Random Forest - Classification

The Data

We will be using the same dataset through our discussions on classification with tree-methods (Decision Tree,Random Forests, and Gradient Boosted Trees) in order to compare performance metrics across these related models.

We will work with the "Palmer Penguins" dataset, as it is simple enough to help us fully understand how changing hyperparameters can change classification results.

Data were collected and made available by Dr. Kristen Gorman and the Palmer Station, Antarctica LTER, a member of the Long Term Ecological Research Network.

Gorman KB, Williams TD, Fraser WR (2014) Ecological Sexual Dimorphism and Environmental Variability within a Community of Antarctic Penguins (Genus Pygoscelis). PLoS ONE 9(3): e90081. doi:10.1371/journal.pone.0090081

Summary: The data folder contains two CSV files. For intro courses/examples, you probably want to use the first one (penguins_size.csv).

- **penguins_size.csv: Simplified data from original penguin data sets. Contains variables:**
  - **species: penguin species (Chinstrap, Adélie, or Gentoo)**
  - **culmen_length_mm: culmen length (mm)**
  - **culmen_depth_mm: culmen depth (mm)**
  - **flipper_length_mm: flipper length (mm)**
  - **body_mass_g: body mass (g)**
  - **island: island name (Dream, Torgersen, or Biscoe) in the Palmer Archipelago (Antarctica)**
  - **sex: penguin sex**
- **(Not used) penguins_lter.csv: Original combined data for 3 penguin species**

Note: The culmen is "the upper ridge of a bird's beak"

Our goal is to create a model that can help predict a species of a penguin based on physical attributes, then we can use that model to help researchers classify penguins in the field, instead of needing an experienced biologist

Imports

In [1]:

```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
```

In [2]:

```
df=pd.read_csv("D:\\Study\\Programming\\python\\Python course from udemy\\Udemy - 2022 Python for Machine Learning & Data Science Masterclass\\01 - Introduction to Course\\1UNZIP-FOR-NOTEBOOKS-FINAL\\DATA\\penguins_size.csv")
df.head()
```

Out[2]:

	species	island	culmen_length_mm	culmen_depth_mm	flipper_length_mm	body_mass_g	sex
0	Adelie	Torgersen	39.1	18.7	181.0	3750.0	MALE
1	Adelie	Torgersen	39.5	17.4	186.0	3800.0	FEMALE

	species	island	culmen_length_mm	culmen_depth_mm	flipper_length_mm	body_mass_g	sex
2	Adelie	Torgersen	40.3	18.0	195.0	3250.0	FEMALE
3	Adelie	Torgersen	NaN	NaN	NaN	NaN	NaN
4	Adelie	Torgersen	36.7	19.3	193.0	3450.0	FEMALE

In [3]:

```
# Here we are droping all null values
df = df.dropna()
df.head()
```

Out[3]:

	species	island	culmen_length_mm	culmen_depth_mm	flipper_length_mm	body_mass_g	sex
0	Adelie	Torgersen	39.1	18.7	181.0	3750.0	MALE
1	Adelie	Torgersen	39.5	17.4	186.0	3800.0	FEMALE
2	Adelie	Torgersen	40.3	18.0	195.0	3250.0	FEMALE
4	Adelie	Torgersen	36.7	19.3	193.0	3450.0	FEMALE
5	Adelie	Torgersen	39.3	20.6	190.0	3650.0	MALE

Train | Test Split

In [4]:

```
X=pd.get_dummies(df.drop('species',axis=1),drop_first=True)
```

In [5]:

```
y=df['species']
```

In [6]:

```
from sklearn.model_selection import train_test_split
```

In [7]:

```
X_train,X_test,y_train,y_test = train_test_split(X,y,test_size=0.30,random_state=101)
```

Random Forest Classification

In [8]:

```
from sklearn.ensemble import RandomForestClassifier
```

In [9]:

```
#help(RandomForestClassifier)
```

In [10]:

```
rfc = RandomForestClassifier(n_estimators=10,
                             max_features='auto',
                             random_state=101)
```

In [11]:

```
rfc.fit(X_train,y_train)
```

```
C:\Users\Chromsy\AppData\Roaming\Python\Python39\site-packages\sklearn\ensemble\_forest.p
y:424: FutureWarning: `max_features='auto'` has been deprecated in 1.1 and will be remove
d in 1.3. To keep the past behaviour, explicitly set `max_features='sqrt'` or remove this
parameter as it is also the default value for RandomForestClassifiers and ExtraTreesClass
ifiers.
```

```
  warn(
```

Out[11]:

```
▾                        RandomForestClassifier
RandomForestClassifier(max_features='auto', n_estimators=10, random_state=101)
```

In [12]:

```
preds = rfc.predict(X_test)
```

In [13]:

```
from sklearn.metrics import confusion_matrix,classification_report
```

In [14]:

```
from mlxtend.plotting import plot_confusion_matrix
```

In [15]:

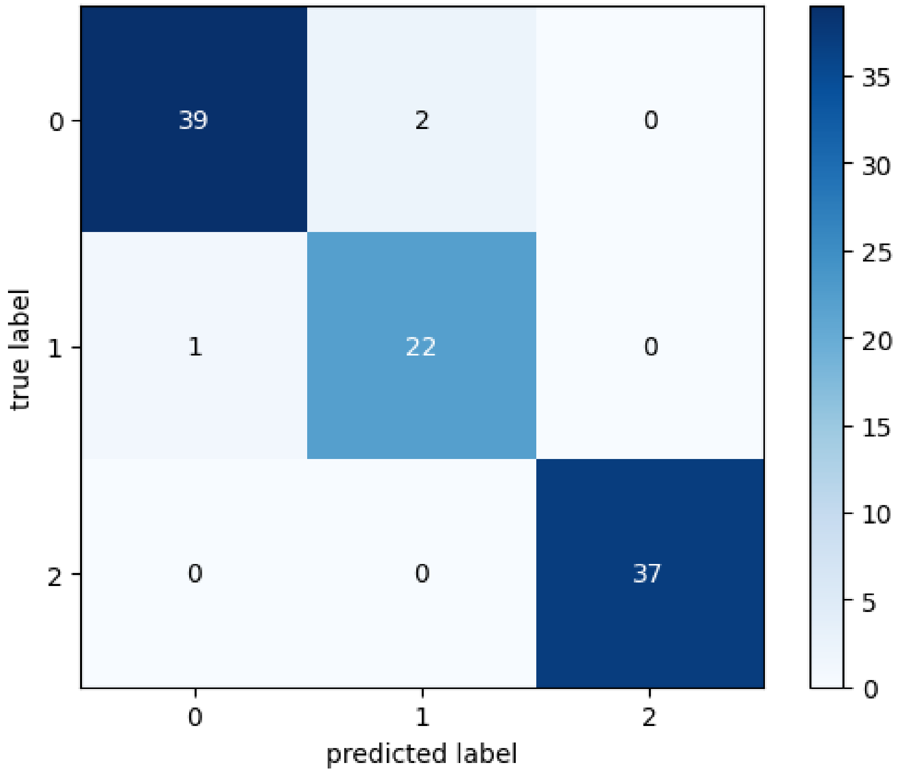
```
d=confusion_matrix(y_test,preds)
d
```

Out[15]:

```
array([[39,  2,  0],
       [ 1, 22,  0],
       [ 0,  0, 37]], dtype=int64)
```

In [16]:

```
plot_confusion_matrix(d,colorbar=True);
```



In [17]:

```
print(classification_report(y_test,preds))
```

```
              precision    recall  f1-score   support

      Adelie       0.97      0.95      0.96        41
   Chinstrap       0.92      0.96      0.94        23
      Gentoo       1.00      1.00      1.00        37

                                       0.97       101
```

```
    accuracy                           0.97       101
   macro avg       0.96      0.97      0.97       101
weighted avg       0.97      0.97      0.97       101
```

Feature Importance

Very useful attribute of the trained model!

In [18]:

```
rfc.feature_importances_
```

Out[18]:

```
array([0.31867744, 0.1018487 , 0.17343398, 0.21316964, 0.14512091,
       0.03720114, 0.00632264, 0.00422556])
```

In [19]:

```
# creating a DataFrame so that we can see the importance of each feature
pd.DataFrame(index=X.columns,data=rfc.feature_importances_,columns=['Feature Importance'
])
```

Out[19]:

	Feature Importance
culmen_length_mm	0.318677
culmen_depth_mm	0.101849
flipper_length_mm	0.173434
body_mass_g	0.213170
island_Dream	0.145121
island_Torgersen	0.037201
sex_FEMALE	0.006323
sex_MALE	0.004226

Choosing correct number of trees

Let's explore if continually adding more trees improves performance...

In [20]:

```
test_error = []
from sklearn.metrics import accuracy_score

for n in range(1,40):
    # Use n random trees
    model = RandomForestClassifier(n_estimators=n,max_features='auto')
    model.fit(X_train,y_train)
    test_preds = model.predict(X_test)
    test_error.append(1-accuracy_score(test_preds,y_test))
```

```
C:\Users\Chromsy\AppData\Roaming\Python\Python39\site-packages\sklearn\ensemble\_forest.p
y:424: FutureWarning: `max_features='auto'` has been deprecated in 1.1 and will be remove
d in 1.3. To keep the past behaviour, explicitly set `max_features='sqrt'` or remove this
parameter as it is also the default value for RandomForestClassifiers and ExtraTreesClass
ifiers.
  warn(
C:\Users\Chromsy\AppData\Roaming\Python\Python39\site-packages\sklearn\ensemble\_forest.p
y:424: FutureWarning: `max_features='auto'` has been deprecated in 1.1 and will be remove
d in 1.3. To keep the past behaviour, explicitly set `max_features='sqrt'` or remove this
parameter as it is also the default value for RandomForestClassifiers and ExtraTreesClass
ifiers.
```

```
  warn(
C:\Users\Chromsy\AppData\Roaming\Python\Python39\site-packages\sklearn\ensemble\_forest.p
y:424: FutureWarning: `max_features='auto'` has been deprecated in 1.1 and will be remove
d in 1.3. To keep the past behaviour, explicitly set `max_features='sqrt'` or remove this
parameter as it is also the default value for RandomForestClassifiers and ExtraTreesClass
ifiers.
  warn(
C:\Users\Chromsy\AppData\Roaming\Python\Python39\site-packages\sklearn\ensemble\_forest.p
y:424: FutureWarning: `max_features='auto'` has been deprecated in 1.1 and will be remove
d in 1.3. To keep the past behaviour, explicitly set `max_features='sqrt'` or remove this
parameter as it is also the default value for RandomForestClassifiers and ExtraTreesClass
ifiers.
  warn(
C:\Users\Chromsy\AppData\Roaming\Python\Python39\site-packages\sklearn\ensemble\_forest.p
y:424: FutureWarning: `max_features='auto'` has been deprecated in 1.1 and will be remove
d in 1.3. To keep the past behaviour, explicitly set `max_features='sqrt'` or remove this
parameter as it is also the default value for RandomForestClassifiers and ExtraTreesClass
ifiers.
  warn(
C:\Users\Chromsy\AppData\Roaming\Python\Python39\site-packages\sklearn\ensemble\_forest.p
y:424: FutureWarning: `max_features='auto'` has been deprecated in 1.1 and will be remove
d in 1.3. To keep the past behaviour, explicitly set `max_features='sqrt'` or remove this
parameter as it is also the default value for RandomForestClassifiers and ExtraTreesClass
ifiers.
  warn(
C:\Users\Chromsy\AppData\Roaming\Python\Python39\site-packages\sklearn\ensemble\_forest.p
y:424: FutureWarning: `max_features='auto'` has been deprecated in 1.1 and will be remove
d in 1.3. To keep the past behaviour, explicitly set `max_features='sqrt'` or remove this
parameter as it is also the default value for RandomForestClassifiers and ExtraTreesClass
ifiers.
  warn(
C:\Users\Chromsy\AppData\Roaming\Python\Python39\site-packages\sklearn\ensemble\_forest.p
y:424: FutureWarning: `max_features='auto'` has been deprecated in 1.1 and will be remove
d in 1.3. To keep the past behaviour, explicitly set `max_features='sqrt'` or remove this
parameter as it is also the default value for RandomForestClassifiers and ExtraTreesClass
ifiers.
  warn(
C:\Users\Chromsy\AppData\Roaming\Python\Python39\site-packages\sklearn\ensemble\_forest.p
y:424: FutureWarning: `max_features='auto'` has been deprecated in 1.1 and will be remove
d in 1.3. To keep the past behaviour, explicitly set `max_features='sqrt'` or remove this
parameter as it is also the default value for RandomForestClassifiers and ExtraTreesClass
ifiers.
  warn(
C:\Users\Chromsy\AppData\Roaming\Python\Python39\site-packages\sklearn\ensemble\_forest.p
y:424: FutureWarning: `max_features='auto'` has been deprecated in 1.1 and will be remove
d in 1.3. To keep the past behaviour, explicitly set `max_features='sqrt'` or remove this
parameter as it is also the default value for RandomForestClassifiers and ExtraTreesClass
ifiers.
  warn(
C:\Users\Chromsy\AppData\Roaming\Python\Python39\site-packages\sklearn\ensemble\_forest.p
y:424: FutureWarning: `max_features='auto'` has been deprecated in 1.1 and will be remove
d in 1.3. To keep the past behaviour, explicitly set `max_features='sqrt'` or remove this
parameter as it is also the default value for RandomForestClassifiers and ExtraTreesClass
ifiers.
  warn(
C:\Users\Chromsy\AppData\Roaming\Python\Python39\site-packages\sklearn\ensemble\_forest.p
y:424: FutureWarning: `max_features='auto'` has been deprecated in 1.1 and will be remove
d in 1.3. To keep the past behaviour, explicitly set `max_features='sqrt'` or remove this
parameter as it is also the default value for RandomForestClassifiers and ExtraTreesClass
ifiers.
  warn(
C:\Users\Chromsy\AppData\Roaming\Python\Python39\site-packages\sklearn\ensemble\_forest.p
y:424: FutureWarning: `max_features='auto'` has been deprecated in 1.1 and will be remove
d in 1.3. To keep the past behaviour, explicitly set `max_features='sqrt'` or remove this
parameter as it is also the default value for RandomForestClassifiers and ExtraTreesClass
ifiers.
  warn(
C:\Users\Chromsy\AppData\Roaming\Python\Python39\site-packages\sklearn\ensemble\_forest.p
y:424: FutureWarning: `max_features='auto'` has been deprecated in 1.1 and will be remove
d in 1.3. To keep the past behaviour, explicitly set `max_features='sqrt'` or remove this
parameter as it is also the default value for RandomForestClassifiers and ExtraTreesClass
ifiers.
```

