Model Building for Space Missions

September 3, 2023

[1]:
```
import pandas as pd
import numpy as np
import seaborn as sns
import matplotlib.pyplot as plt
import warnings
warnings.filterwarnings('ignore')
%matplotlib inline
```

[2]:
```
import chardet
with open('data\space_mission', 'rb') as f:
    result = chardet.detect(f.read())
result
```

[2]:
```
{'encoding': 'ascii', 'confidence': 1.0, 'language': ''}
```

[3]:
```
space_mission = pd.read_csv('data\space_mission', encoding= 'ascii')
space_mission
```

[3]:
```
                    Mission     Spacecraft Mission Type     Outcome Country  \
0        Pioneer 0 (Able I)        Pioneer      Orbiter     Failure     USA
1             Luna E-1 No.1           Luna     Impactor     Failure  Russia
2       Pioneer 1 (Able II)        Pioneer      Orbiter     Failure     USA
3             Luna E-1 No.2           Luna     Impactor     Failure  Russia
4      Pioneer 2 (Able III)        Pioneer      Orbiter     Failure     USA
..                       …           …          …       …     …
151                  SORA-Q         SORA-Q        Rover     Failure   Japan
152  Emirates Lunar Mission         Rashid        Rover     Failure     UAE
153        Lunar Flashlight          Lunar        Flyby     Failure     USA
154           Chandrayaan-3  Chandrayaan-3      Orbiter  Successful   India
155                  Luna 25           Luna       Lander     Failure  Russia

        launch vehicle  Launch year
0                 Thor         1958
1                 Luna         1958
2                 Thor         1958
3                 Luna         1958
4                 Thor         1958
..                 …          …
```

```
151             Falcon         2022
152             Falcon         2022
153             Falcon         2022
154               LVM3         2023
155  Soyuz-2.1b/Fregat         2023

[156 rows x 7 columns]
```

[4]:
```
space_mission.isna().sum()
```

[4]:
```
Mission          0
Spacecraft       0
Mission Type     0
Outcome          0
Country          0
launch vehicle   0
Launch year      0
dtype: int64
```

[ ]:
```

```

[5]:
```
space_mission['Outcome'].unique()
```

[5]:
```
array(['Failure', 'Successful'], dtype=object)
```

[6]:
```
# Label Encoding by using map function
space_mission['Outcome'] = space_mission['Outcome'].map({'Failure': 0,␣
 ↪'Successful': 1})
```

[7]:
```
# One hot encoding for Country
df1= pd.get_dummies(space_mission['Country'],dummy_na= False )
space_mission = pd.concat([space_mission, df1], axis=1)
space_mission.drop('Country', axis=1, inplace = True)
```

[8]:
```
space_mission.head(5)
```

[8]:
```
                Mission Spacecraft Mission Type  Outcome launch vehicle  \
0    Pioneer 0 (Able I)    Pioneer      Orbiter        0           Thor
1         Luna E-1 No.1       Luna     Impactor        0           Luna
2   Pioneer 1 (Able II)    Pioneer      Orbiter        0           Thor
3         Luna E-1 No.2       Luna     Impactor        0           Luna
4  Pioneer 2 (Able III)    Pioneer      Orbiter        0           Thor

   Launch year  China  European  India  Israel  Italy  Japan  Luxembourg  \
0         1958      0         0      0       0      0      0           0
1         1958      0         0      0       0      0      0           0
2         1958      0         0      0       0      0      0           0
3         1958      0         0      0       0      0      0           0
```

```
4         1958      0         0      0       0      0      0           0

   Russia  South Korea  UAE  USA
0       0            0    0    1
1       1            0    0    0
2       0            0    0    1
3       1            0    0    0
4       0            0    0    1
```

