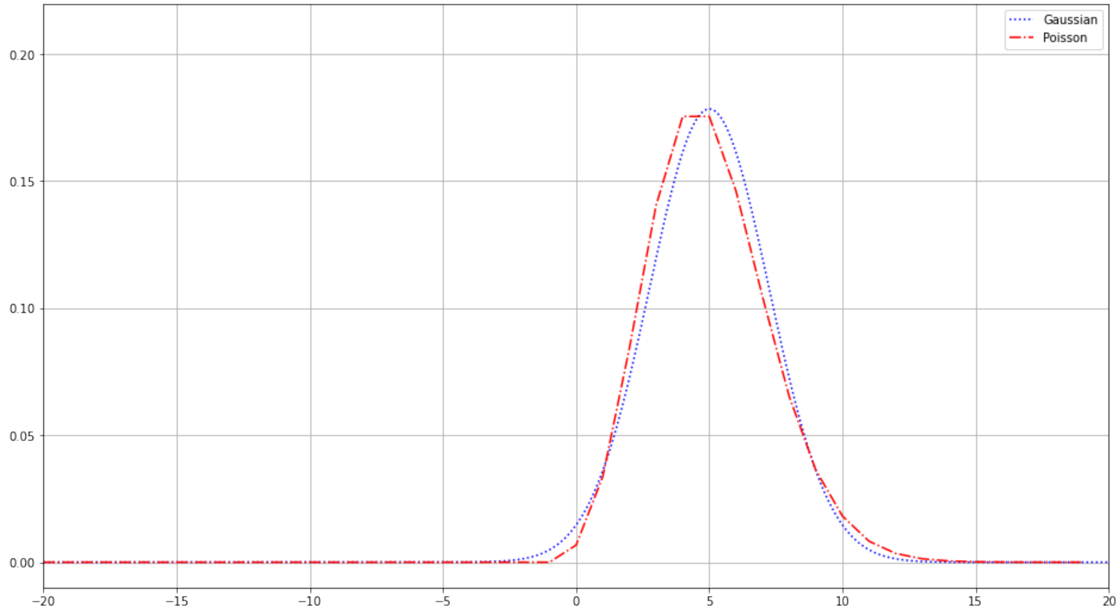
```python
plt.figure(figsize=(16, 9))

#For Gaussian
plt.plot(np.arange(-50, 50, 0.1), q2_gaussian, label="Gaussian", color='b', ls = ':')
plt.hlines(np.max(q2_gaussian), -50, 50, color='b', ls = ':')
plt.scatter(0, np.max(q2_gaussian), color='b', s=150, marker='*')
plt.text(1.5, np.max(q2_gaussian)+0.005, f"Max Gaussian: {np.max(q2_gaussian):.3f}", color='b')

#For Cauchy
plt.plot(np.arange(-50, 50, 0.1), q2_cauchy, label="Cauchy", color='r', ls = '-.')
plt.hlines(np.max(q2_cauchy), -50, 50, color='r', ls = '-.')
plt.scatter(0, np.max(q2_cauchy), color='r', s=150, marker='*')
plt.text(1.5, np.max(q2_cauchy)+0.005, f"Max Cauchy: {np.max(q2_cauchy):.3f}", color='r')

plt.grid(which='both')
plt.ylim(0, 0.3)
plt.xlim(-50, 50)
plt.xticks(np.arange(-50, 51, 10))
plt.legend()
plt.show()
```



3. Plot Poisson distribution with mean of 5, superposed on top of a Gaussian distribution with mean of 5 and standard deviation of square root of 5.

Use two different line styles for the two distributions and make sure the plot contains legends for both of them.

[ ]:
```
q3_poisson = st.poisson(5).pmf(np.arange(-20, 20, 1))    #Generating Poisson␣
↪PDF for x in [-20, 20]
q3_gaussian = st.norm(5, np.sqrt(5)).pdf(np.arange(-20, 20, 0.01))  ␣
↪#Generating Gaussian PDF for x in [-20, 20] with step size 0.01

plt.figure(figsize=(16, 9))

#For Gaussian
plt.plot(np.arange(-20, 20, 0.01), q3_gaussian, label="Gaussian", color='b', ls␣
↪= ':')
#plt.hlines(np.max(q3_gaussian), -20, 20, color='b', ls = ':')
#plt.scatter(np.arange(-20, 20, 0.01)[np.argmax(q3_gaussian)], np.
↪max(q3_gaussian), color='b', s=150, marker='*')
#plt.text(np.arange(-20, 20, 0.01)[np.argmax(q3_gaussian)] + 0.5, np.
↪max(q3_gaussian)+0.005, f"Max Gaussian: {np.max(q3_gaussian):.3f}",␣
↪color='b')

#For Poisson
plt.plot(np.arange(-20, 20, 1), q3_poisson, label="Poisson", color='r', ls = '-.
↪')
#plt.hlines(np.max(q3_poisson), -20, 20, color='r', ls = '-.')
#plt.scatter(np.arange(-20, 20, 0.01)[np.argmax(q3_poisson)], np.
↪max(q3_poisson), color='r', s=150, marker='*')
#plt.text(np.arange(-20, 20, 0.01)[np.argmax(q3_poisson)] + 0.3, np.
↪max(q3_poisson)+0.005, f"Max Poisson: {np.max(q3_poisson):.3f}", color='r')

plt.grid(which='both')
plt.ylim(-0.01, 0.22)
plt.xlim(-20, 20)
#plt.xticks(np.arange(0, 21, 1))
plt.legend()
plt.show()
```



