pulsar2

October 8, 2022

1 Pulsar Emission Data Analysis

2 All Imports that may or may not be needed and used for the notebook

[ ]:
```
#currently including any and all Imports that maybe needed for the project.
import pandas as pd
import numpy as np
import seaborn as sns
import matplotlib.pyplot as plt
%matplotlib inline
from sklearn.model_selection import train_test_split
from sklearn import linear_model
from sklearn.metrics import r2_score, mean_squared_error
from sklearn.linear_model import LogisticRegression, LinearRegression
from sklearn.metrics import confusion_matrix, accuracy_score
from sklearn.feature_selection import RFE
import datetime as dt
from sklearn.cluster import KMeans
from sklearn.metrics import pairwise_distances
from scipy.cluster.hierarchy import linkage, dendrogram, cut_tree
from scipy.spatial.distance import pdist
from sklearn.feature_extraction.text import TfidfVectorizer
import matplotlib.dates as mdates
from scipy.stats import pearsonr
from scipy import stats
import statistics
import math
from statsmodels.graphics.tsaplots import plot_acf, plot_pacf
from statsmodels.tsa.stattools import acf, pacf
from statsmodels.tsa.tsatools import lagmat
from numpy import array
from sklearn.model_selection import train_test_split
from keras.models import Sequential
from keras.layers import LSTM
from keras.layers import Dense
from keras.layers import Bidirectional
```

3 Section for extracting from a tar file.

Currently implemented for original TAR File structure.

[ ]:
```
#This is also found in the main file under tarunzip.py
import tarfile
import os
import sys

#tar = tarfile.open("pulseTarFile.tar")
#tar.extractall('./Data')
#tar.close()
```

3.1 Beginning of Exploration

3.1.1 Examining the data

In this section we are determining the total integrity of the data to determine if further comprehensive data cleaning and uniforming processes are needed.

[ ]:
```
colnames = ['Pulse Number', 'Brightness', 'Uncertainty']
pulsar = pd.read_csv("Data/J0953+0755.pulses", sep = ' ', header = None, names␣
↪= colnames)
```

[ ]:
```
pulsar.shape
```

[ ]:
```
(14329, 3)
```

[ ]:
```
pulsar.head(25)
```

[ ]:

	Pulse Number	Brightness	Uncertainty
0	1	0.334330	0.015570
1	2	-0.098659	0.014051
2	3	0.123514	0.011901
3	4	0.443923	0.014365
4	5	1.590446	0.057785
5	6	1.233848	0.018692
6	7	0.857876	0.022208
7	8	0.254255	0.018185
8	9	0.292077	0.021672
9	10	0.439929	0.046293
10	11	0.824310	0.036243
11	12	1.443460	0.088372
12	13	0.127981	0.018070
13	14	0.327896	0.012362
14	15	2.473663	0.099205
15	16	0.683800	0.049683
16	17	0.744937	0.033909
17	18	0.628764	0.032342
18	19	5.077294	0.093078

```
19             20    0.554981     0.025086
20             21    1.006799     0.029068
21             22    4.359872     0.091381
22             23    1.576034     0.030928
23             24    1.218368     0.067754
24             25    1.377933     0.036103
```

[ ]:
```python
pulsar.describe()
```

[ ]:
```
        Pulse Number    Brightness   Uncertainty
count  14329.000000  14329.000000  14329.000000
mean    7165.000000      0.994458      0.034561
std     4136.570339      1.211127      0.029641
min        1.000000     -0.219110      0.010120
25%     3583.000000      0.184157      0.014351
50%     7165.000000      0.481894      0.021999
75%    10747.000000      1.337406      0.043380
max    14329.000000      8.552022      0.242041
```

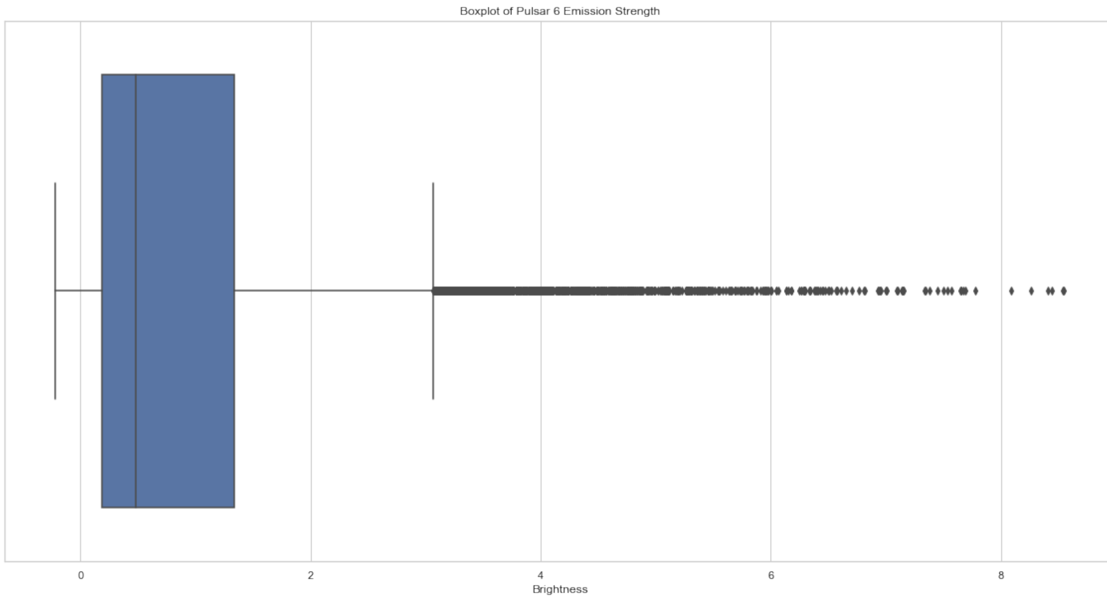
[ ]:
```python
nullBoolBrightness = pd.isnull(pulsar["Brightness"])

pulsar[nullBoolBrightness]
```

[ ]:
```
Empty DataFrame
Columns: [Pulse Number, Brightness, Uncertainty]
Index: []
```