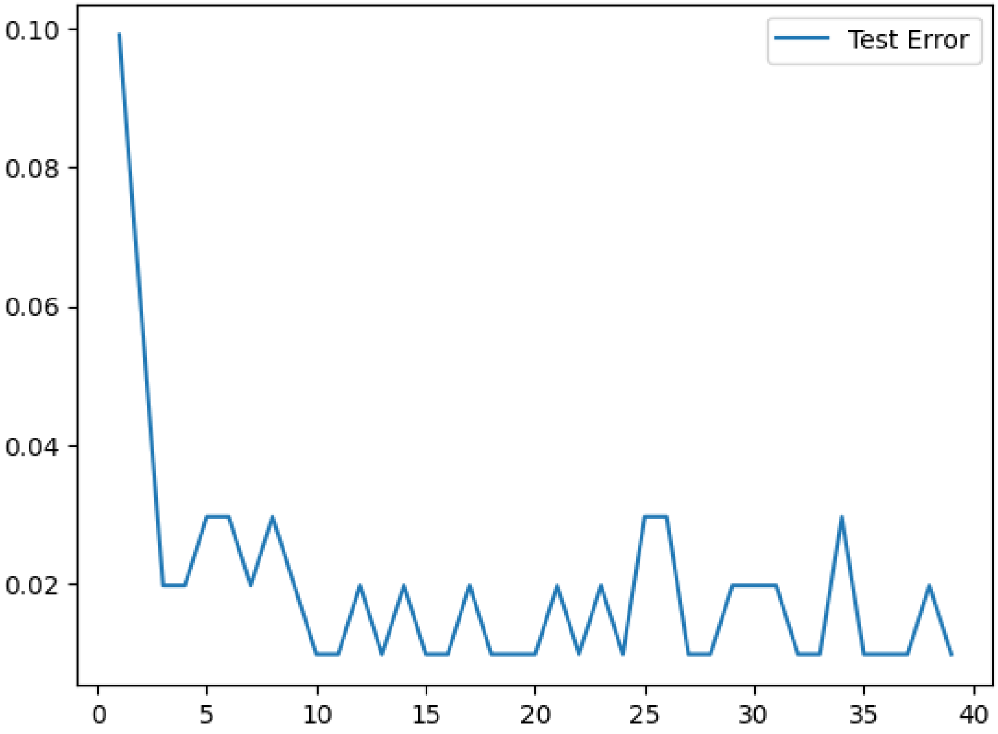
```
  warn(
C:\Users\Chromsy\AppData\Roaming\Python\Python39\site-packages\sklearn\ensemble\_forest.p
y:424: FutureWarning: `max_features='auto'` has been deprecated in 1.1 and will be remove
d in 1.3. To keep the past behaviour, explicitly set `max_features='sqrt'` or remove this
parameter as it is also the default value for RandomForestClassifiers and ExtraTreesClass
ifiers.
  warn(
C:\Users\Chromsy\AppData\Roaming\Python\Python39\site-packages\sklearn\ensemble\_forest.p
y:424: FutureWarning: `max_features='auto'` has been deprecated in 1.1 and will be remove
d in 1.3. To keep the past behaviour, explicitly set `max_features='sqrt'` or remove this
parameter as it is also the default value for RandomForestClassifiers and ExtraTreesClass
ifiers.
  warn(
C:\Users\Chromsy\AppData\Roaming\Python\Python39\site-packages\sklearn\ensemble\_forest.p
y:424: FutureWarning: `max_features='auto'` has been deprecated in 1.1 and will be remove
d in 1.3. To keep the past behaviour, explicitly set `max_features='sqrt'` or remove this
parameter as it is also the default value for RandomForestClassifiers and ExtraTreesClass
ifiers.
  warn(
C:\Users\Chromsy\AppData\Roaming\Python\Python39\site-packages\sklearn\ensemble\_forest.p
y:424: FutureWarning: `max_features='auto'` has been deprecated in 1.1 and will be remove
d in 1.3. To keep the past behaviour, explicitly set `max_features='sqrt'` or remove this
parameter as it is also the default value for RandomForestClassifiers and ExtraTreesClass
ifiers.
  warn(
C:\Users\Chromsy\AppData\Roaming\Python\Python39\site-packages\sklearn\ensemble\_forest.p
y:424: FutureWarning: `max_features='auto'` has been deprecated in 1.1 and will be remove
d in 1.3. To keep the past behaviour, explicitly set `max_features='sqrt'` or remove this
parameter as it is also the default value for RandomForestClassifiers and ExtraTreesClass
ifiers.
  warn(
C:\Users\Chromsy\AppData\Roaming\Python\Python39\site-packages\sklearn\ensemble\_forest.p
y:424: FutureWarning: `max_features='auto'` has been deprecated in 1.1 and will be remove
d in 1.3. To keep the past behaviour, explicitly set `max_features='sqrt'` or remove this
parameter as it is also the default value for RandomForestClassifiers and ExtraTreesClass
ifiers.
  warn(
C:\Users\Chromsy\AppData\Roaming\Python\Python39\site-packages\sklearn\ensemble\_forest.p
y:424: FutureWarning: `max_features='auto'` has been deprecated in 1.1 and will be remove
d in 1.3. To keep the past behaviour, explicitly set `max_features='sqrt'` or remove this
parameter as it is also the default value for RandomForestClassifiers and ExtraTreesClass
ifiers.
  warn(
C:\Users\Chromsy\AppData\Roaming\Python\Python39\site-packages\sklearn\ensemble\_forest.p
y:424: FutureWarning: `max_features='auto'` has been deprecated in 1.1 and will be remove
d in 1.3. To keep the past behaviour, explicitly set `max_features='sqrt'` or remove this
parameter as it is also the default value for RandomForestClassifiers and ExtraTreesClass
ifiers.
  warn(
C:\Users\Chromsy\AppData\Roaming\Python\Python39\site-packages\sklearn\ensemble\_forest.p
y:424: FutureWarning: `max_features='auto'` has been deprecated in 1.1 and will be remove
d in 1.3. To keep the past behaviour, explicitly set `max_features='sqrt'` or remove this
parameter as it is also the default value for RandomForestClassifiers and ExtraTreesClass
ifiers.
  warn(
C:\Users\Chromsy\AppData\Roaming\Python\Python39\site-packages\sklearn\ensemble\_forest.p
y:424: FutureWarning: `max_features='auto'` has been deprecated in 1.1 and will be remove
d in 1.3. To keep the past behaviour, explicitly set `max_features='sqrt'` or remove this
parameter as it is also the default value for RandomForestClassifiers and ExtraTreesClass
ifiers.
  warn(
C:\Users\Chromsy\AppData\Roaming\Python\Python39\site-packages\sklearn\ensemble\_forest.p
y:424: FutureWarning: `max_features='auto'` has been deprecated in 1.1 and will be remove
d in 1.3. To keep the past behaviour, explicitly set `max_features='sqrt'` or remove this
parameter as it is also the default value for RandomForestClassifiers and ExtraTreesClass
ifiers.
  warn(
C:\Users\Chromsy\AppData\Roaming\Python\Python39\site-packages\sklearn\ensemble\_forest.p
y:424: FutureWarning: `max_features='auto'` has been deprecated in 1.1 and will be remove
d in 1.3. To keep the past behaviour, explicitly set `max_features='sqrt'` or remove this
parameter as it is also the default value for RandomForestClassifiers and ExtraTreesClass
ifiers.
```

```
  warn(
C:\Users\Chromsy\AppData\Roaming\Python\Python39\site-packages\sklearn\ensemble\_forest.p
y:424: FutureWarning: `max_features='auto'` has been deprecated in 1.1 and will be remove
d in 1.3. To keep the past behaviour, explicitly set `max_features='sqrt'` or remove this
parameter as it is also the default value for RandomForestClassifiers and ExtraTreesClass
ifiers.
  warn(
C:\Users\Chromsy\AppData\Roaming\Python\Python39\site-packages\sklearn\ensemble\_forest.p
y:424: FutureWarning: `max_features='auto'` has been deprecated in 1.1 and will be remove
d in 1.3. To keep the past behaviour, explicitly set `max_features='sqrt'` or remove this
parameter as it is also the default value for RandomForestClassifiers and ExtraTreesClass
ifiers.
  warn(
C:\Users\Chromsy\AppData\Roaming\Python\Python39\site-packages\sklearn\ensemble\_forest.p
y:424: FutureWarning: `max_features='auto'` has been deprecated in 1.1 and will be remove
d in 1.3. To keep the past behaviour, explicitly set `max_features='sqrt'` or remove this
parameter as it is also the default value for RandomForestClassifiers and ExtraTreesClass
ifiers.
  warn(
C:\Users\Chromsy\AppData\Roaming\Python\Python39\site-packages\sklearn\ensemble\_forest.p
y:424: FutureWarning: `max_features='auto'` has been deprecated in 1.1 and will be remove
d in 1.3. To keep the past behaviour, explicitly set `max_features='sqrt'` or remove this
parameter as it is also the default value for RandomForestClassifiers and ExtraTreesClass
ifiers.
  warn(
C:\Users\Chromsy\AppData\Roaming\Python\Python39\site-packages\sklearn\ensemble\_forest.p
y:424: FutureWarning: `max_features='auto'` has been deprecated in 1.1 and will be remove
d in 1.3. To keep the past behaviour, explicitly set `max_features='sqrt'` or remove this
parameter as it is also the default value for RandomForestClassifiers and ExtraTreesClass
ifiers.
  warn(
C:\Users\Chromsy\AppData\Roaming\Python\Python39\site-packages\sklearn\ensemble\_forest.p
y:424: FutureWarning: `max_features='auto'` has been deprecated in 1.1 and will be remove
d in 1.3. To keep the past behaviour, explicitly set `max_features='sqrt'` or remove this
parameter as it is also the default value for RandomForestClassifiers and ExtraTreesClass
ifiers.
  warn(
C:\Users\Chromsy\AppData\Roaming\Python\Python39\site-packages\sklearn\ensemble\_forest.p
y:424: FutureWarning: `max_features='auto'` has been deprecated in 1.1 and will be remove
d in 1.3. To keep the past behaviour, explicitly set `max_features='sqrt'` or remove this
parameter as it is also the default value for RandomForestClassifiers and ExtraTreesClass
ifiers.
  warn(
C:\Users\Chromsy\AppData\Roaming\Python\Python39\site-packages\sklearn\ensemble\_forest.p
y:424: FutureWarning: `max_features='auto'` has been deprecated in 1.1 and will be remove
d in 1.3. To keep the past behaviour, explicitly set `max_features='sqrt'` or remove this
parameter as it is also the default value for RandomForestClassifiers and ExtraTreesClass
ifiers.
  warn(
C:\Users\Chromsy\AppData\Roaming\Python\Python39\site-packages\sklearn\ensemble\_forest.p
y:424: FutureWarning: `max_features='auto'` has been deprecated in 1.1 and will be remove
d in 1.3. To keep the past behaviour, explicitly set `max_features='sqrt'` or remove this
parameter as it is also the default value for RandomForestClassifiers and ExtraTreesClass
ifiers.
  warn(
C:\Users\Chromsy\AppData\Roaming\Python\Python39\site-packages\sklearn\ensemble\_forest.p
y:424: FutureWarning: `max_features='auto'` has been deprecated in 1.1 and will be remove
d in 1.3. To keep the past behaviour, explicitly set `max_features='sqrt'` or remove this
parameter as it is also the default value for RandomForestClassifiers and ExtraTreesClass
ifiers.
  warn(
C:\Users\Chromsy\AppData\Roaming\Python\Python39\site-packages\sklearn\ensemble\_forest.p
y:424: FutureWarning: `max_features='auto'` has been deprecated in 1.1 and will be remove
d in 1.3. To keep the past behaviour, explicitly set `max_features='sqrt'` or remove this
parameter as it is also the default value for RandomForestClassifiers and ExtraTreesClass
ifiers.
  warn(
C:\Users\Chromsy\AppData\Roaming\Python\Python39\site-packages\sklearn\ensemble\_forest.p
y:424: FutureWarning: `max_features='auto'` has been deprecated in 1.1 and will be remove
d in 1.3. To keep the past behaviour, explicitly set `max_features='sqrt'` or remove this
parameter as it is also the default value for RandomForestClassifiers and ExtraTreesClass
ifiers.
```

```
  warn(
C:\Users\Chromsy\AppData\Roaming\Python\Python39\site-packages\sklearn\ensemble\_forest.p
y:424: FutureWarning: `max_features='auto'` has been deprecated in 1.1 and will be remove
d in 1.3. To keep the past behaviour, explicitly set `max_features='sqrt'` or remove this
parameter as it is also the default value for RandomForestClassifiers and ExtraTreesClass
ifiers.
  warn(
```

