Data Science Exploration 2 - Probability mass function

October 26, 2022

0.1 ECE 131A Data science exploration 2: Please complete this jupyter notebook by filling out the code blocks. Once you have completed the notebook, generate a PDF of the completed notebook and upload the PDF to Gradescope by 11:59 PM on 10/27/2022.

0.2 In this data science exploration, we will be performing basic statistical analysis on two real world datasets. The analysis will consist of plotting the empirical distribution of the quantities of interest in the dataset and visualizing how well the empirical distribution matches with some discrete probability distributions learned in the class. In the first part of the assignment, we will be analyzing an alpha particle emissions dataset. In the second part of the assignment, we will be analyzing a traffic violation dataset.

[ ]:

```
## Importing the necessary packages
import pandas as pd
import numpy as np
import seaborn as sns
from scipy import stats
import matplotlib.pyplot as plt
```

0.3 Alpha emissions dataset: the data consists of measurements of alpha particle emissions from a sample of americium-241. The csv file contains a table with the frequency distribution of the number of alpha particle emissions in 1207 ten second intervals.

[ ]:

```
## Loading the dataset as a pandas dataframe and printing the header
df_alpha = pd.read_csv('alpha_particle_emissions.csv')
df_alpha.head()
```

[ ]:

```
   Number  Frequency
0       0          1
1       1          4
2       2         13
3       3         28
4       4         56
```

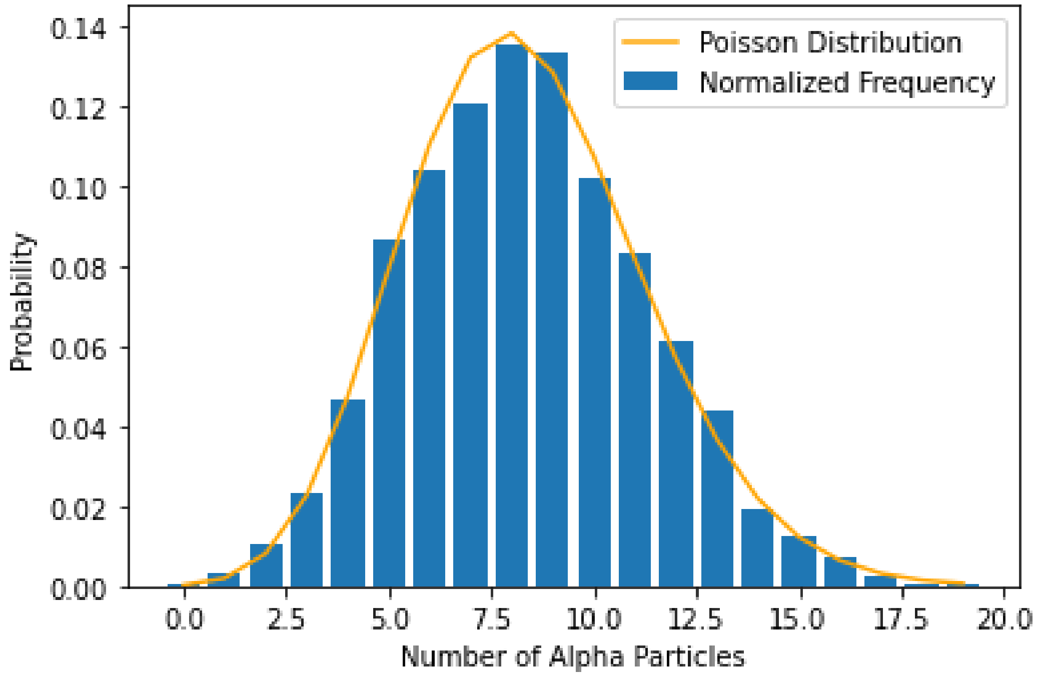
[ ]:

```
df_alpha
```

```
[ ]:    Number  Frequency
    0        0          1
    1        1          4
    2        2         13
    3        3         28
    4        4         56
    5        5        105
    6        6        126
    7        7        146
    8        8        164
    9        9        161
    10      10        123
    11      11        101
    12      12         74
    13      13         53
    14      14         23
    15      15         15
    16      16          9
    17      17          3
    18      18          1
    19      19          1
    20   Total       1207
```