[ ]:
```python
pulsar["Brightness"].describe()
```

[ ]:
```
count    14329.000000
mean         0.994458
std          1.211127
min         -0.219110
25%          0.184157
50%          0.481894
75%          1.337406
max          8.552022
Name: Brightness, dtype: float64
```

[ ]:
```python
plt.figure(figsize=(20,10))
sns.set_theme(style="whitegrid")
ax = sns.boxplot(x=pulsar["Brightness"]).set_title("Boxplot of Pulsar 6␣
↪Emission Strength")
```



[ ]:
```
medianpulse6 = pulsar["Brightness"].median()
print("Median of Pulsar6: ", medianpulse6)
pulsar['Binary'] = np.where(pulsar['Brightness'] > medianpulse6, 1, 0)
```

```
Median of Pulsar6:  0.4818942
```

[ ]:
```
pulsar
```

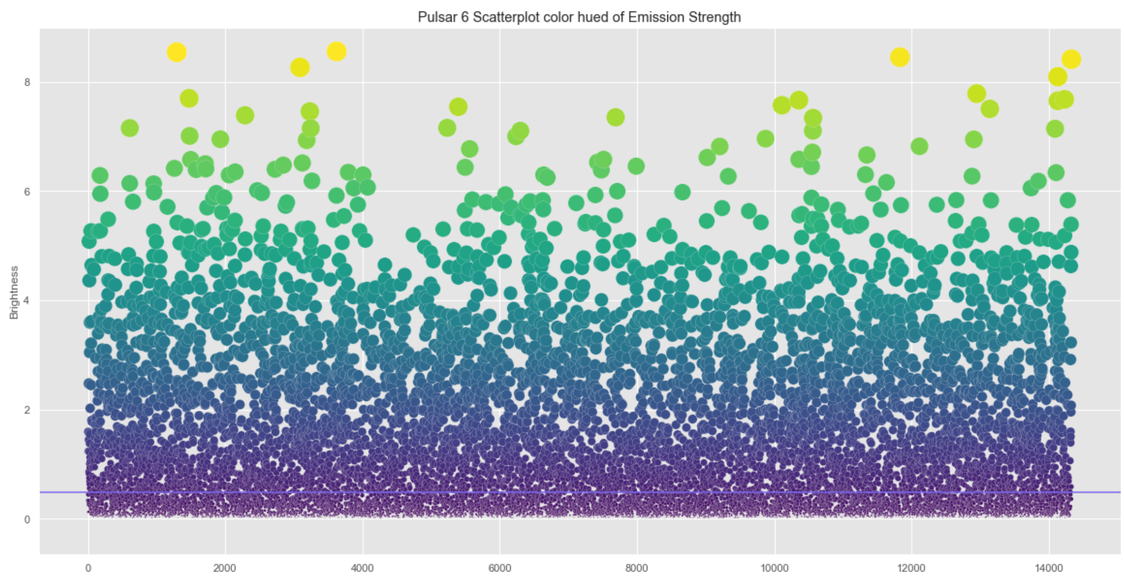
[ ]:
```
       Pulse Number  Brightness  Uncertainty  Binary
0                 1    0.334330     0.015570       0
1                 2   -0.098659     0.014051       0
2                 3    0.123514     0.011901       0
3                 4    0.443923     0.014365       0
4                 5    1.590446     0.057785       1
…               …         …           …       …
14324         14325    4.876881     0.097181       1
14325         14326    2.074136     0.080444       1
14326         14327    0.585504     0.026204       1
14327         14328    0.360930     0.035051       0
14328         14329    8.409811     0.120164       1

[14329 rows x 4 columns]
```

[ ]:
```
plt.figure(figsize=(20,10))
sns.set_style("darkgrid", {"axes.facecolor": ".75"})
strength = pulsar.Brightness.values
plt.style.use('ggplot')
```

```
ax = sns.scatterplot(data=pulsar["Brightness"], s= strength*50, c=strength,␣
↪cmap="viridis", marker="o").set_title('Pulsar 6 Scatterplot color hued of␣
↪Emission Strength')
ax= plt.axhline( y=0.4818942, ls='-',c='mediumslateblue')
```

```
c:\Users\oxlay\anaconda3\lib\site-packages\matplotlib\collections.py:1003:
RuntimeWarning: invalid value encountered in sqrt
  scale = np.sqrt(self._sizes) * dpi / 72.0 * self._factor
```



[ ]:
```
print(len(pulsar[(pulsar.Brightness > 0.4818942)]))
print(len(pulsar[(pulsar.Brightness < 0.4818942)]))
```

```
7164
7164
```