In [21]:

```
plt.plot(range(1,40),test_error,label='Test Error')
plt.legend();
```



Clearly there are diminishing returns, on such a small dataset, we've pretty much extracted all the information we can after about 5 trees

Random Forest - HyperParameter Exploration

https://archive.ics.uci.edu/ml/datasets/banknote+authentication

Data

In [22]:

```
df=pd.read_csv("D:\\Study\\Programming\\python\\Python course from udemy\\Udemy - 2022 P
ython for Machine Learning & Data Science Masterclass\\01 - Introduction to Course\\1UNZI
P-FOR-NOTEBOOKS-FINAL\\DATA\\data_banknote_authentication.csv")
df.head()
```

Out[22]:

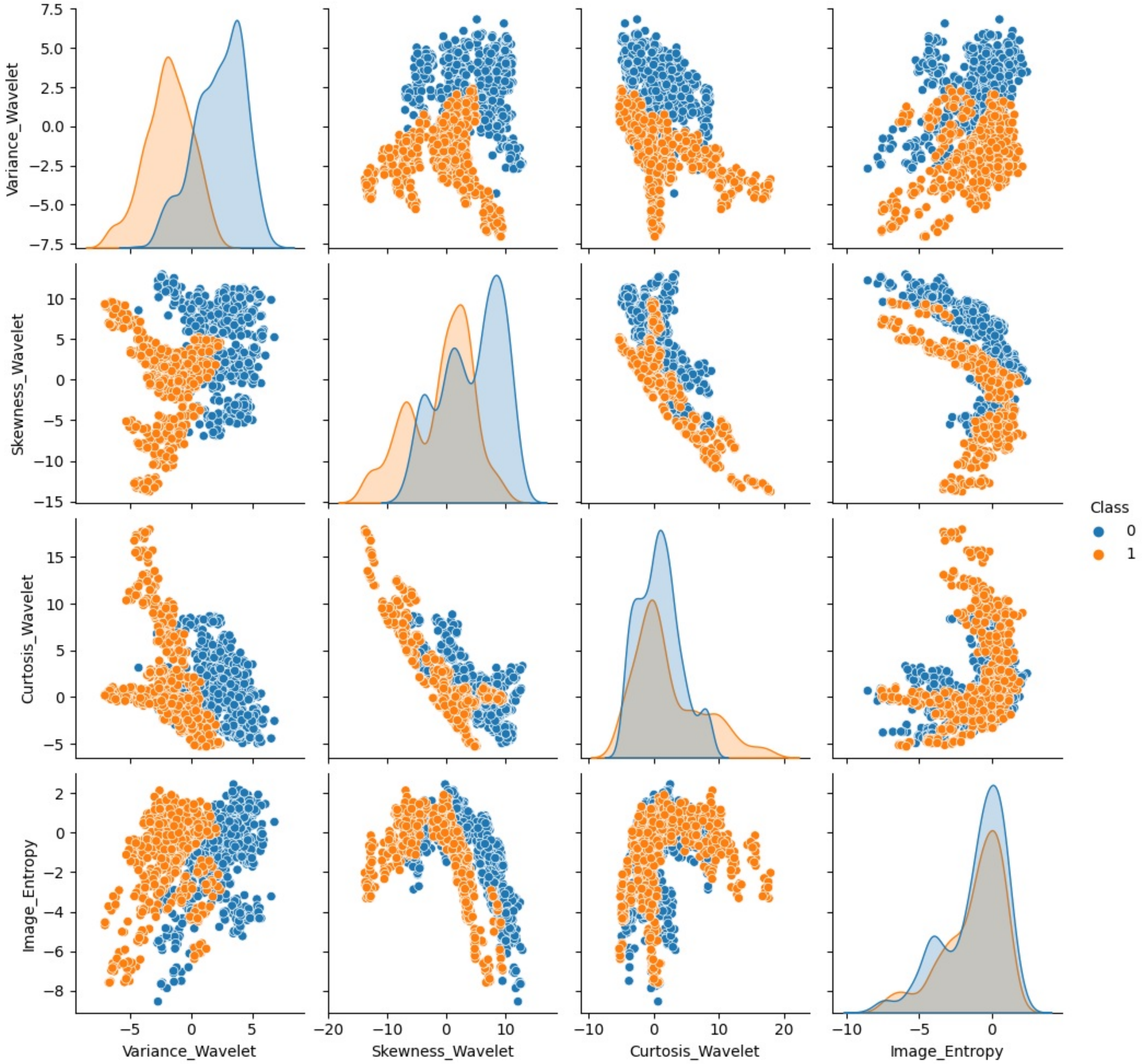
	Variance_Wavelet	Skewness_Wavelet	Curtosis_Wavelet	Image_Entropy	Class
0	3.62160	8.6661	-2.8073	-0.44699	0
1	4.54590	8.1674	-2.4586	-1.46210	0
2	3.86600	-2.6383	1.9242	0.10645	0
3	3.45660	9.5228	-4.0112	-3.59440	0
4	0.32924	-4.4552	4.5718	-0.98880	0

In [23]:

```
sns.pairplot(df,hue='Class')
```

Out[23]:

```
<seaborn.axisgrid.PairGrid at 0x1ed3da63f40>
```



In [24]:

```
X= df.drop('Class',axis=1)
y=df['Class']
```

In [25]:

```
from sklearn.model_selection import train_test_split
```

In [26]:

```
X_train,X_test,y_train,y_test= train_test_split(X,y,test_size=0.15,random_state=101)
```

In [27]:

```
from sklearn.model_selection import GridSearchCV
```

In [28]:

```
param_grid={'n_estimators':[64,100,128,200],
            'max_features':[2,3,4],
            'bootstrap':[True,False],
            'oob_score':[True,False]}
# Note, oob_score only makes sense when bootstrap=True!
```

In [29]:

```
rfc = RandomForestClassifier()
```

In [30]:

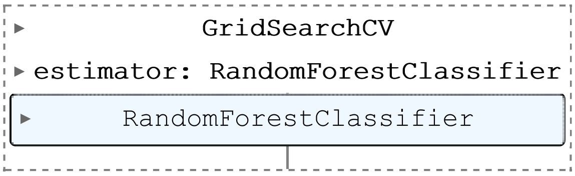
```
grid = GridSearchCV(rfc,param_grid)
```

In [31]:

```
grid.fit(X_train,y_train)
```

```
C:\Users\Chromsy\AppData\Roaming\Python\Python39\site-packages\sklearn\model_selection\_v
alidation.py:378: FitFailedWarning:
60 fits failed out of a total of 240.
The score on these train-test partitions for these parameters will be set to nan.
If these failures are not expected, you can try to debug them by setting error_score='rai
se'.

Below are more details about the failures:
--------------------------------------------------------------------------------
60 fits failed with the following error:
Traceback (most recent call last):
  File "C:\Users\Chromsy\AppData\Roaming\Python\Python39\site-packages\sklearn\model_sele
ction\_validation.py", line 686, in _fit_and_score
    estimator.fit(X_train, y_train, **fit_params)
  File "C:\Users\Chromsy\AppData\Roaming\Python\Python39\site-packages\sklearn\ensemble\_
forest.py", line 434, in fit
    raise ValueError("Out of bag estimation only available if bootstrap=True")
ValueError: Out of bag estimation only available if bootstrap=True

  warnings.warn(some_fits_failed_message, FitFailedWarning)
C:\Users\Chromsy\AppData\Roaming\Python\Python39\site-packages\sklearn\model_selection\_s
earch.py:952: UserWarning: One or more of the test scores are non-finite: [0.99314038 0.9
9314038 0.99399875 0.99314038 0.99314038 0.99314038
 0.99399875 0.99399875 0.99399875 0.99228201 0.99314038 0.99142365
 0.99314038 0.99314038 0.99314038 0.99399875 0.98799017 0.98799017
 0.98884854 0.98799017 0.9871318  0.98799017 0.98799017 0.98970691
        nan 0.99313305        nan 0.99313672        nan 0.99399142
        nan 0.99313672        nan 0.99228201        nan 0.98970691
        nan 0.99227835        nan 0.99056528        nan 0.97684604
        nan 0.98112688        nan 0.97770441        nan 0.97770441]
  warnings.warn(
```

Out[31]:



In [32]:

```
grid.best_params_
```

Out[32]:

```
{'bootstrap': True, 'max_features': 2, 'n_estimators': 100, 'oob_score': True}
```

In [33]:

```
predis = grid.predict(X_test)
```

In [34]:

```
print(classification_report(y_test,predis))
```

```
              precision    recall  f1-score   support

           0       1.00      0.98      0.99       124
           1       0.98      1.00      0.99        82

    accuracy                           0.99       206
   macro avg       0.99      0.99      0.99       206
weighted avg       0.99      0.99      0.99       206
```

In [35]:

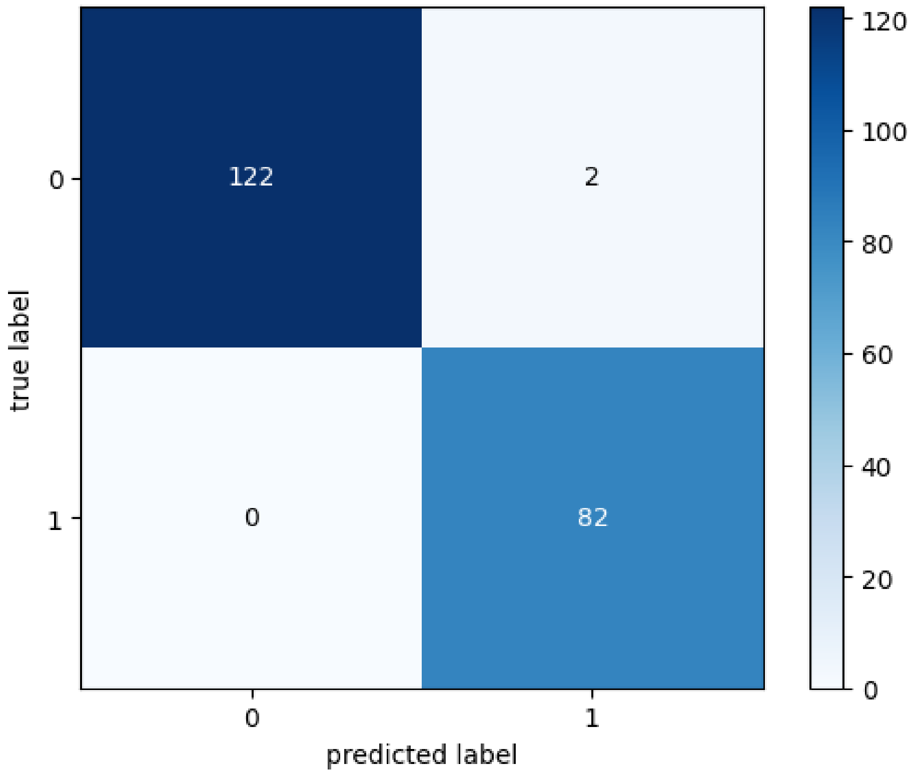
```
p=confusion_matrix(y_test,predis)
p
```

Out[35]:

```
array([[122,   2],
       [  0,  82]], dtype=int64)
```

In [36]:

```
plot_confusion_matrix(p,colorbar=True);
```



In [37]:

```
# No underscore, reports back original oob_score parameter
grid.best_estimator_.oob_score
# If it true then it would generate value
```

Out[37]:

```
True
```

In [44]:

```
# With underscore, reports back fitted attribute of oob_score
grid.best_estimator_.oob_score_
# That value is only generate when .oob_score is True , show error if its False
```

Out[44]:

```
0.9965694682675815
```

Understanding Number of Estimators (Trees)