0.4 Plot a normalized histogram of alpha particle emissions: number of alpha particle emissions in the horizontal axis and the normalized frequency in the vertical axis. Also, plot the probability mass function of a poisson random variable fitting the histogram on the same graph.

```
[ ]: ## Helpful functions: plt.hist(), stats.poisson.pmf()

     # Start your code here

     Frequency=df_alpha.Frequency.to_numpy()[:-1].astype(int)
     Number=df_alpha.Number.to_numpy()[:-1].astype(int)
     plt.bar(Number,Frequency/np.sum(Frequency),label='Normalized Frequency')
     mean=np.sum(Number*Frequency)/np.sum(Frequency)

     plt.plot(Number,stats.poisson.pmf(Number,mean),color="orange",label='Poisson Distribution')
     plt.legend()
     plt.xlabel('Number of Alpha Particles')
     plt.ylabel('Probability')
     plt.show()
     # End your code here
```



0.5 Traffic violation dataset: data on traffic and pedestrian stops by police in rhode island from January 1 2005 to December 30 2015. The data has many attributes but in this assignment we will only focus on some of the attributes

```
[ ]: ## Loading the dataset as a pandas dataframe and printing the header
     df_police = pd.read_csv('police_project.csv')
     df_police.head()
```

```
[ ]:     stop_date stop_time  county_name driver_gender  driver_age_raw  \
     0  2005-01-02     01:55          NaN             M          1985.0
     1  2005-01-18     08:15          NaN             M          1965.0
     2  2005-01-23     23:15          NaN             M          1972.0
     3  2005-02-20     17:15          NaN             M          1986.0
     4  2005-03-14     10:00          NaN             F          1984.0

        driver_age driver_race     violation_raw violation  search_conducted  \
     0        20.0       White          Speeding  Speeding             False
     1        40.0       White          Speeding  Speeding             False
     2        33.0       White          Speeding  Speeding             False
     3        19.0       White  Call for Service     Other             False
     4        21.0       White          Speeding  Speeding             False

       search_type   stop_outcome is_arrested stop_duration  drugs_related_stop
```

```
0          NaN        Citation        False       0-15 Min                 False
1          NaN        Citation        False       0-15 Min                 False
2          NaN        Citation        False       0-15 Min                 False
3          NaN  Arrest Driver          True      16-30 Min                 False
4          NaN        Citation        False       0-15 Min                 False
```

0.6 Process the dataframe and create a new dataframe with the following structure:

0.7 - Rows correspond to the stop date

0.8 - Column 1 correspond to the total number of speeding violations on that stop date

0.9 - Column 2 correspond to the total number of drug related stops on that stop date

0.10 - Column 3 correspond to the total number of stops by police on that stop date

0.11 After you have created the dataframe, print the header of the dataframe.

[ ]:
```
## Helpful functions: df.reset_index().groupby().agg()

# Start your code here
df_police_mod=df_police.copy()
df_police_mod["counts"]=np.ones(len(df_police_mod))
df_police_mod["speeding"]=(df_police_mod["violation"]=="Speeding").astype(int)
df_police_mod["drugs"]=(df_police_mod["drugs_related_stop"]).astype(int)
df_police_mod=df_police_mod[["stop_date","counts","speeding","drugs"]]
df_police_mod=df_police_mod.groupby("stop_date").agg([sum])
df_police_mod.head()

# End your code here
```

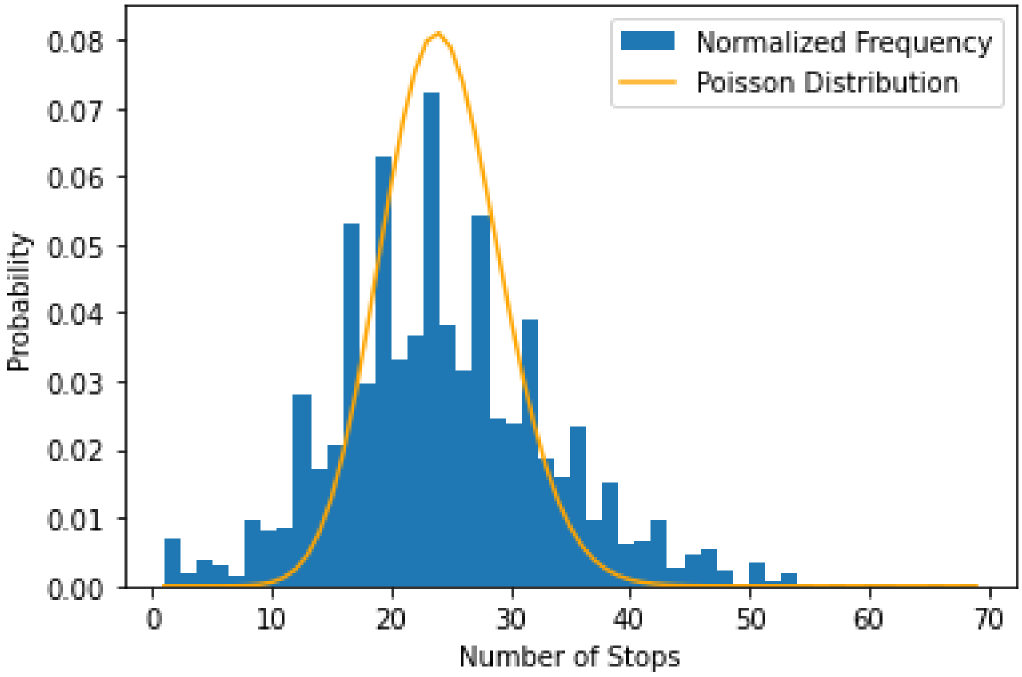
[ ]:
```
           counts speeding drugs
              sum      sum   sum
stop_date
2005-01-02    1.0        1     0
2005-01-18    1.0        1     0
2005-01-23    1.0        1     0
2005-02-20    1.0        0     0
2005-03-14    1.0        1     0
```