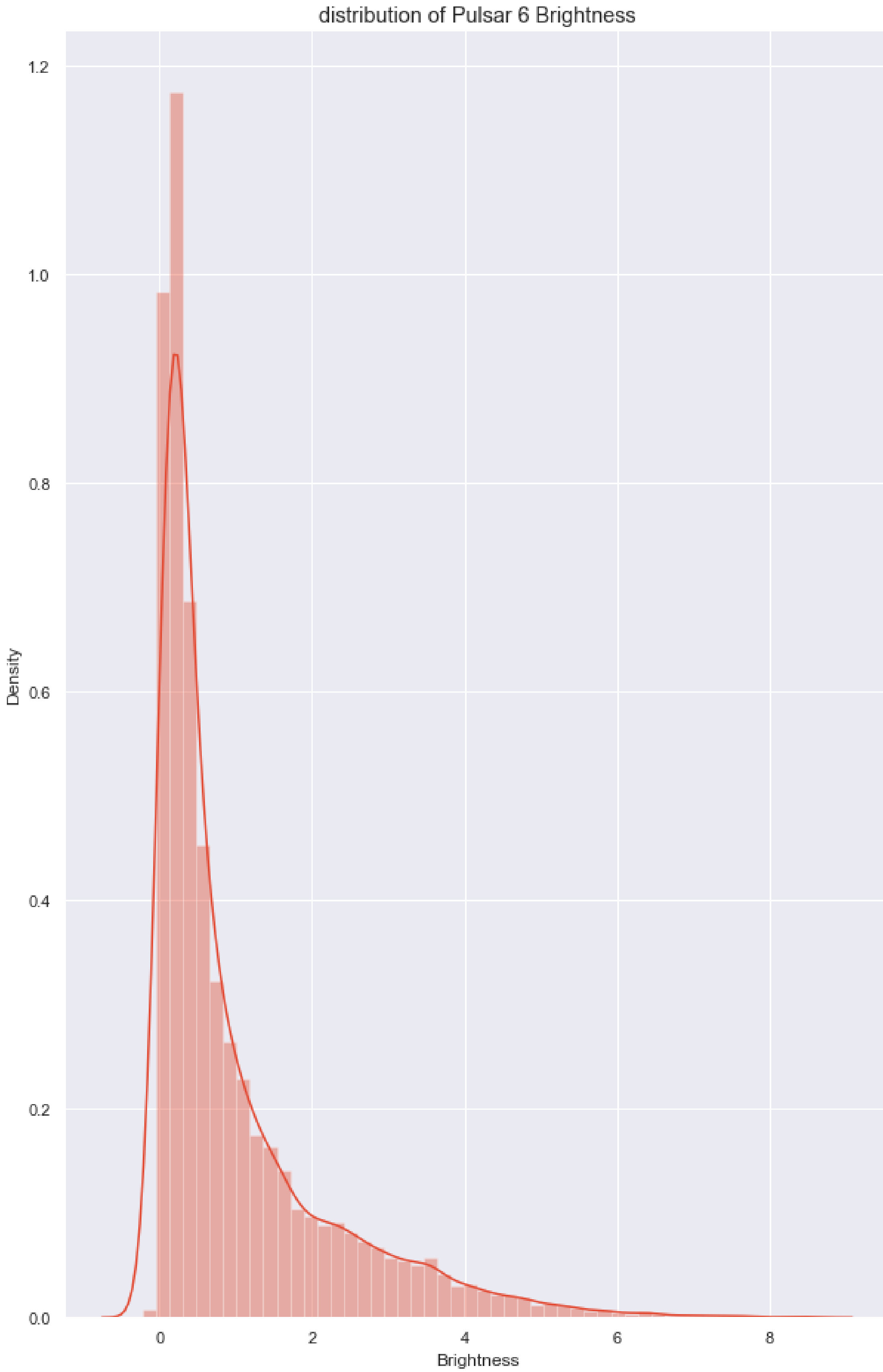
[ ]:
```
#plt.figure(figsize=(20,10))
#sns.set_style("darkgrid", {"axes.facecolor": ".75"})
#strength = pulsar.Brightness.values
#ax = plt.axhline( y=0.4818942, ls='-',c='mediumslateblue')
#ax = sns.swarmplot(data=pulsar["Brightness"], c="blue").set_title('Pulsar 6␣
↪Swarm plot of Emission Strength')
```

[ ]:
```
plt.figure(figsize=(10, 16))
with sns.axes_style('darkgrid'):
    sns.distplot(pulsar.Brightness)
plt.title("distribution of Pulsar 6 Brightness")
```

```
c:\Users\oxlay\anaconda3\lib\site-packages\seaborn\distributions.py:2619:
FutureWarning: `distplot` is a deprecated function and will be removed in a
```

```
future version. Please adapt your code to use either `displot` (a figure-level
function with similar flexibility) or `histplot` (an axes-level function for
histograms).
  warnings.warn(msg, FutureWarning)
```

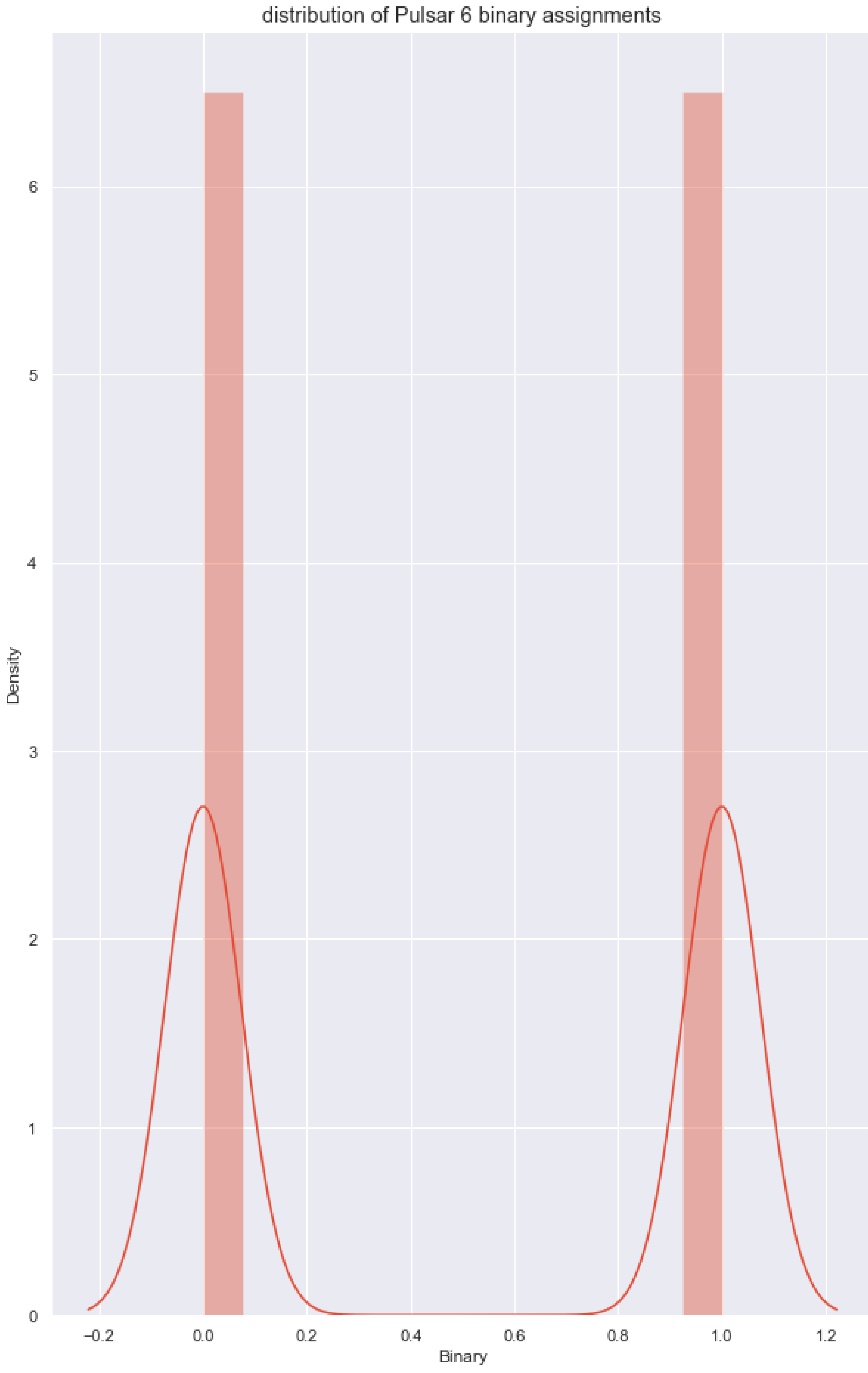
```
[ ]: Text(0.5, 1.0, 'distribution of Pulsar 6 Brightness')
```