Let's plot out error vs. Number of Estimators

In [39]:

```
from sklearn.metrics import accuracy_score
```

In [45]:

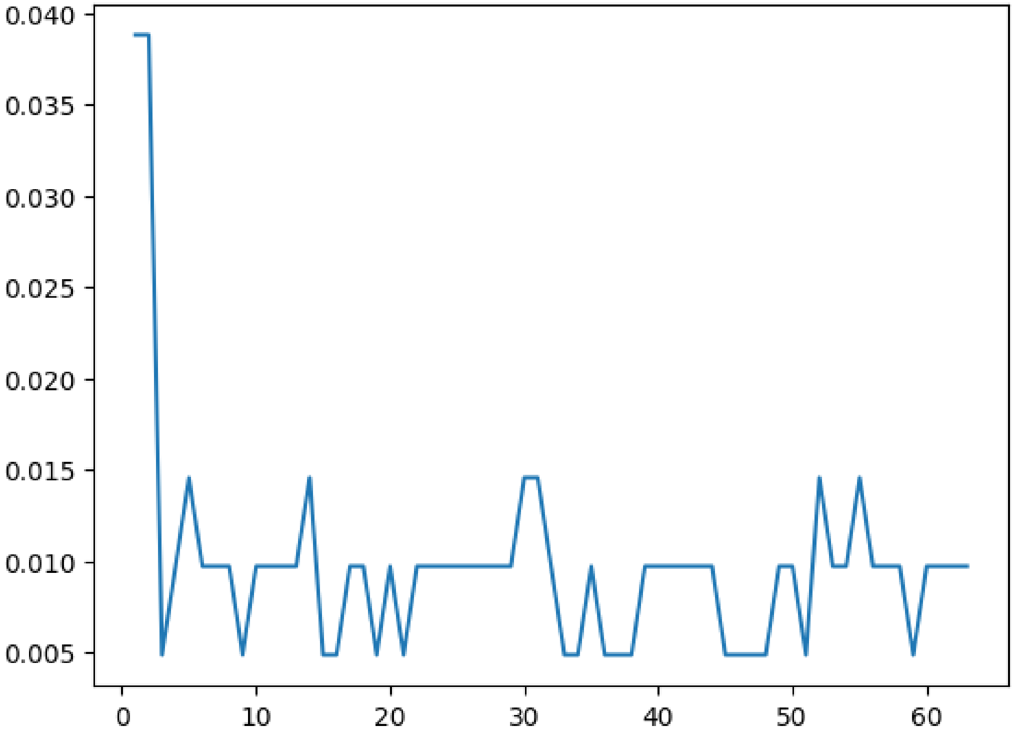
```
error = []
misclassifications = []

for n in range(1,64):
    rfc = RandomForestClassifier(n_estimators=n,bootstrap=True,max_features=2)
    rfc.fit(X_train,y_train)
    preds = rfc.predict(X_test)
    err = 1- accuracy_score(y_test,preds)
    n_missed=np.sum(preds != y_test)# watch the video to understand this line!!
    error.append(err)
    misclassifications.append(n_missed)
```

In [46]:

```
plt.plot(range(1,64),error)
```

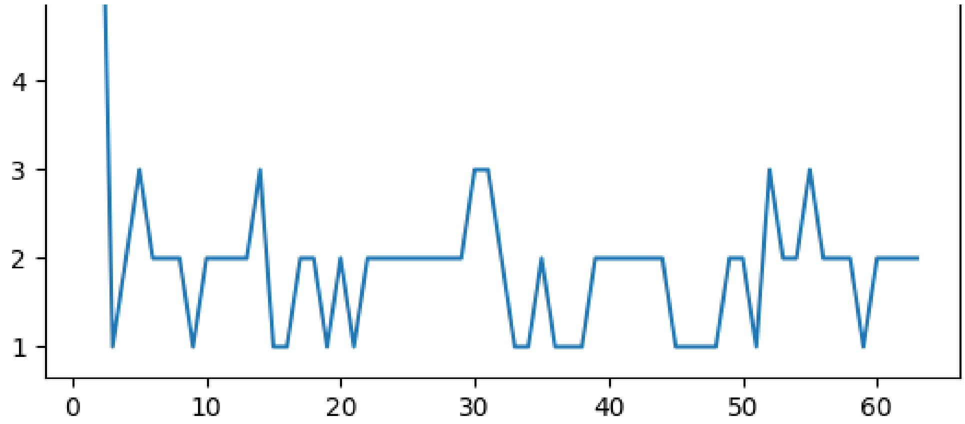
Out[46]:

```
[<matplotlib.lines.Line2D at 0x1ed4ef6bdc0>]
```



In [47]:

```
plt.plot(range(1,64),misclassifications);
```



Random Forest - Regression

Plus: An Additional Analysis of Various Regression Methods!

The Data

We just got hired by a tunnel boring company which uses X-rays in an attempt to know rock density, ideally this will allow them to switch out boring heads on their equipment before having to mine through the rock!

They have given us some lab test results of signal strength returned in nHz to their sensors for various rock density types tested. You will notice it has almost a sine wave like relationship, where signal strength oscillates based off the density, the researchers are unsure why this is, but

In [48]:

```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
```

Data

In [49]:

```
df = pd.read_csv("D:\\Study\\Programming\\python\\Python course from udemy\\Udemy - 2022
Python for Machine Learning & Data Science Masterclass\\01 - Introduction to Course\\1UNZ
IP-FOR-NOTEBOOKS-FINAL\\DATA\\rock_density_xray.csv")
df.head()
```

Out[49]:

	Rebound Signal Strength nHz	Rock Density kg/m3
0	72.945124	2.456548
1	14.229877	2.601719
2	36.597334	1.967004
3	9.578899	2.300439
4	21.765897	2.452374

In [50]:

```
df.columns=['Signal','Density']
```

In [51]:

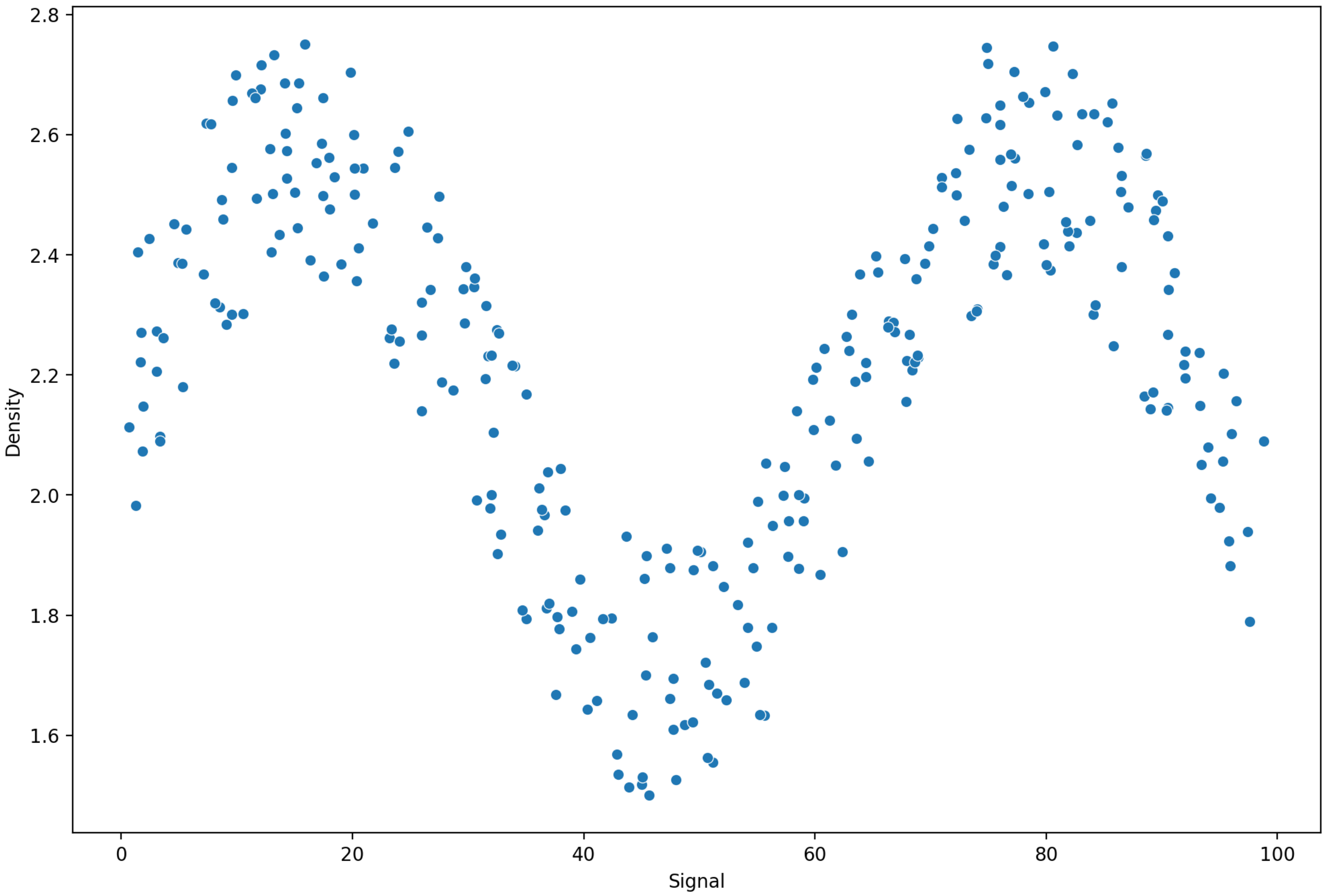
```
df.head()
```

Out[51]:

	Signal	Density
0	72.945124	2.456548
1	14.229877	2.601719
2	36.597334	1.967004
3	9.578899	2.300439
4	21.765897	2.452374

In [56]:

```
plt.figure(figsize=(12,8),dpi=200)
sns.scatterplot(x='Signal',y='Density',data=df);
```



Splitting the Data

Let's split the data in order to be able to have a Test set for performance metric evaluation.

In [98]:

```
X = df['Signal'].values.reshape(-1,1)
y = df['Density']
```

In [68]:

```
from sklearn.model_selection import train_test_split
```

In [69]:

```
X_train,X_test,y_train,y_test = train_test_split(X,y,test_size=0.1,random_state=101)
```

Linear Regression

In [70]:

```
from sklearn.linear_model import LinearRegression
```

In [71]:

```
lr_model = LinearRegression()
```

In [72]:

```
lr_model.fit(X_train,y_train)
```

Out[72]:

```
▾ LinearRegression
LinearRegression()
```

In [73]:

```
lr_pred = lr_model.predict(X_test)
```

In [89]:

```
# All number are close to 2.22
lr_pred
```

Out[89]:

```
array([2.22029657, 2.22047771, 2.22035637, 2.22034337, 2.22039737,
       2.22050555, 2.22042659, 2.22028877, 2.22034673, 2.22029714,
       2.22041506, 2.22050153, 2.22043891, 2.22042003, 2.22047022,
       2.22032403, 2.22033377, 2.22030628, 2.22035154, 2.22035373,
       2.22029266, 2.22036798, 2.22033018, 2.22030611, 2.22042754,
       2.22044019, 2.2204142 , 2.22040303, 2.22048946, 2.22047495])
```

In [90]:

```
from sklearn.metrics import mean_squared_error,mean_absolute_error
```

In [91]:

```
mean_absolute_error(y_test,lr_pred)
```

Out[91]:

```
0.211198973318633
```

In [75]:

```
np.sqrt(mean_squared_error(y_test,lr_pred))
```

Out[75]:

```
0.2570051996584629
```

What does the fit look like?