0.12 Plot a normalized histogram of the total number of stops by police in a day: total number of stops by police in the horizontal axis and the normalized frequency in the vertical axis. Also, plot the probability mass function of a poisson random variable fitting the normalized histogram on the same graph.

[ ]:

```
## Helpful functions: plt.hist(), stats.poisson.pmf()

# Start your code here

plt.hist(df_police_mod["counts"],bins=50,density=True,label="Normalized␣
 ↪Frequency")
min_counts=np.min(df_police_mod["counts"].astype(int).to_numpy())
max_counts=np.max(df_police_mod["counts"].astype(int).to_numpy())
plt.plot(np.arange(min_counts,max_counts+1),stats.poisson.pmf(np.
 ↪arange(min_counts,max_counts+1),np.mean(df_police_mod["counts"])),
color="orange",label="Poisson Distribution")

plt.legend()
plt.xlabel('Number of Stops')
plt.ylabel('Probability')
plt.show()
# End your code here
```

```
c:\Users\Lawrence\anaconda3\lib\site-packages\numpy\core\fromnumeric.py:3438:
FutureWarning: In a future version, DataFrame.mean(axis=None) will return a
scalar mean over the entire DataFrame. To retain the old behavior, use
'frame.mean(axis=0)' or just 'frame.mean()'
  return mean(axis=axis, dtype=dtype, out=out, **kwargs)
```

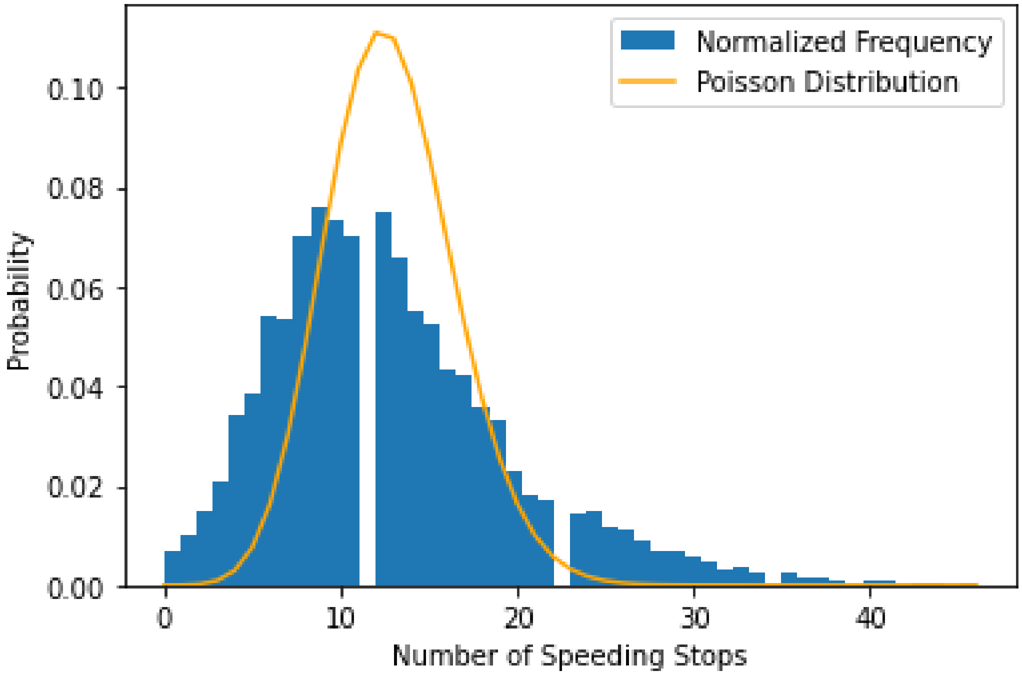


0.13 Plot a normalized histogram of the total number of speeding violations in a day: total number of speeding violations in the horizontal axis and the normalized frequency in the vertical axis. Also, plot the probability mass function of a poisson random variable fitting the normalized histogram on the same graph.