distribution of Pulsar 6 Brightness
Density
Brightness
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
2
4
6
8

[ ]:
```
plt.figure(figsize=(10, 16))
with sns.axes_style('darkgrid'):
    sns.distplot(pulsar.Binary)
plt.title("distribution of Pulsar 6 binary assignments")
```

```
c:\Users\oxlay\anaconda3\lib\site-packages\seaborn\distributions.py:2619:
FutureWarning: `distplot` is a deprecated function and will be removed in a
future version. Please adapt your code to use either `displot` (a figure-level
function with similar flexibility) or `histplot` (an axes-level function for
histograms).
  warnings.warn(msg, FutureWarning)
```

[ ]:
```
Text(0.5, 1.0, 'distribution of Pulsar 6 binary assignments')
```


distribution of Pulsar 6 binary assignments
Density
0
1
2
3
4
5
6
−0.2
0.0
0.2
0.4
0.6
0.8
1.0
1.2
Binary

3.2 Binary Classification

[ ]:
```
X = pulsar[['Brightness', 'Uncertainty']]
y = pulsar['Binary']
```

[ ]:
```
X.head()
```

[ ]:
```
   Brightness  Uncertainty
0    0.334330     0.015570
1   -0.098659     0.014051
2    0.123514     0.011901
3    0.443923     0.014365
4    1.590446     0.057785
```

[ ]:
```
y.head()
```

[ ]:
```
0    0
1    0
2    0
3    0
4    1
Name: Binary, dtype: int32
```

[ ]:
```
from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test = train_test_split(X, y , test_size=0.20)
```

[ ]:
```
from sklearn.preprocessing import StandardScaler

train_scaler = StandardScaler()
X_train = train_scaler.fit_transform(X_train)

test_scaler = StandardScaler()
X_test = test_scaler.fit_transform(X_test)
```

[ ]:
```
model = LogisticRegression()

model.fit(X_train, y_train)
```

[ ]:
```
LogisticRegression()
```

[ ]:
```
predictions = model.predict(X_test)
```

[ ]:
```
from sklearn.metrics import confusion_matrix
```

```
cm = confusion_matrix(y_test, predictions)

TN, FP, FN, TP = confusion_matrix(y_test, predictions).ravel()

print('True Positive(TP)  = ', TP)
print('False Positive(FP) = ', FP)
print('True Negative(TN)  = ', TN)
print('False Negative(FN) = ', FN)
```

```
True Positive(TP)  =  1420
False Positive(FP) =  8
True Negative(TN)  =  1428
False Negative(FN) =  10
```

[ ]:
```
accuracy =  (TP + TN) / (TP + FP + TN + FN)

print("Accuracy of the model is ", accuracy)
```

```
Accuracy of the model is  0.9937194696441033
```

3.3 Bidirectional LSTM Model

[ ]:
```
brightness_list = list(pulsar['Brightness'])
brightness_list[:10]
```

[ ]:
```
[0.3343305,
 -0.09865925,
 0.1235136,
 0.4439226,
 1.590446,
 1.233848,
 0.8578762,
 0.2542552,
 0.2920765,
 0.4399285]
```

[ ]:
```
def split_list(blist, steps):
    X, y = list(), list()
    for i in range(len(blist)):
        # find the end of this pattern
        end_ix = i + steps
        # check if we are beyond the sequence
        if end_ix > len(blist)-1:
            break
        # gather input and output parts of the pattern
        list_x, list_y = blist[i:end_ix], blist[end_ix]
        X.append(list_x)
        y.append(list_y)
```

```
    return array(X), array(y)
```

[ ]:
```
X, y = split_list(brightness_list, 100)
X = X.reshape((X.shape[0], X.shape[1], 1))
X[:1]
```

[ ]:
```
array([[[ 0.3343305 ],
        [-0.09865925],
        [ 0.1235136 ],
        [ 0.4439226 ],
        [ 1.590446  ],
        [ 1.233848  ],
        [ 0.8578762 ],
        [ 0.2542552 ],
        [ 0.2920765 ],
        [ 0.4399285 ],
        [ 0.8243096 ],
        [ 1.44346   ],
        [ 0.127981  ],
        [ 0.327896  ],
        [ 2.473663  ],
        [ 0.6838004 ],
        [ 0.7449372 ],
        [ 0.6287637 ],
        [ 5.077294  ],
        [ 0.5549809 ],
        [ 1.006799  ],
        [ 4.359872  ],
        [ 1.576034  ],
        [ 1.218368  ],
        [ 1.377933  ],
        [ 0.930978  ],
        [ 3.043829  ],
        [ 1.546754  ],
        [ 1.121343  ],
        [ 0.2231065 ],
        [ 1.046509  ],
        [ 3.591599  ],
        [ 0.2794989 ],
        [ 2.020426  ],
        [ 0.1834685 ],
        [ 0.1728863 ],
        [ 0.08091074],
        [ 0.482004  ],
        [ 0.4997924 ],
        [ 0.1020256 ],
        [ 0.1811799 ],
```

```
[ 0.0734898 ],
[ 0.1686549 ],
[ 0.1140138 ],
[ 0.2534638 ],
[ 2.445954  ],
[ 5.267987  ],
[ 3.209211  ],
[ 3.61146   ],
[ 0.4521517 ],
[ 0.3187844 ],
[ 0.1093535 ],
[ 0.349598  ],
[ 1.801916  ],
[ 4.641071  ],
[ 0.9302299 ],
[ 0.2540756 ],
[ 0.1235713 ],
[ 0.07940372],
[ 0.6344433 ],
[ 1.77306   ],
[ 1.09541   ],
[ 0.7851931 ],
[ 1.048576  ],
[ 0.4031171 ],
[ 0.06401307],
[ 0.5247178 ],
[ 1.18829   ],
[ 0.9450719 ],
[ 0.1678216 ],
[ 1.293165  ],
[ 0.7533471 ],
[ 0.2794956 ],
[ 0.32502   ],
[ 0.337905  ],
[ 0.2770691 ],
[ 0.1680058 ],
[ 0.3047891 ],
[ 0.1164062 ],
[ 0.1846148 ],
[ 0.4561068 ],
[ 0.0423768 ],
[ 0.541339  ],
[ 0.2756999 ],
[ 0.2174998 ],
[ 1.347416  ],
[ 4.561518  ],
[ 1.020322  ],
```

```
[ 0.288448  ],
[ 0.1711328 ],
[ 0.524166  ],
[ 1.066911  ],
[ 0.1387746 ],
[ 0.07770184],
[ 0.7084595 ],
[ 0.7501087 ],
[ 0.1608082 ],
[ 0.5056017 ],
[ 1.310186  ],
[ 0.1655302 ]]])
```