In [80]:

```
signal_range = np.arange(0,100)
```

In [82]:

```
lr_output = lr_model.predict(signal_range.reshape(-1,1))
```

In [92]:

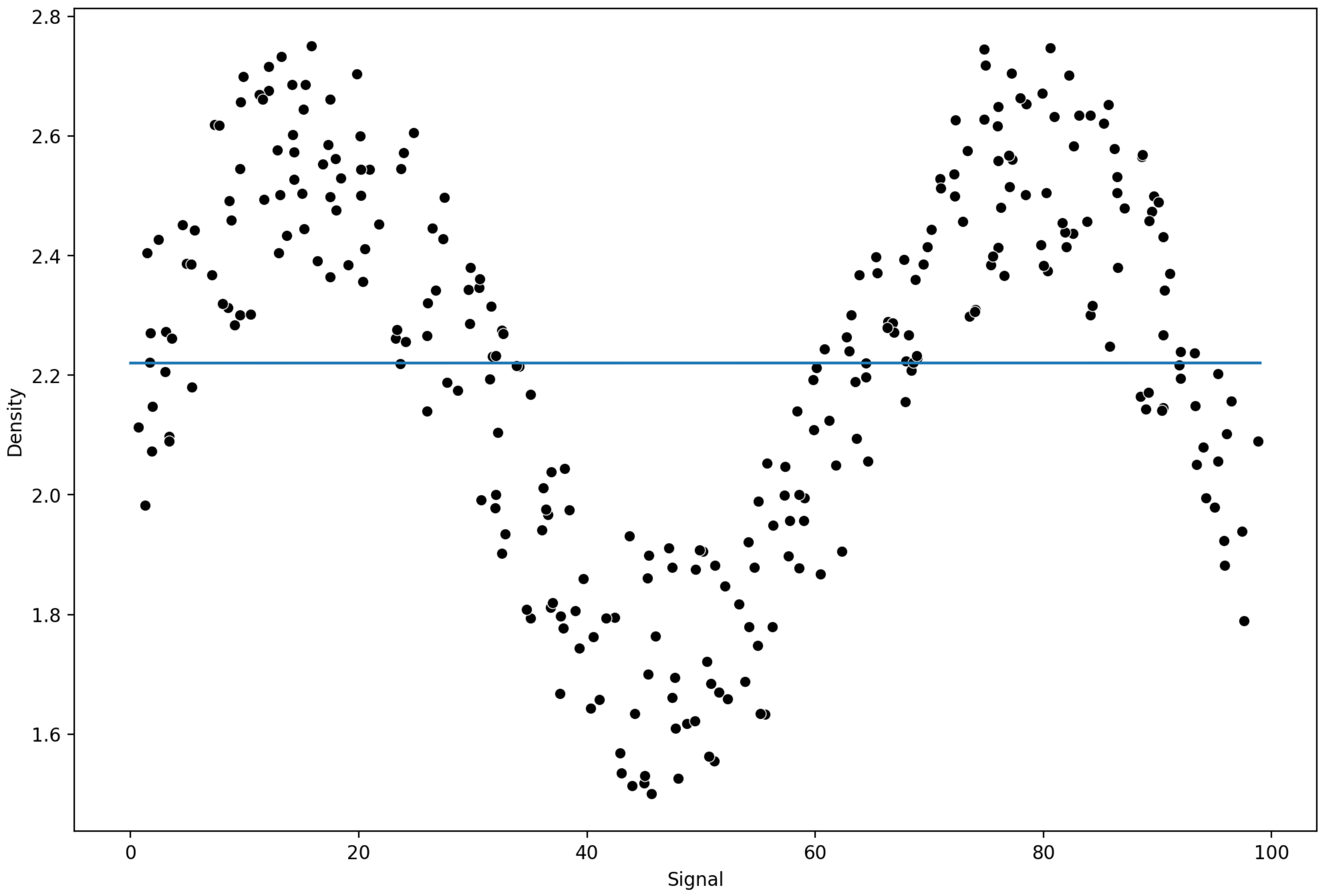
```
lr_output
```

Out[92]:

```
array([2.22028446, 2.22028673, 2.22028899, 2.22029126, 2.22029353,
       2.22029579, 2.22029806, 2.22030032, 2.22030259, 2.22030485,
       2.22030712, 2.22030938, 2.22031165, 2.22031391, 2.22031618,
       2.22031844, 2.22032071, 2.22032297, 2.22032524, 2.2203275 ,
       2.22032977, 2.22033204, 2.2203343 , 2.22033657, 2.22033883,
       2.2203411 , 2.22034336, 2.22034563, 2.22034789, 2.22035016,
       2.22035242, 2.22035469, 2.22035695, 2.22035922, 2.22036148,
       2.22036375, 2.22036602, 2.22036828, 2.22037055, 2.22037281,
       2.22037508, 2.22037734, 2.22037961, 2.22038187, 2.22038414,
       2.2203864 , 2.22038867, 2.22039093, 2.2203932 , 2.22039546,
       2.22039773, 2.22039999, 2.22040226, 2.22040453, 2.22040679,
       2.22040906, 2.22041132, 2.22041359, 2.22041585, 2.22041812,
       2.22042038, 2.22042265, 2.22042491, 2.22042718, 2.22042944,
       2.22043171, 2.22043397, 2.22043624, 2.2204385 , 2.22044077,
       2.22044304, 2.2204453 , 2.22044757, 2.22044983, 2.2204521 ,
       2.22045436, 2.22045663, 2.22045889, 2.22046116, 2.22046342,
       2.22046569, 2.22046795, 2.22047022, 2.22047248, 2.22047475,
       2.22047701, 2.22047928, 2.22048155, 2.22048381, 2.22048608,
       2.22048834, 2.22049061, 2.22049287, 2.22049514, 2.2204974 ,
       2.22049967, 2.22050193, 2.2205042 , 2.22050646, 2.22050873])
```

In [84]:

```
plt.figure(figsize=(12,8),dpi=200)
sns.scatterplot(x='Signal',y='Density',data=df,color='black')
plt.plot(signal_range,lr_output);
```



Polynomial Regression

Attempting with a Polynomial Regression Model

Let's explore why our standard regression approach of a polynomial could be difficult to fit here, keep in mind, we're in a fortunate situation where we can easily visualize results of y vs x.

Function to Help Run Models

In [85]:

```
from sklearn.linear_model import LinearRegression
model = LinearRegression()
```

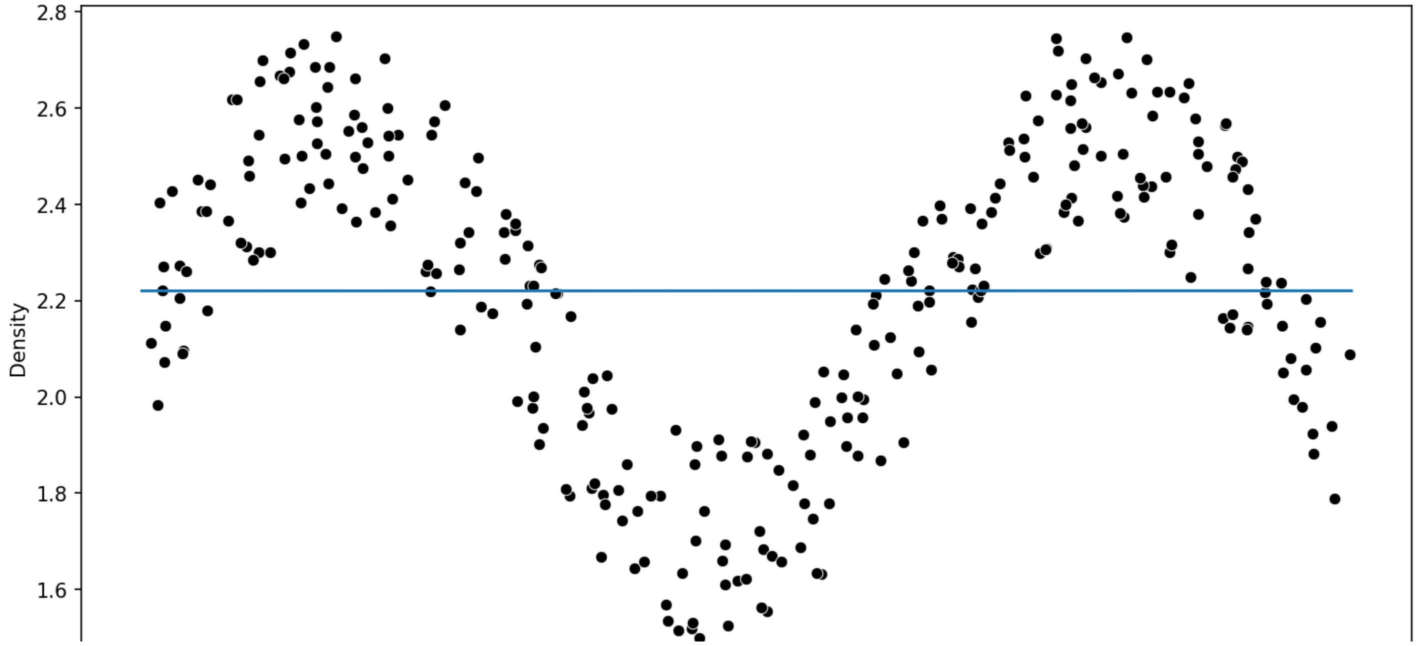
In [101]:

```
def run_model(model,X_train,y_train,X_test,y_test):

    # Fit Model
    model.fit(X_train,y_train)

    # Get Metrics

    preds = model.predict(X_test)

    # Evaluation
    rmse = np.sqrt(mean_squared_error(y_test,preds))
    mae = mean_absolute_error(y_test,preds)
    print(f"MAE : {mae}")
    print(f"RMSE: {rmse}")

    #Plot results
    signal_range = np.arange(0,100)
    output = model.predict(signal_range.reshape(-1,1))

    plt.figure(figsize=(12,6),dpi=150)
    sns.scatterplot(x='Signal',y='Density',data=df,color='black')
    plt.plot(signal_range,output)
```

In [102]:

```
model = LinearRegression()
run_model(model,X_train,y_train,X_test,y_test)
```

```
MAE : 0.211198973318633
RMSE: 0.2570051996584629
```



Pipeline for Poly Orders

In [103]:

```
from sklearn.pipeline import make_pipeline
```

In [104]:

```
from sklearn.preprocessing import PolynomialFeatures
```

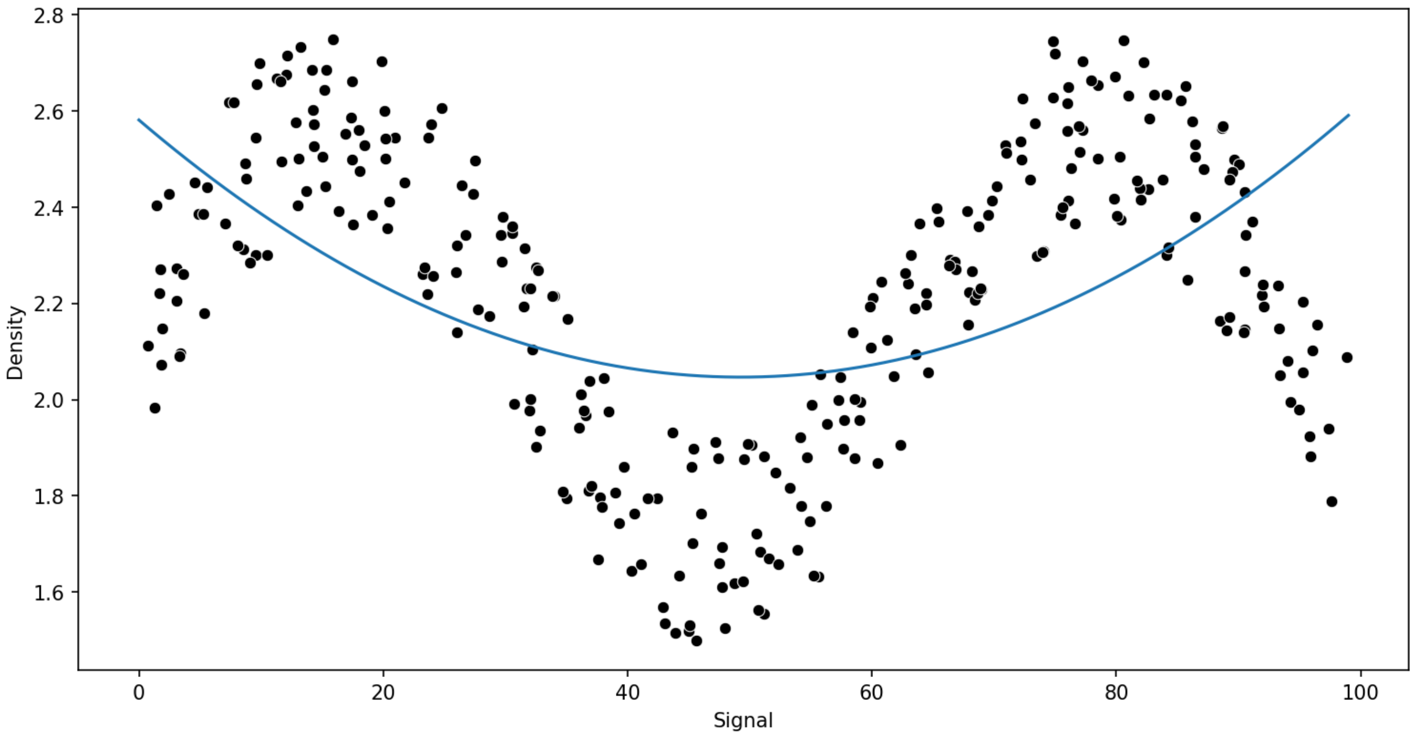
In [105]:

```
pipe = make_pipeline(PolynomialFeatures(2),LinearRegression())
```

In [106]:

```
run_model(pipe,X_train,y_train,X_test,y_test)
```

```
MAE : 0.22903105443511335
RMSE: 0.2817309563725596
```