[ ]:
```
## Helpful functions: plt.hist(), stats.poisson.pmf()

# Start your code here

plt.hist(df_police_mod["speeding"],bins=50,density=True,label="Normalized␣
  ↪Frequency")
min_counts=np.min(df_police_mod["speeding"].astype(int).to_numpy())
max_counts=np.max(df_police_mod["speeding"].astype(int).to_numpy())
plt.plot(np.arange(min_counts,max_counts+1),stats.poisson.pmf(np.
  ↪arange(min_counts,max_counts+1),np.mean(df_police_mod["speeding"])),
color="orange",label="Poisson Distribution")

plt.legend()
plt.xlabel('Number of Speeding Stops')
plt.ylabel('Probability')
plt.show()
# End your code here
```

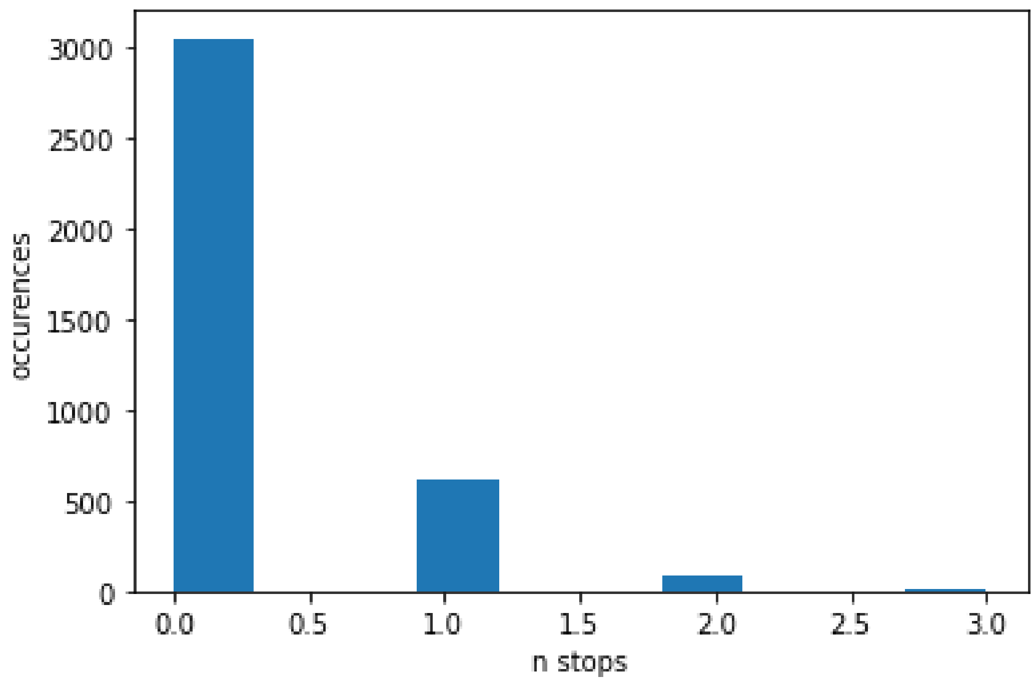
```
c:\Users\Lawrence\anaconda3\lib\site-packages\numpy\core\fromnumeric.py:3438:
```

```
FutureWarning: In a future version, DataFrame.mean(axis=None) will return a
scalar mean over the entire DataFrame. To retain the old behavior, use
'frame.mean(axis=0)' or just 'frame.mean()'
  return mean(axis=axis, dtype=dtype, out=out, **kwargs)
```



0.14 Plot the un-normalized histogram of the total number of drug related stops in a day: total number of drug related stops in the horizontal axis and the frequency in the vertical axis. Which discrete random variable can fit the empirical distribution well?

[ ]:
```
## Helpful functions: plt.hist()

# Start your code here

plt.hist(df_police_mod["drugs"])
plt.xlabel("n stops")
plt.ylabel("occurences")
plt.show()
# End your code here
```



A Zipf would fit this well