[ ]:

```
X_train, X_test, y_train, y_test = train_test_split(X, y , test_size=0.20)
```

[ ]:

```
model = Sequential()
model.add(Bidirectional(LSTM(50, activation='relu'), input_shape=(100, 1)))
model.add(Dense(8, activation='relu'))
model.add(Dense(1, activation='sigmoid'))
model.compile(loss='binary_crossentropy', optimizer='adam',␣
 ↪metrics=['accuracy'])
```

[ ]:

```
history = model.fit(X_train, y_train, epochs=1, verbose=1, batch_size=10)
```

```
1139/1139 [==============================] - 25s 21ms/step - loss: 228.4728 -
accuracy: 0.0000e+00
```

[ ]:

```
y_pred = model.predict(X_test, verbose=0)
y_pred[:10]
```

[ ]:

```
array([[0.92071056],
       [0.9388161 ],
       [0.89009047],
       [0.97404736],
       [0.9535792 ],
       [0.9790253 ],
       [0.97632176],
       [0.9037658 ],
       [0.94391733],
       [0.96781904]], dtype=float32)
```

[ ]:

```
model.evaluate(X_test, y_test)
```

```
89/89 [==============================] - 1s 11ms/step - loss: -0.0719 -
accuracy: 0.0000e+00
```

[ ]:

```
[-0.07192137837409973, 0.0]
```

3.4 ML Evaluation.

3.4.1 Logistic Regression

This model appears to have gained some insight in the data and accurately defined a majority of the data. The accuracy of the model is >95% which indicates that it was able to determine a trend and apply it in a useful manner in the predictions during evaluation. Further, the confusion matrix further supports the high accuracy and likely usefulness of the model with only 3 false assignments. However, in analysis this is only to determine if there is a correlation between binary assignment and the emission strength x error in measurement. This doesn't aid us in our overall randomness determination, but it does determine that uncertainty has a role in the binary assignment and the overall trust of emission strength.

3.4.2 Bidirectional LSTM

This model is very error prone as the loss value is consistently at 60& or higher at every epoch during training and at exactly 63.07% in evaluation with a 0% accuracy this indicates that there is either a great error in the formation of the model, data used or trend being obtained. Alternatively it could indicate that there is no trend there to predict. Likely this indicates that the model is not valuable for any meaningful analysis.

4 Preliminary runs test

4.0.1 Math Logic

$$Z = \frac{R - \tilde{R}}{s_R}$$

$$\tilde{R} = \frac{2_{n1n2}}{n1 + n2} + 1$$

$$s_R^2 = \frac{2_{n1n2}(2n1n2 - n1 - n2)}{(n1 + n2)^2(n1 + n2 - 1)}$$

link to resource: https://www.geeksforgeeks.org/runs-test-of-randomness-in-python/

$ Z_{critical} = 1.96 $ as the confidence interval level of 95% thus this is a 2 tailed test. If the probability as corrosponding to this confidence interval $ H_{null} $ will be rejected as it is not statistically significant as denoted by $|Z| > Z_{critical} $

There is also code attempting to change it from a z-score probability to a P-score for ease of understanding and clarity.