[9]:
```
space_mission['launch vehicle'].unique()
```

[9]:
```
array(['Thor', 'Luna', 'Juno', 'Atlas-D', 'Atlas', 'Molniya-L',
       'Molniya-M', 'Molniya', 'Delta', 'Proton-K/D', 'Saturn', 'N1',
       'Mu-3S-II', 'Mu-4S-II', 'Titan', 'Proton-K/DM3', 'Athena', 'M-V',
       'Ariane', 'H-IIA', 'Long March', 'PSLV-XL', 'Minotaur', 'Falcon',
       'LVM3', 'Electron', 'SLS', 'Soyuz-2.1b/Fregat'], dtype=object)
```

[10]:
```
space_mission['Spacecraft'].unique()
```

[10]:
```
array(['Pioneer', 'Luna', 'E-1A', 'Ranger', 'Kosmos', 'Zond', 'Surveyor',
       'Explorer', 'Lunar', 'Soyuz', 'Apollo', 'PFS-1', 'PFS-2',
       'Mariner', 'ISEE-3', 'Hiten', 'Hagoromo', 'Geotail', 'WIND',
       'Clementine', 'HGS-1', 'Nozomi', 'WMAP', 'SMART-1', 'STEREO',
       'ARTEMIS', 'Kaguya', 'Okina', 'Ouna', "Chang'e", 'Chandrayaan-1',
       'Moon', 'LCROSS', 'Ebb', 'Flow', 'LADEE', 'Yutu', 'Return',
       'Manfred', 'TESS', 'Queqiao', 'Longjiang-1', 'Longjiang-2',
       'Yutu-2', 'Beresheet', 'Chandrayaan-2', 'CAPSTONE', 'Danuri',
       'Artemis', 'LunaH-Map', 'ArgoMoon', 'LunIR', 'Near-Earth',
       'EQUULEUS', 'OMOTENASHI', 'BioSentinel', 'CubeSat', 'Team',
       'Hakuto-R', 'SORA-Q', 'Rashid', 'Chandrayaan-3'], dtype=object)
```

[11]:
```
space_mission['Mission Type'].unique()
```

[11]:
```
array(['Orbiter', 'Impactor', 'Flyby', 'Lander', 'Crewed orbiter',
       'Orbiter,Lander,Rover', 'Lander,Sample Return', 'Rover',
       'Flyby / Impactor (post mission)', 'Relay Satellite',
       'Sample Return'], dtype=object)
```

[12]:
```
space_mission[space_mission['Mission Type'] == 'Crewed orbiter']
```

[12]:
```
     Mission Spacecraft    Mission Type  Outcome launch vehicle  Launch year  \
62  Apollo 8     Apollo  Crewed orbiter        1         Saturn         1968

    China  European  India  Israel  Italy  Japan  Luxembourg  Russia  \
62      0         0      0       0      0      0           0       0

    South Korea  UAE  USA
62            0    0    1
```

[13]:
```
space_mission[space_mission['Mission Type'] == 'Sample Return']
```

[13]:
```
       Mission Spacecraft   Mission Type  Outcome launch vehicle  Launch year  \
136  Chang'e 5    Chang'e  Sample Return        1     Long March         2020

     China  European  India  Israel  Italy  Japan  Luxembourg  Russia  \
136      1         0      0       0      0      0           0       0

     South Korea  UAE  USA
136            0    0    0
```

[14]:
```
# Lets convert 'Crewed orbiter' --> 'Orbiter' and 'Lander,Sample Return' -- >␣
↪'Sample Return'
```

[15]:
```
space_mission['Mission Type'].replace({'Crewed orbiter':'Orbiter',␣
↪'Lander,Sample Return':'Sample Return'}, inplace = True )
```

[16]:
```
space_mission['Mission Type'].unique()
```

[16]:
```
array(['Orbiter', 'Impactor', 'Flyby', 'Lander', 'Orbiter,Lander,Rover',
       'Sample Return', 'Rover', 'Flyby / Impactor (post mission)',
       'Relay Satellite'], dtype=object)
```