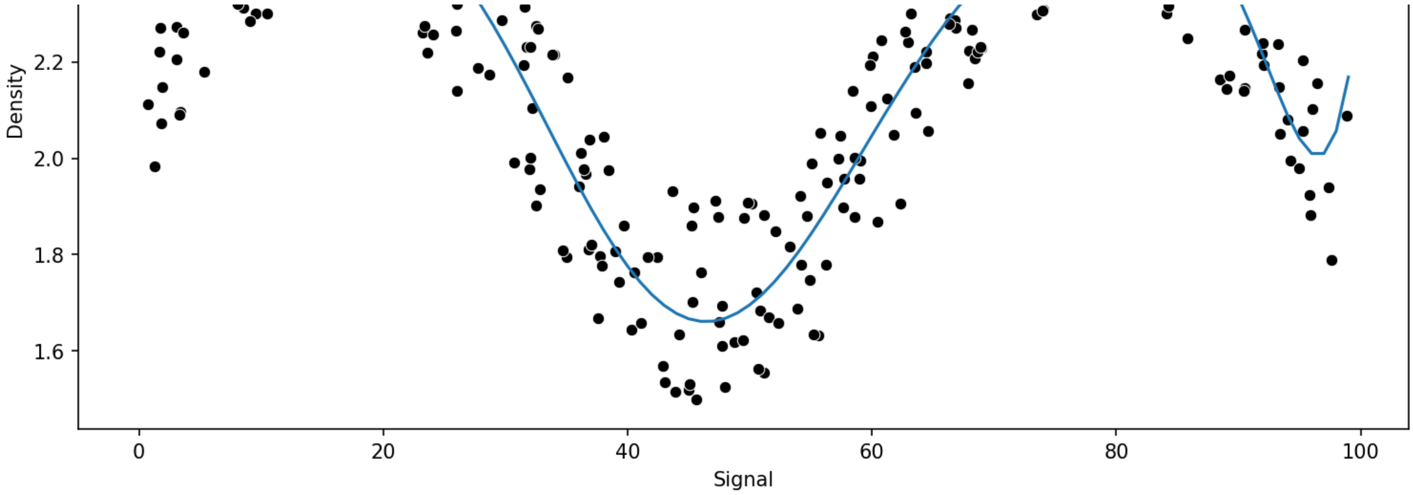


Comparing Various Polynomial Orders

In [107]:

```
pipe = make_pipeline(PolynomialFeatures(10),LinearRegression())
run_model(pipe,X_train,y_train,X_test,y_test)
```

```
MAE : 0.12478026429426053
RMSE: 0.14049911421019984
```



KNN Regression

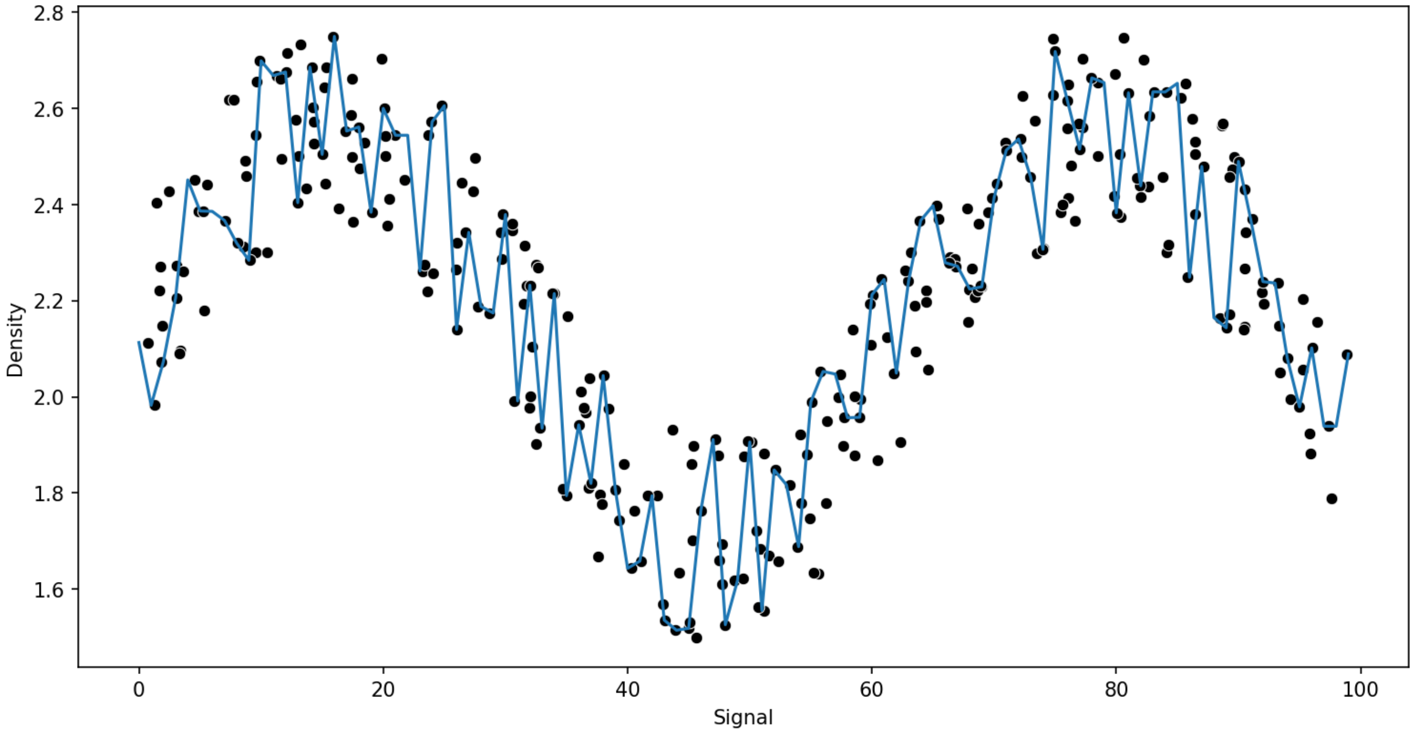
In [108]:

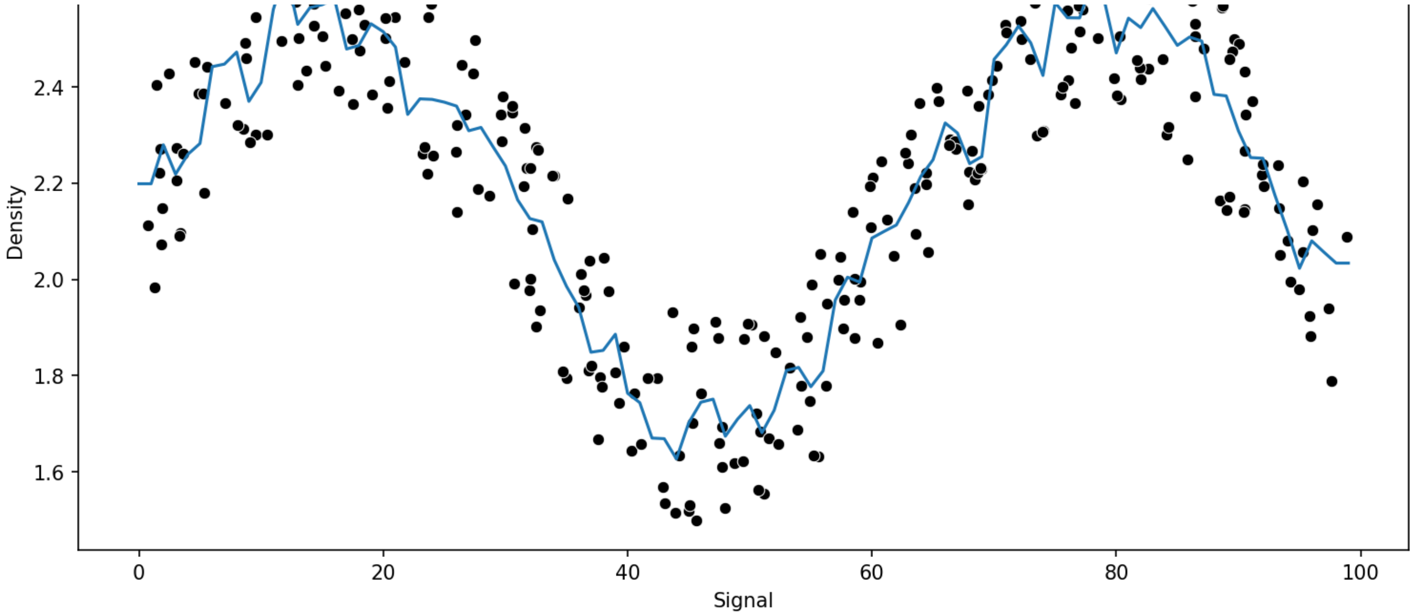
```
from sklearn.neighbors import KNeighborsRegressor
```

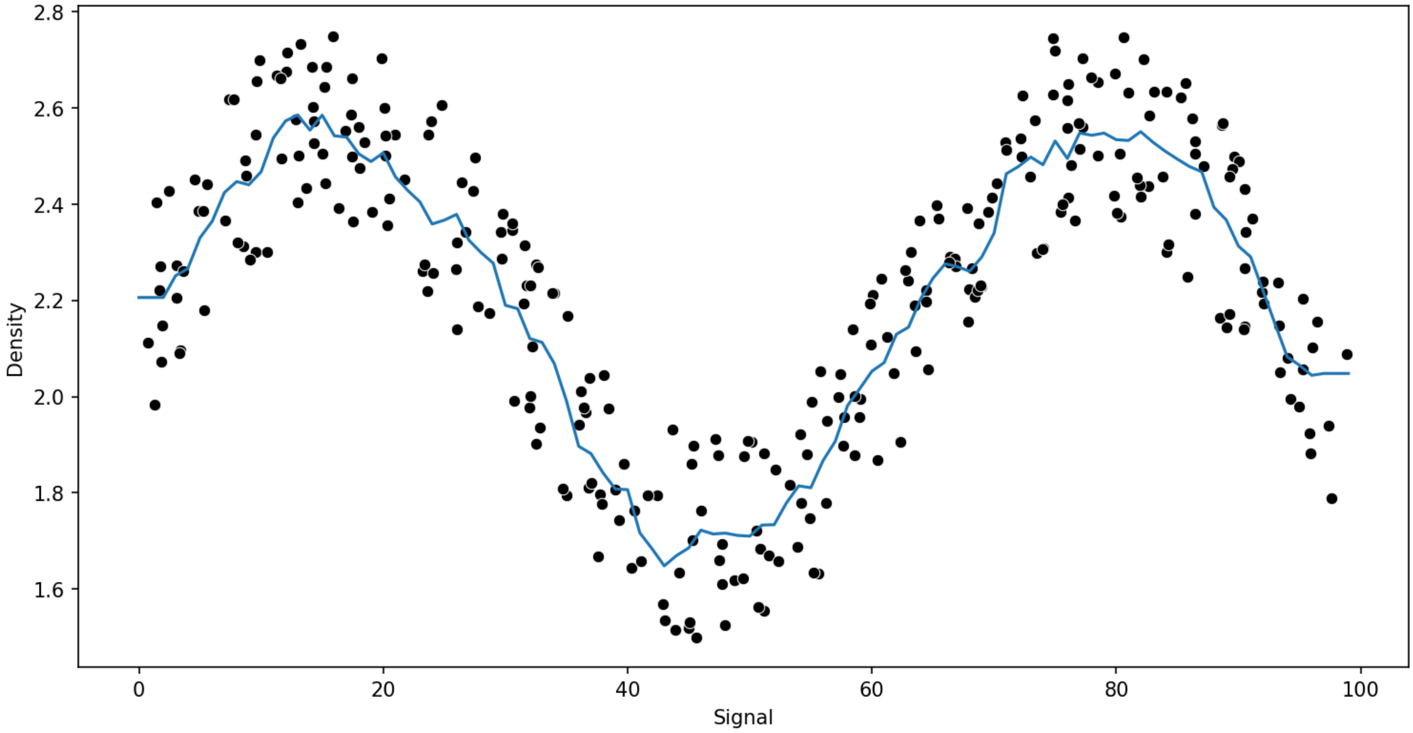
In [109]:

```
preds ={}
k_values = [1,5,10]
for n in k_values:

    model = KNeighborsRegressor(n_neighbors=n)
    run_model(model,X_train,y_train,X_test,y_test)
```

```
MAE : 0.11877297474442378
RMSE: 0.1523487028635337
MAE : 0.12198383614100558
RMSE: 0.13730685016923647
MAE : 0.11635971693292672
RMSE: 0.13277855732740926
```