5 FUNCTION CODE FOR RUNS TEST

[ ]:
```
binaryData1 = pulsar['Binary'].tolist()
print("pulsar6 original: ",binaryData1)
```

```
pulsar6 original:  [0, 0, 0, 0, 1, 1, 1, 0, 0, 0, 1, 1, 0, 0, 1, 1, 1, 1, 1, 1,
1, 1, 1, 1, 1, 1, 1, 1, 1, 0, 1, 1, 0, 1, 0, 0, 0, 1, 1, 0, 0, 0, 0, 0, 0, 1, 1,
1, 1, 0, 0, 0, 0, 1, 1, 1, 0, 0, 0, 1, 1, 1, 1, 1, 0, 0, 1, 1, 1, 0, 1, 1, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 1, 1, 1, 0, 0, 1, 1, 0, 0, 1, 1, 0, 1, 1, 0, 0,
1, 0, 1, 0, 0, 0, 1, 0, 0, 1, 0, 1, 0, 0, 0, 0, 1, 0, 0, 1, 0, 1, 0, 1, 0, 0, 1,
1, 1, 1, 1, 0, 0, 0, 0, 0, 1, 1, 1, 1, 0, 0, 1, 1, 0, 0, 1, 1, 1, 0, 0, 0, 1, 1,
0, 0, 0, 1, 1, 0, 1, 0, 1, 1, 1, 1, 1, 0, 1, 0, 0, 1, 0, 0, 0, 0, 1, 0, 1, 1, 1,
1, 1, 1, 1, 1, 1, 1, 1, 1, 0, 0, 0, 0, 0, 0, 1, 1, 1, 1, 0, 1, 1, 0, 1, 1, 0, 1,
0, 0, 1, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 1, 1, 1, 1, 0, 0, 1, 1, 1, 1, 1, 0, 1, 1,
0, 1, 0, 0, 0, 0, 1, 0, 1, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 0, 0, 0,
0, 1, 0, 0, 0, 1, 1, 0, 0, 1, 1, 0, 0, 1, 1, 1, 1, 0, 1, 1, 0, 0, 1, 1, 1, 1, 0,
1, 0, 1, 1, 1, 1, 1, 1, 1, 1, 1, 0, 0, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1,
1, 1, 1, 1, 0, 1, 0, 0, 1, 0, 1, 1, 1, 1, 0, 1, 0, 1, 1, 0, 0, 0, 0, 0, 1, 1, 0,
0, 1, 0, 0, 0, 1, 1, 1, 0, 0, 0, 1, 1, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 1, 1, 0,
0, 0, 1, 1, 1, 1, 0, 0, 0, 1, 1, 0, 0, 1, 1, 0, 1, 0, 1, 1, 0, 1, 1, 0, 0, 1, 1,
1, 0, 0, 1, 0, 1, 1, 1, 0, 0, 0, 0, 1, 0, 0, 1, 0, 0, 1, 0, 1, 1, 1, 0, 0, 1, 0,
1, 0, 1, 1, 0, 1, 1, 1, 1, 1, 0, 1, 0, 1, 1, 1, 1, 0, 1, 1, 0, 0, 0, 0, 0, 0, 1,
1, 0, 1, 0, 0, 1, 0, 1, 0, 0, 0, 1, 0, 1, 1, 1, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0,
0, 1, 1, 1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 0, 1, 1, 1, 0, 0, 0,
0, 0, 1, 0, 0, 1, 1, 1, 0, 0, 0, 1, 1, 0, 1, 1, 1, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0,
1, 1, 1, 1, 0, 0, 1, 0, 1, 0, 0, 0, 0, 0, 0, 1, 0, 1, 0, 1, 0, 0, 0, 1, 1, 0, 0,
0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0, 0, 0, 1, 1, 1, 1, 1, 1, 1, 0, 0, 1, 1, 1, 1, 0,
1, 1, 1, 0, 0, 1, 1, 1, 1, 1, 0, 1, 1, 0, 1, 0, 1, 1, 1, 0, 1, 1, 1, 1, 0, 1, 1,
1, 1, 1, 1, 1, 1, 1, 0, 1, 0, 1, 1, 0, 1, 0, 1, 1, 1, 0, 1, 1, 0, 0, 1, 0, 0, 0,
0, 0, 0, 0, 0, 0, 1, 1, 1, 1, 1, 0, 0, 0, 0, 1, 1, 1, 1, 1, 1, 0, 0, 1, 0, 0, 0,
0, 0, 0, 0, 1, 1, 0, 0, 0, 1, 1, 0, 0, 1, 1, 0, 0, 0, 0, 0, 1, 0, 1, 1, 1, 0, 0,
0, 0, 0, 1, 1, 1, 1, 0, 1, 1, 1, 1, 1, 0, 1, 1, 1, 0, 0, 0, 1, 1, 0, 1, 0, 0, 0,
0, 1, 0, 1, 0, 0, 0, 0, 0, 1, 1, 0, 1, 1, 1, 1, 1, 1, 0, 0, 0, 1, 1, 1, 1, 0, 0,
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```

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```

6 Below we begin autocorrelation and autocovariance analysis

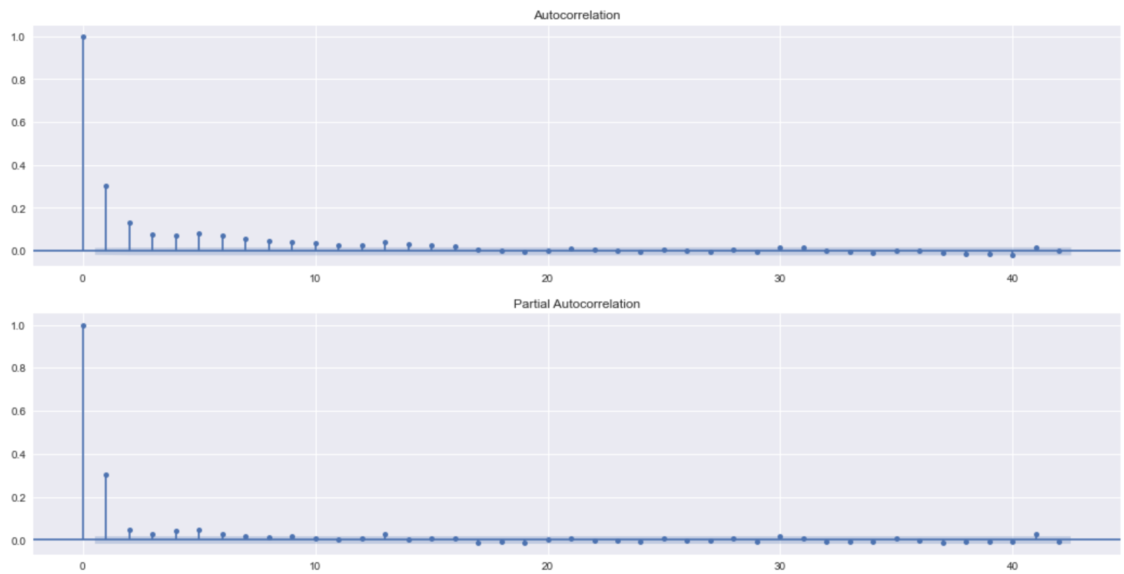
To get started with this I am playing around with guide from: https://towardsdatascience.com/a-step-by-step-guide-to-calculating-autocorrelation-and-partial-autocorrelation-8c4342b784e8

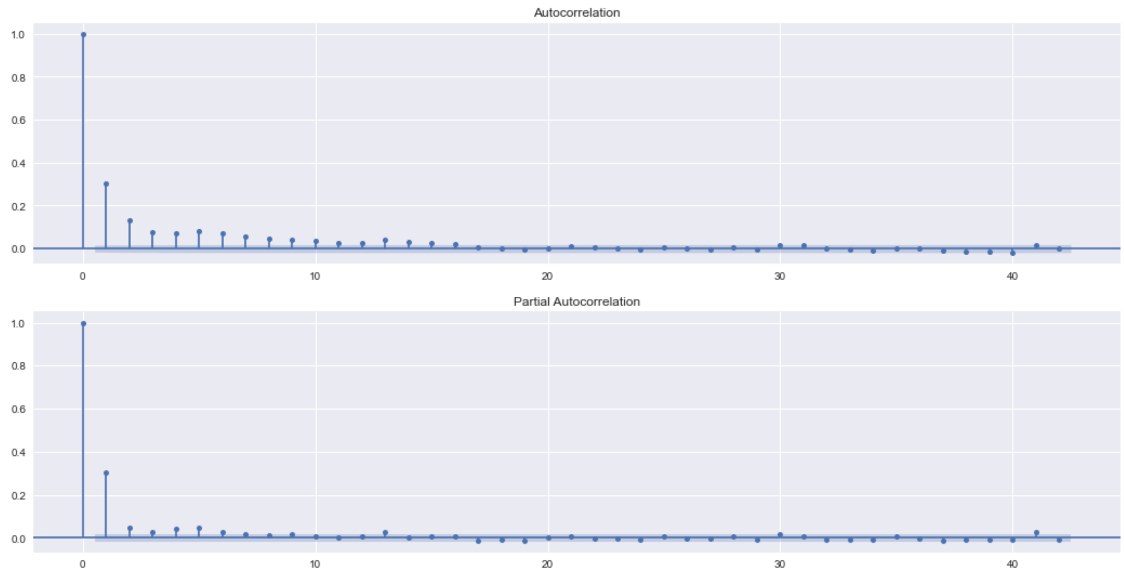
[ ]:
```
plt.style.use("seaborn")
plt.rcParams["figure.figsize"] = (18, 9)