[17]:
```
space_mission[space_mission['Mission Type'] == 'Sample Return']
```

[17]:
```
                Mission Spacecraft   Mission Type  Outcome launch vehicle  \
92   Luna E-8-5M No.412       Luna  Sample Return        0     Proton-K/D
93              Luna 24       Luna  Sample Return        1     Proton-K/D
136          Chang'e 5    Chang'e  Sample Return        1     Long March

     Launch year  China  European  India  Israel  Italy  Japan  Luxembourg  \
92          1975      0         0      0       0      0      0           0
93          1976      0         0      0       0      0      0           0
136         2020      1         0      0       0      0      0           0

     Russia  South Korea  UAE  USA
92        1            0    0    0
93        1            0    0    0
136       0            0    0    0
```

Lets replace Mission Type 'Orbiter,Lander,Rover' –> 'Lander' || 'Rover' –> 'Lander' || 'Flyby / Impactor (post mission)' –>'Flyby' || 'Sample Return' –> 'Lander' || 'Relay Satellite' –> 'Orbiter' || 'Impactor' –> 'Flyby'

[18]:
```
space_mission['Mission Type'].replace({'Orbiter,Lander,Rover':'Lander', 'Rover':
↪ 'Lander','Flyby / Impactor (post mission)':'Flyby',
                                       'Sample Return': 'Lander','Relay␣
↪Satellite' : 'Orbiter', 'Impactor' : 'Flyby' }, inplace = True)
```

[19]:
```
space_mission['Mission Type'].unique()
```

[19]:
```
array(['Orbiter', 'Flyby', 'Lander'], dtype=object)
```

[20]:
```
df1 = pd.get_dummies(space_mission['Mission Type'])
space_mission = pd.concat([space_mission, df1], axis = 1)
space_mission.drop('Mission Type', axis=1, inplace = True)
space_mission.head()
```

[20]:

	Mission	Spacecraft	Outcome	launch vehicle	Launch year	\
0	Pioneer 0 (Able I)	Pioneer	0	Thor	1958	
1	Luna E-1 No.1	Luna	0	Luna	1958	
2	Pioneer 1 (Able II)	Pioneer	0	Thor	1958	
3	Luna E-1 No.2	Luna	0	Luna	1958	
4	Pioneer 2 (Able III)	Pioneer	0	Thor	1958	

	China	European	India	Israel	Italy	Japan	Luxembourg	Russia	\
0	0	0	0	0	0	0	0	0	
1	0	0	0	0	0	0	0	1	
2	0	0	0	0	0	0	0	0	
3	0	0	0	0	0	0	0	1	
4	0	0	0	0	0	0	0	0	

	South Korea	UAE	USA	Flyby	Lander	Orbiter
0	0	0	1	0	0	1
1	0	0	0	1	0	0
2	0	0	1	0	0	1
3	0	0	0	1	0	0
4	0	0	1	0	0	1

1 Logistics Regression ML Model

[21]:
```
X= space_mission.drop(['Mission', 'Spacecraft', 'launch vehicle','Outcome' ],␣
 ↪axis = 1)
y= space_mission['Outcome']
```

[22]:
```
#make train test split
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X, y, random_state=42,␣
 ↪test_size=0.33)
```

[23]:
```
# Standardise the data
from sklearn.preprocessing import StandardScaler
scaler = StandardScaler()
X_train= scaler.fit_transform(X_train)
X_test=scaler.transform(X_test)
```

[ ]:

[24]:
```
# Logistics model
from sklearn.linear_model import LogisticRegression
LR = LogisticRegression()
LR.fit(X_train, y_train)
pred_data = LR.predict(X_test)
```

[25]:
```
# Calculating the Precision, Recall, Accuracy score
from sklearn.metrics import accuracy_score, recall_score, precision_score,␣
 ↪confusion_matrix, roc_auc_score, roc_curve
accuracy = accuracy_score(y_test, pred_data)
recall = recall_score(y_test, pred_data)
precision = precision_score(y_test, pred_data)
print('Accuracy score is: ',accuracy_score(y_test, pred_data))
print('Recall Score is : ',recall_score(y_test, pred_data))
print('Precision score is : ',precision_score(y_test, pred_data))
```

```
Accuracy score is:  0.6538461538461539
Recall Score is :  0.7272727272727273
Precision score is :  0.7272727272727273
```