Decision Tree Regression

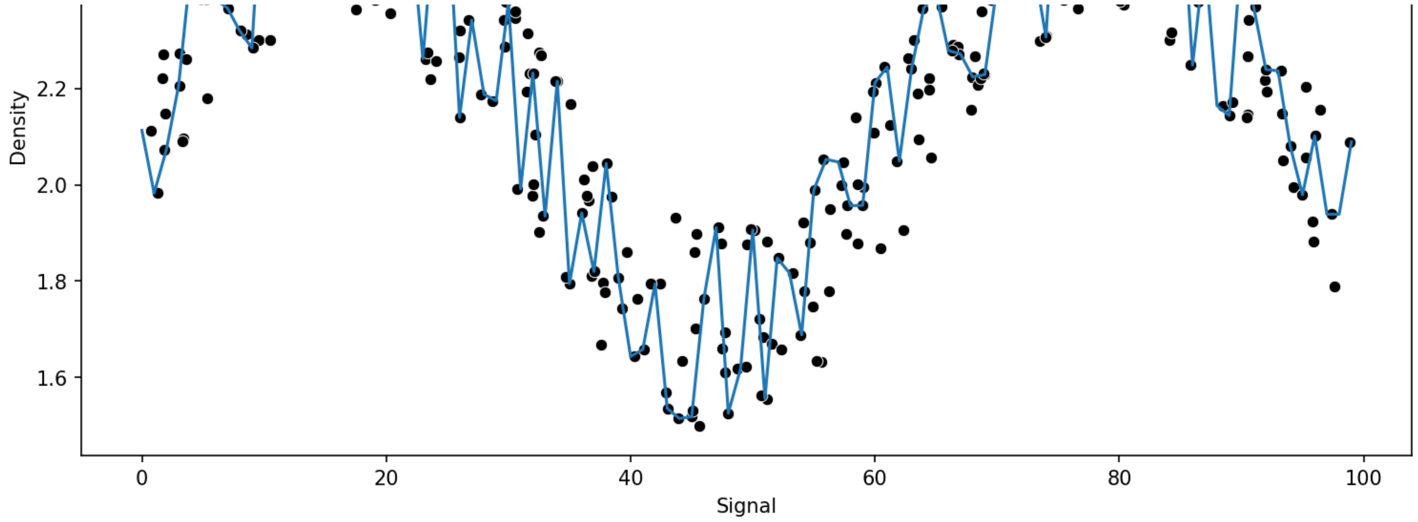
In [110]:

```
from sklearn.tree import DecisionTreeRegressor
```

In [111]:

```
model = DecisionTreeRegressor()

run_model(model,X_train,y_train,X_test,y_test)
```

```
MAE : 0.11877297474442378
RMSE: 0.1523487028635337
```



In [112]:

```
model.get_n_leaves()
```

Out[112]:

```
270
```

Support Vector Regression

In [113]:

```
from sklearn.svm import SVR
```

In [114]:

```
from sklearn.model_selection import GridSearchCV
```

In [115]:

```
param_grid = {'C':[0,0.01,.1,1,5,10,100,1000],'gamma':['auto','scale']}
svr = SVR()
```

In [116]:

```
grid = GridSearchCV(svr,param_grid)
```

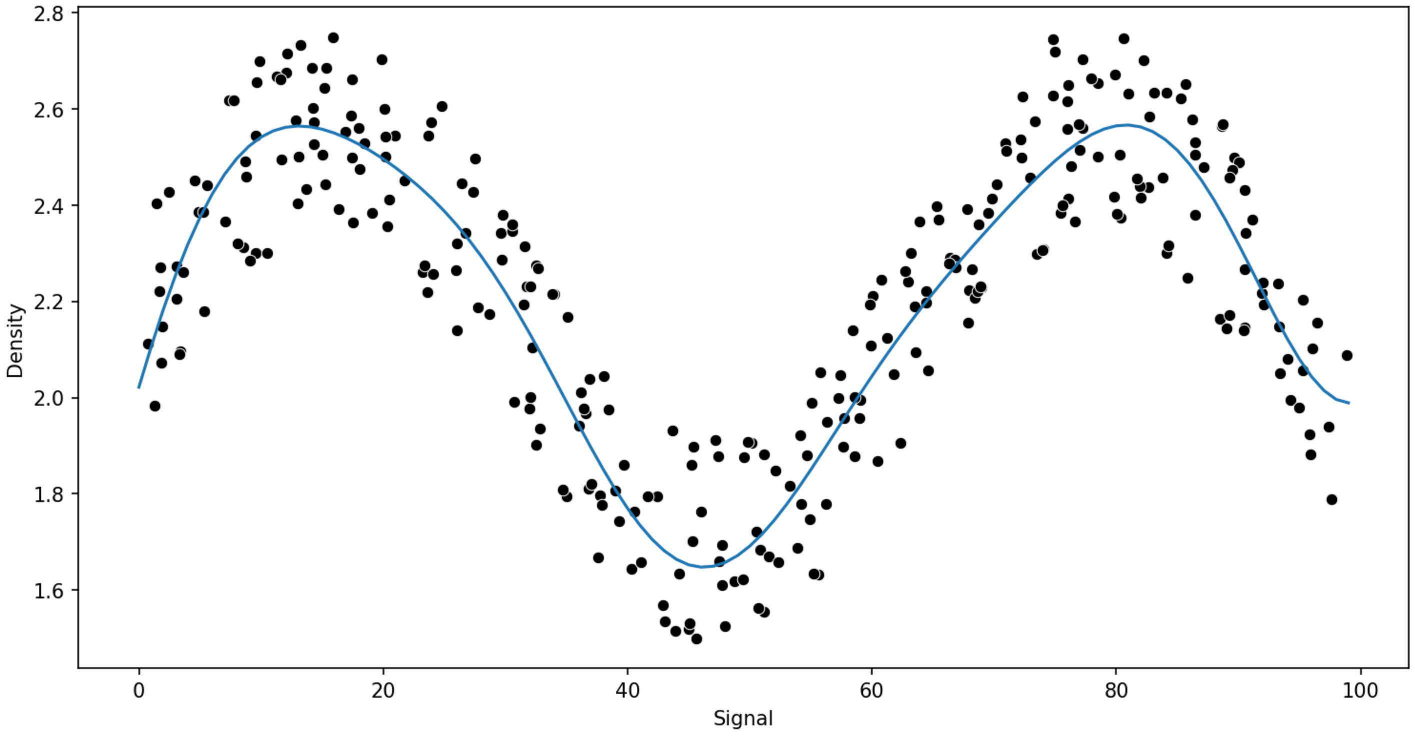
In [117]:

```
run_model(grid,X_train,y_train,X_test,y_test)
```

```
C:\Users\Chromsy\AppData\Roaming\Python\Python39\site-packages\sklearn\model_selection\_v
alidation.py:378: FitFailedWarning:
10 fits failed out of a total of 80.
The score on these train-test partitions for these parameters will be set to nan.
If these failures are not expected, you can try to debug them by setting error_score='rai
se'.

Below are more details about the failures:
------------------------------------------------------------------------------
10 fits failed with the following error:
Traceback (most recent call last):
  File "C:\Users\Chromsy\AppData\Roaming\Python\Python39\site-packages\sklearn\model_sele
ction\_validation.py", line 686, in _fit_and_score
    estimator.fit(X_train, y_train, **fit_params)
  File "C:\Users\Chromsy\AppData\Roaming\Python\Python39\site-packages\sklearn\svm\_base.
py", line 180, in fit
    self._validate_params()
  File "C:\Users\Chromsy\AppData\Roaming\Python\Python39\site-packages\sklearn\base.py",
line 581, in _validate_params
```

```
    validate_parameter_constraints(
  File "C:\Users\Chromsy\AppData\Roaming\Python\Python39\site-packages\sklearn\utils\_par
am_validation.py", line 97, in validate_parameter_constraints
    raise InvalidParameterError(
sklearn.utils._param_validation.InvalidParameterError: The 'C' parameter of SVR must be a
float in the range (0.0, inf). Got 0 instead.

  warnings.warn(some_fits_failed_message, FitFailedWarning)
C:\Users\Chromsy\AppData\Roaming\Python\Python39\site-packages\sklearn\model_selection\_s
earch.py:952: UserWarning: One or more of the test scores are non-finite: [        nan
nan  0.11661693  0.49611358  0.61837619  0.78217721
  0.71070595  0.80490484  0.67106203  0.80395049  0.61816182  0.80394974
  0.31490892  0.80718355 -1.05793335  0.81149958]
  warnings.warn(
```

```
MAE : 0.10854210121348368
RMSE: 0.12646999302046696
```



In [118]:

```
grid.best_estimator_
```

Out[118]:

```
▾ SVR
SVR(C=1000)
```

Random Forest Regression

In [119]:

```
from sklearn.ensemble import RandomForestRegressor
```

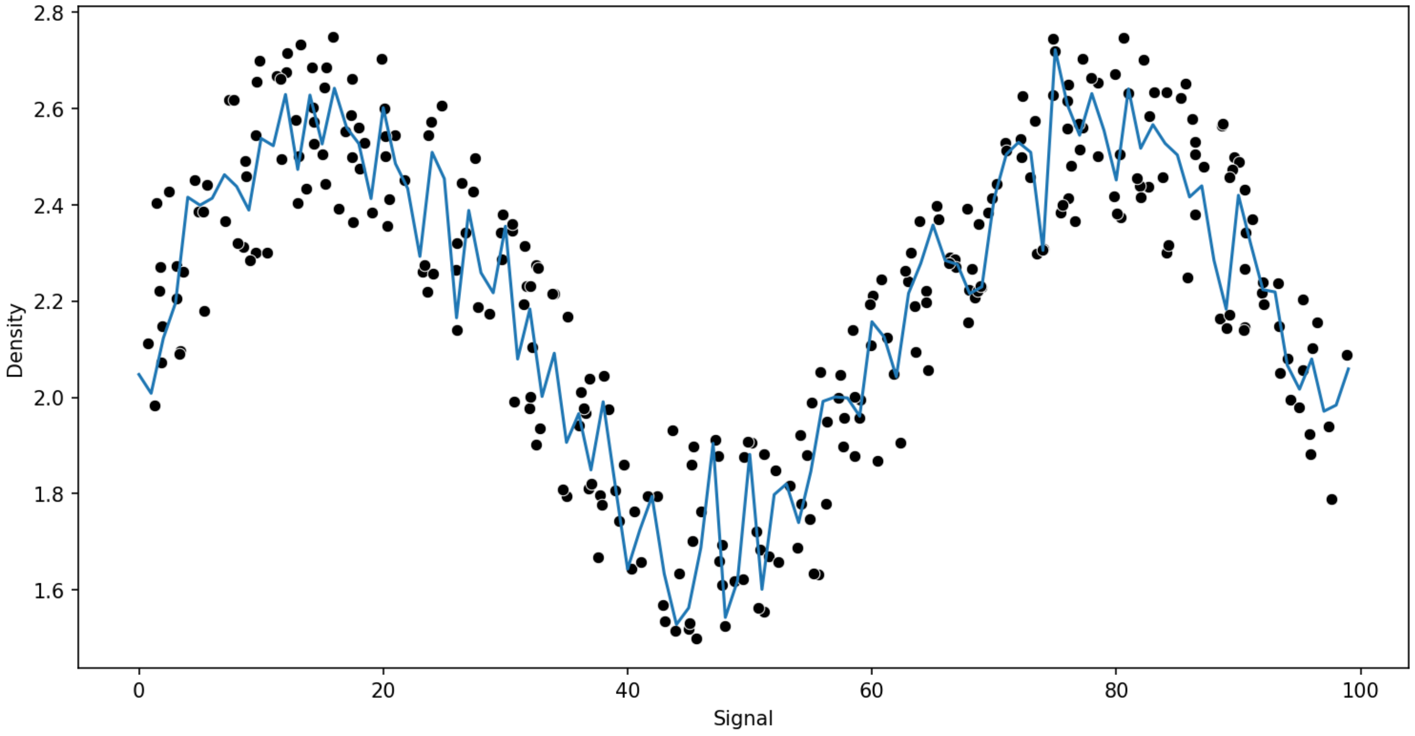
In [120]:

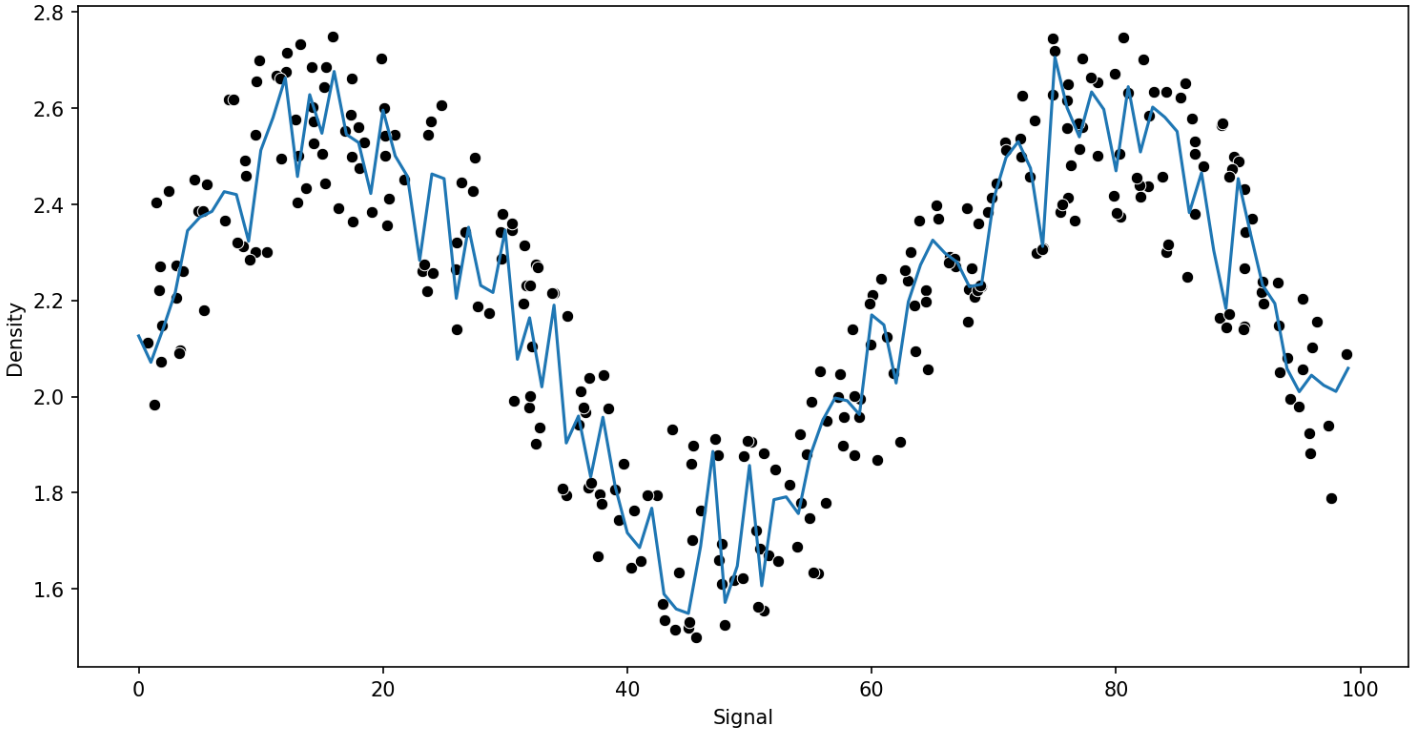
```
# help(RandomForestRegressor)
```

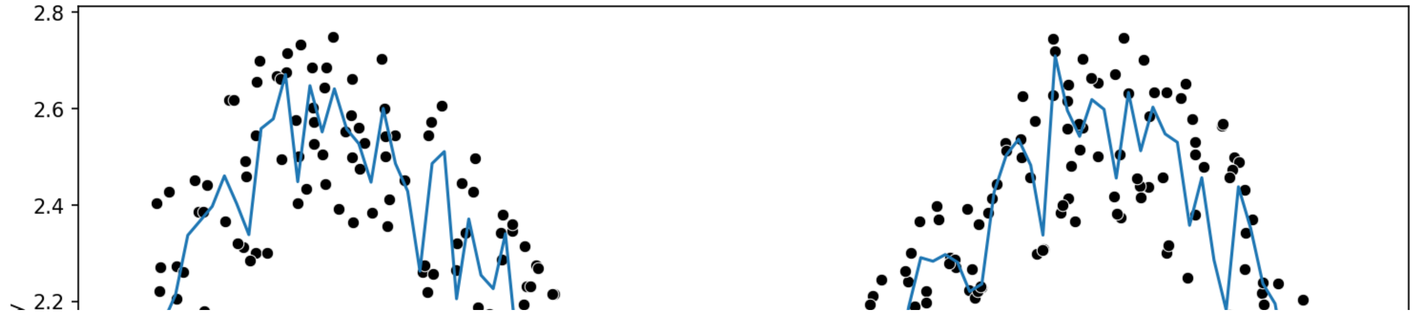
In [121]:

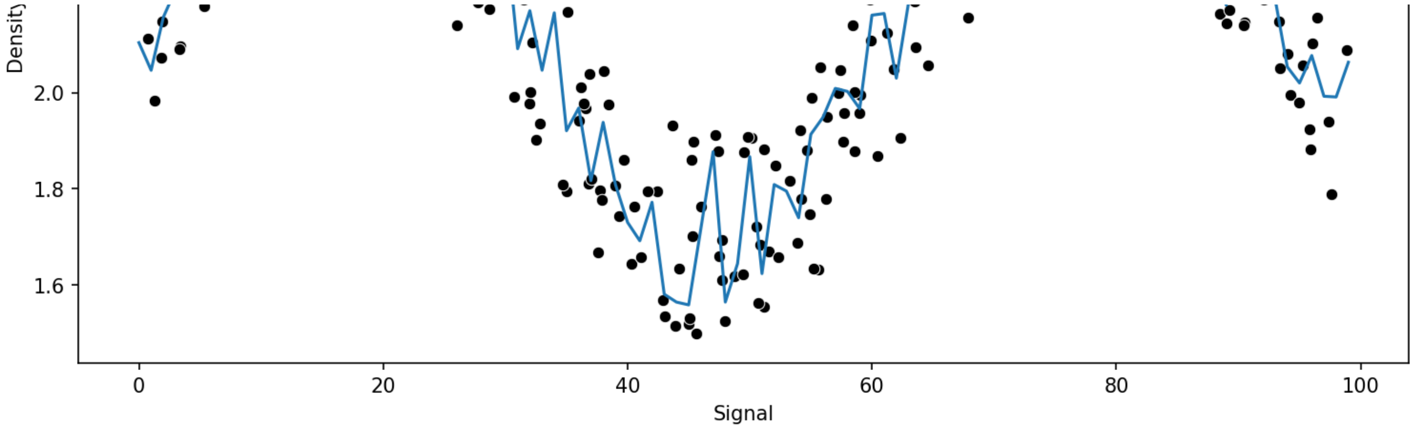
```
trees = [10,50,100]
for n in trees:
    model = RandomForestRegressor(n_estimators=n)

    run_model(model,X_train,y_train,X_test,y_test)
```

```
MAE : 0.10794614401455976
RMSE: 0.12923933126466158
MAE : 0.11190211837017762
RMSE: 0.13637615617898904
MAE : 0.10990104288555731
RMSE: 0.13096990474747555
```









Gradient Boosting

We will cover this in more detail in next section.

In [122]:

```
from sklearn.ensemble import GradientBoostingRegressor
```

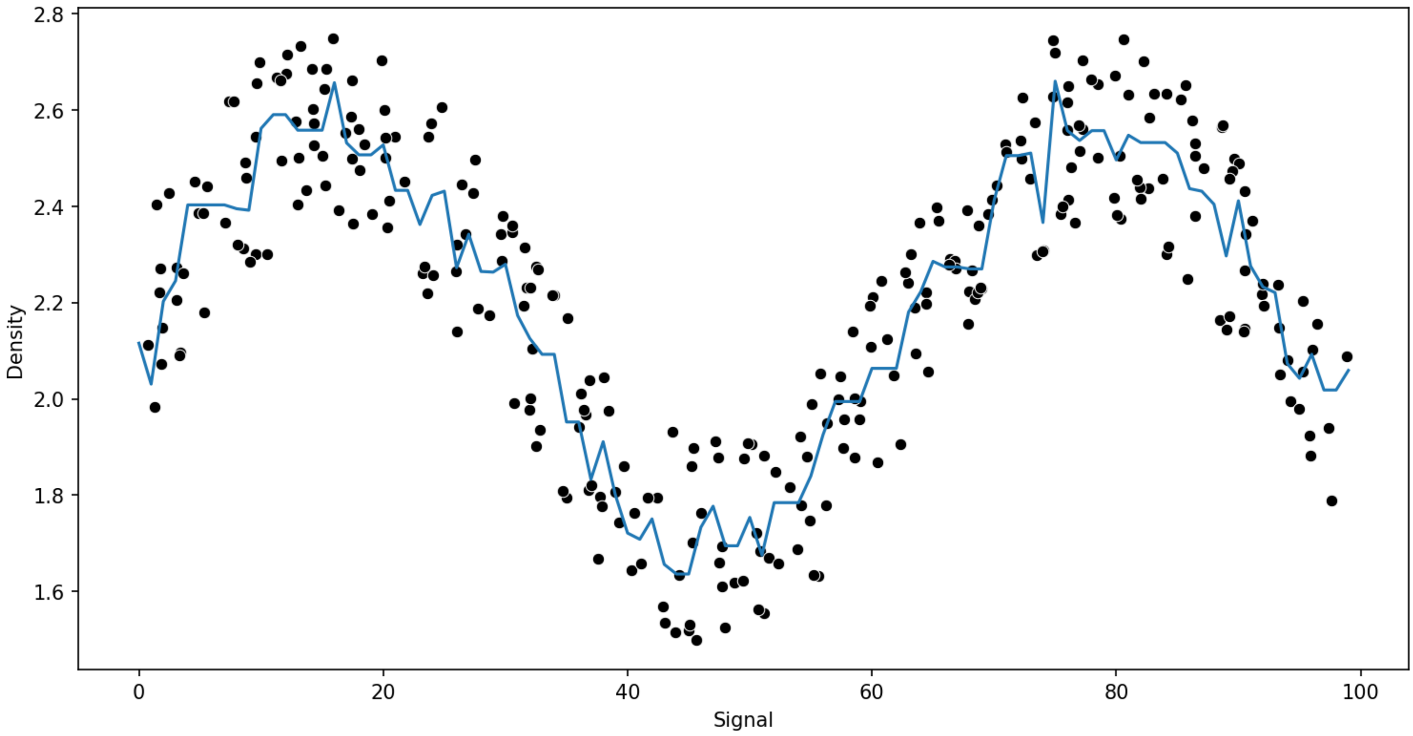
In [123]:

```
# help(GradientBoostingRegressor)
```

In [124]:

```
model = GradientBoostingRegressor()

run_model(model,X_train,y_train,X_test,y_test)
```

```
MAE : 0.11318284854800689
RMSE: 0.13294148649584667
```



Adaboost

In [127]:

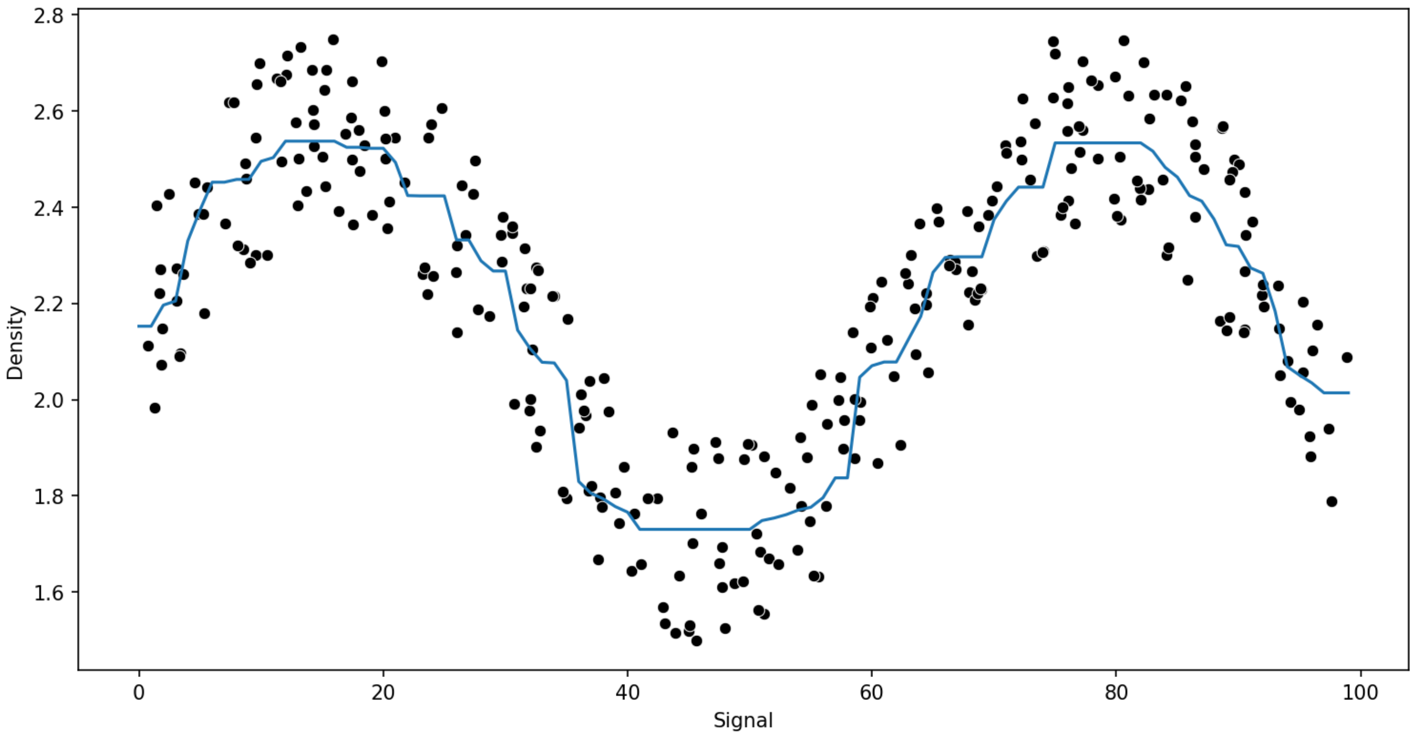
```
from sklearn.ensemble import AdaBoostRegressor
```

In [128]:

In [120]:

```
model = AdaBoostRegressor()

run_model(model,X_train,y_train,X_test,y_test)
```

```
MAE : 0.11711438520863086
RMSE: 0.13457543971524755
```



In [ ]:

```

```