fig, ax = plt.subplots(2,1)

plot_acf(pulsar['Brightness'], ax=ax[0])
plot_pacf(pulsar['Brightness'], ax=ax[1], method="ols")
```

[ ]:





[ ]:
```
acf(pulsar['Brightness'], nlags=10)
```

```
c:\Users\oxlay\anaconda3\lib\site-packages\statsmodels\tsa\stattools.py:667:
FutureWarning: fft=True will become the default after the release of the 0.12
release of statsmodels. To suppress this warning, explicitly set fft=False.
  warnings.warn(
```

[ ]:
```
array([1.        , 0.30152047, 0.13254511, 0.07716124, 0.07364129,
       0.08096058, 0.07046427, 0.05556536, 0.0436438 , 0.04277081,
       0.03660132])
```

[ ]:
```
acfpulsar = pd.DataFrame()
for lag in range(0,11):
    acfpulsar[f"B_lag_{lag}"] = pulsar['Brightness'].shift(lag)


acfpulsar
```

[ ]:

	B_lag_0	B_lag_1	B_lag_2	B_lag_3	B_lag_4	B_lag_5	B_lag_6 \
0	0.334330	NaN	NaN	NaN	NaN	NaN	NaN
1	-0.098659	0.334330	NaN	NaN	NaN	NaN	NaN
2	0.123514	-0.098659	0.334330	NaN	NaN	NaN	NaN
3	0.443923	0.123514	-0.098659	0.334330	NaN	NaN	NaN
4	1.590446	0.443923	0.123514	-0.098659	0.334330	NaN	NaN
…	…	…	…	…	…	…	…
14324	4.876881	5.386421	3.224787	1.953645	4.624813	0.225158	1.502603
14325	2.074136	4.876881	5.386421	3.224787	1.953645	4.624813	0.225158
14326	0.585504	2.074136	4.876881	5.386421	3.224787	1.953645	4.624813

```
14327  0.360930  0.585504  2.074136  4.876881  5.386421  3.224787  1.953645
14328  8.409811  0.360930  0.585504  2.074136  4.876881  5.386421  3.224787

        B_lag_7   B_lag_8   B_lag_9  B_lag_10
0            NaN       NaN       NaN       NaN
1            NaN       NaN       NaN       NaN
2            NaN       NaN       NaN       NaN
3            NaN       NaN       NaN       NaN
4            NaN       NaN       NaN       NaN
…            …        …        …        …
14324  1.389349  1.592995  2.913151  0.181665
14325  1.502603  1.389349  1.592995  2.913151
14326  0.225158  1.502603  1.389349  1.592995
14327  4.624813  0.225158  1.502603  1.389349
14328  1.953645  4.624813  0.225158  1.502603