[26]:
```
CM= confusion_matrix(y_test, pred_data)
CM
```

[26]:
```
array([[10,  9],
       [ 9, 24]], dtype=int64)
```

[27]:
```
TP= CM[0][0]
FP = CM[0][1]
FN= CM[1][0]
TN=CM[1][1]
Accuracy = (TP + TN)/(TP + TN+ FN+ FP)
Accuracy
```

[27]:
```
0.6538461538461539
```

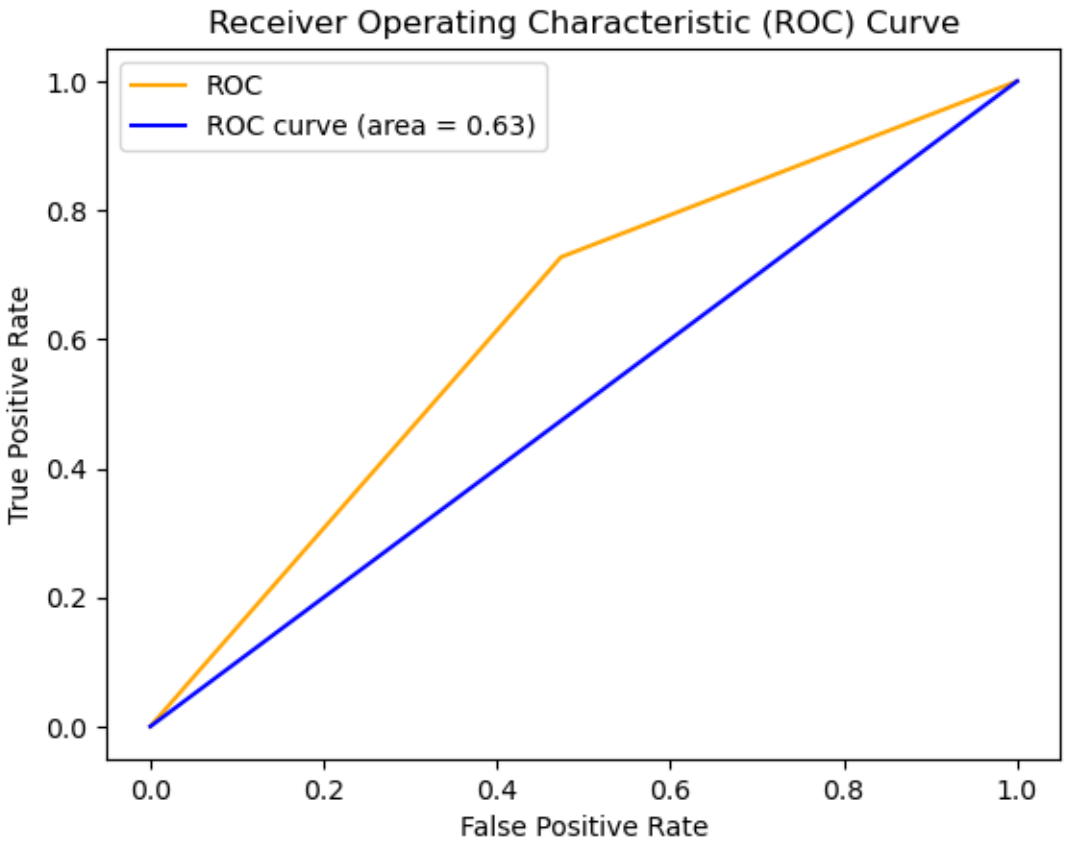
[28]:
```
F1_score = 2 * (recall * precision)/(recall + precision)
F1_score
```