4. The following were the measurements of mean lifetime of K meson (as of 1990) (in units of 10^{-10} s) :

   $0.8920 \pm 0.00044; 0.881 \pm 0.009; 0.8913 \pm 0.00032; 0.9837 \pm 0.00048; 0.8958 \pm 0.00045.$

   Calculate the weighted mean lifetime and uncertainty of the mean.

   $$\text{weighted mean} = \frac{\sum_i \frac{x_i}{\sigma_i^2}}{\sum_i \frac{1}{\sigma_i^2}}$$

   $$\text{uncertainty of the mean} = \frac{1}{\sqrt{\sum_i \frac{1}{\sigma_i^2}}}$$

[ ]:
```
lifetimes = np.asfarray([0.892, 0.881, 0.8913, 0.9837, 0.8958])
errors = np.asfarray([0.00044, 0.009, 0.00032, 0.00048, 0.00045])

weighted_mean = np.sum(np.divide(lifetimes, np.square(errors)))/np.sum(np.
 ↪divide(1, np.square(errors)))

uncertainity = 1/np.sqrt(np.sum(np.divide(1, np.square(errors))))

print(f"Weighted mean of given samples: \t%f" % weighted_mean)

print(f"Uncertainity of weighted mean:  \t%f" % uncertainity)
```

```
Weighted mean of given samples:         0.908919
```

```
Uncertainity of weighted mean:          0.000203
```

5. Download the eccentricity distribution of exoplanets from the exoplanet catalog http://exoplanet.eu/catalog/.

   Look for the column titled e, which denotes the eccentricity. Draw the histogram of this distribution.

   Then redraw the same histogram after Gaussianizing the distribution using the Box-transformation either using scipy.stats.boxcox

   or from first principles using the equations shown in class or in arXiv:1508.00931. Note that exoplanets without eccentricity data can be ignored.

[ ]:
```python
exoplanet_data = pd.read_csv("exoplanet.eu_catalog.csv")
print(exoplanet_data['eccentricity'].count())
```

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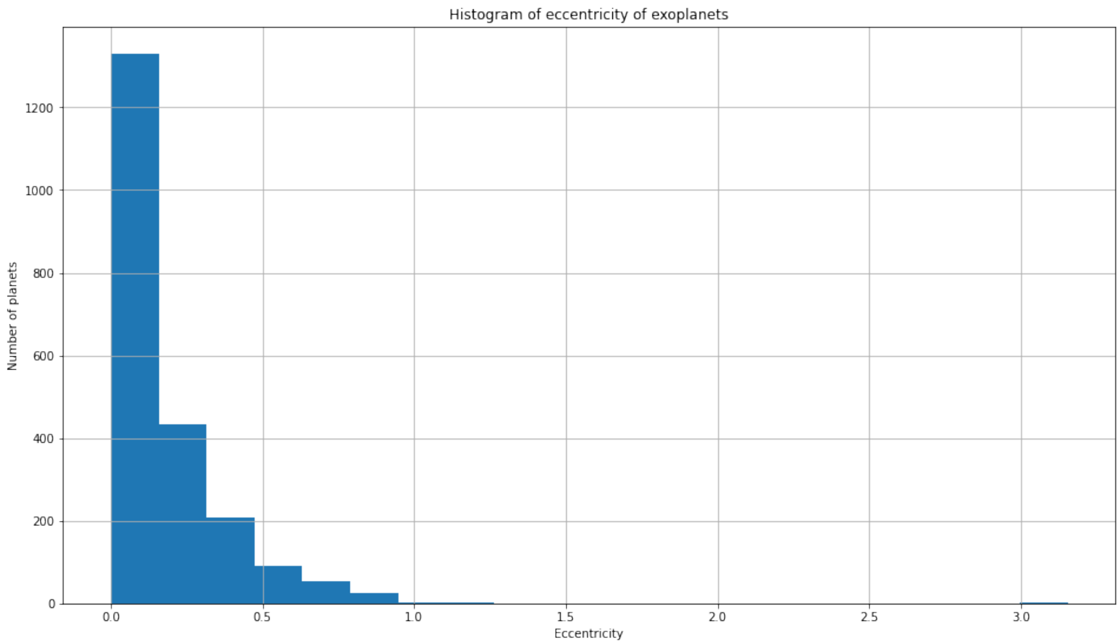
```

[ ]:
```python
plt.figure(figsize=(16, 9))
plt.hist(exoplanet_data['eccentricity'], bins=20)
plt.grid(which='both')
plt.xlabel("Eccentricity")
plt.ylabel("Number of planets")
plt.title("Histogram of eccentricity of exoplanets")
plt.show()
```



scipy.stats.boxcox does not accept non-positive entries so all such entries are ignored.

[ ]:
```
for x in exoplanet_data.index:
  if not(exoplanet_data.loc[x, "eccentricity"] > 0):
    exoplanet_data.drop(x, inplace = True)
print(exoplanet_data['eccentricity'].count())
```

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[ ]:
```
plt.figure(figsize=(16, 9))
plt.hist(st.boxcox(exoplanet_data['eccentricity'])[0], bins=20)
plt.xlabel("Eccentricity")
plt.ylabel("Number of planets")
plt.title("Box-Cox transformation of Histogram eccentricity of exoplanets")
plt.show()
```