[14329 rows x 11 columns]
```

[ ]:
```
acfpulsar.corr()["B_lag_0"].values
```

[ ]:
```
array([1.        , 0.30191886, 0.13272532, 0.07726788, 0.07374568,
       0.08110522, 0.07062283, 0.0556971 , 0.04374889, 0.04288793,
       0.0367024 ])
```

6.0.1 Getting every 5th as per the auto correlation

6.0.2 Creating a new set of discrete 100 sets and examining them specifically

6.0.3 Further Random testing to move into extensive testing

Getting every 5th as per the auto correlation

[ ]:
```
held5ths = pulsar[pulsar.index % 5 == 0]
held5ths
```

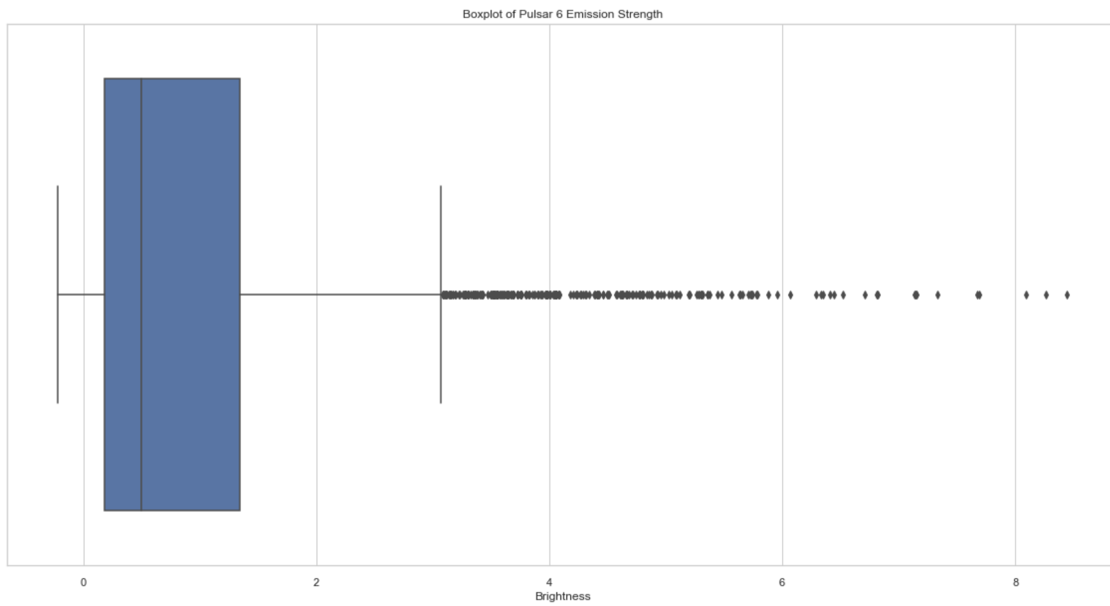
[ ]:
```
       Pulse Number  Brightness  Uncertainty  Binary
0                 1    0.334330     0.015570       0
5                 6    1.233848     0.018692       1
10               11    0.824310     0.036243       1
15               16    0.683800     0.049683       1
20               21    1.006799     0.029068       1
…               …          …            …        …
14305         14306    0.081548     0.011737       0
14310         14311    0.060433     0.011708       0
14315         14316    2.913151     0.089312       1
14320         14321    4.624813     0.095899       1
14325         14326    2.074136     0.080444       1

[2866 rows x 4 columns]
```

[ ]:
```
medianheld5ths = held5ths["Brightness"].median()
medianheld5ths
```

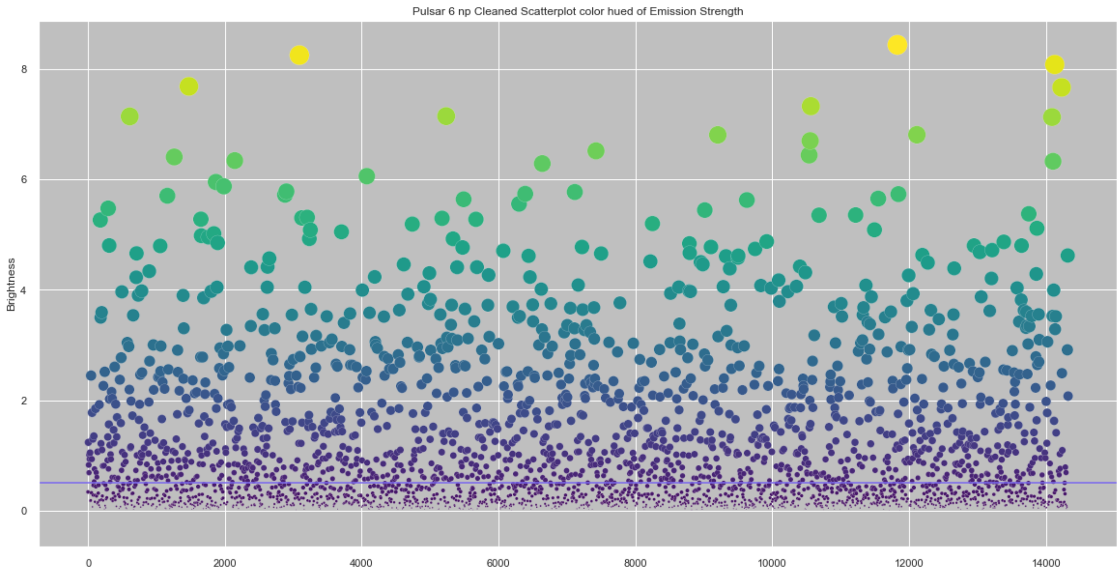
[ ]: 0.49492415

[ ]:
```
plt.figure(figsize=(20,10))
sns.set_theme(style="whitegrid")
ax = sns.boxplot(x=held5ths["Brightness"]).set_title("Boxplot of Pulsar 6␣
↪Emission Strength")
```



[ ]:
```
plt.figure(figsize=(20,10))
sns.set_style("darkgrid", {"axes.facecolor": ".75"})
strength = held5ths.Brightness.values
ax = sns.scatterplot(data=held5ths["Brightness"], s= strength*50, c=strength,␣
↪cmap="viridis", marker="o").set_title('Pulsar 6 np Cleaned Scatterplot color␣
↪hued of Emission Strength')
ax = plt.axhline( y=0.49492415, ls='-',c='mediumslateblue')
```

```
c:\Users\oxlay\anaconda3\lib\site-packages\matplotlib\collections.py:1003:
RuntimeWarning: invalid value encountered in sqrt
  scale = np.sqrt(self._sizes) * dpi / 72.0 * self._factor
```




```
[ ]: #plt.figure(figsize=(20,10))
     #sns.set_style("darkgrid", {"axes.facecolor": ".75"})
     #strength = held5ths.Brightness.values
     #ax = plt.axhline( y=0.49492415, ls='-',c='mediumslateblue')
     #ax = sns.swarmplot(data=held5ths["Brightness"], c="blue").set_title('Pulsar 6␣
      ↪Swarm plot of Emission Strength')
```

```
[ ]: print(len(held5ths[(held5ths.Brightness > 0.49492415)]))
     print(len(held5ths[(held5ths.Brightness < 0.49492415)]))
```

```
1433
1433
```

Randomness testing

```
[ ]: np.savetxt(r'every5thbinarypulsar2.txt', held5ths.Binary, fmt='%d',␣
      ↪delimiter='')
     np.savetxt(r'allpulsar2.txt', pulsar.Binary, fmt='%d', delimiter='')
```

```
[ ]: pulsar.Binary
```

```
[ ]: 0        0
     1        0
     2        0
     3        0
     4        1
             ..
     14324    1
     14325    1
```

```
14326    1
14327    0
14328    1
Name: Binary, Length: 14329, dtype: int32
```