[28]:
```
0.7272727272727273
```

[29]:
```
auc= roc_auc_score(y_test, pred_data)
auc
```

[29]:
```
0.6267942583732058
```

[30]:
```
# ROC
TPR, FPR, Treshold = roc_curve(y_test, pred_data)
plt.plot(TPR, FPR, label= "ROC", color= 'orange')
plt.plot([0,1], [0,1], color= 'blue', label= 'ROC curve (area = %0.2f)' % auc)
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('Receiver Operating Characteristic (ROC) Curve')
plt.legend()
plt.show()
```



2 SVM–> SVC ML Model

[31]:
```
X= space_mission.drop(['Mission', 'Spacecraft', 'launch vehicle','Outcome' ],␣
 ↪axis = 1)
y= space_mission['Outcome']
#make train test split
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X, y, random_state=42,␣
 ↪test_size=0.33)
```

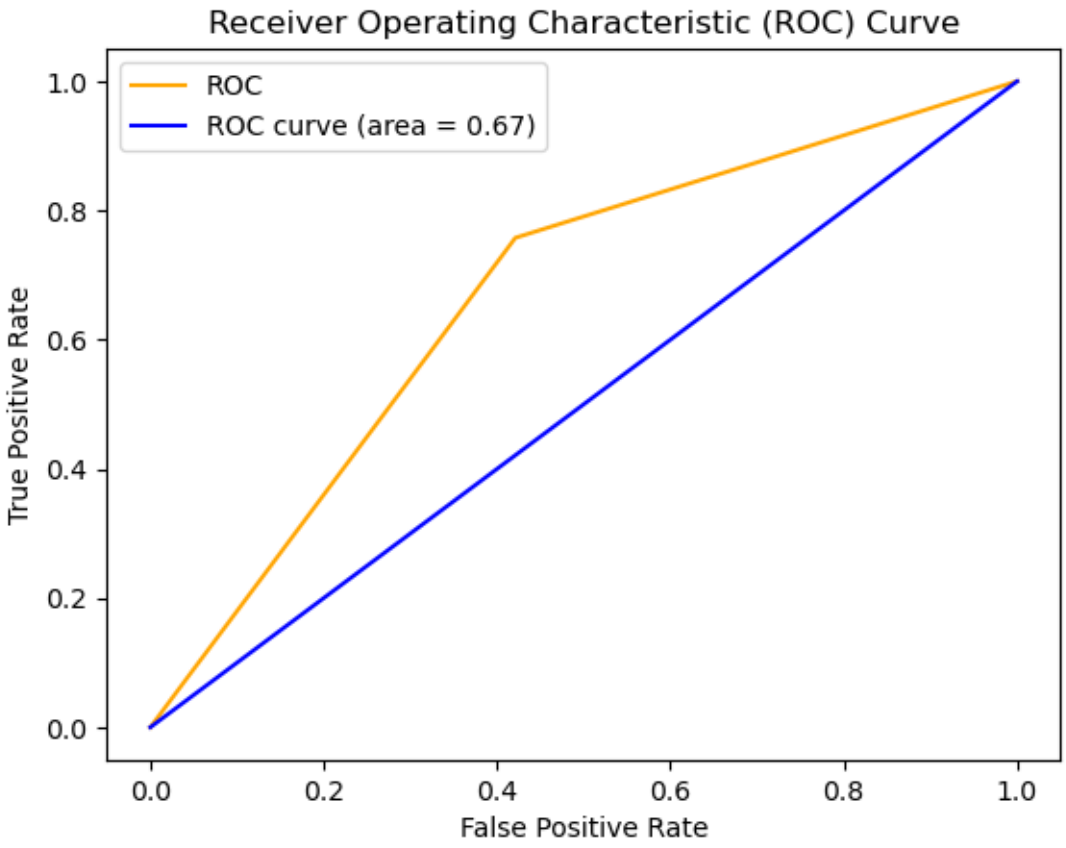
```
# Standardise the data
from sklearn.preprocessing import StandardScaler
scaler = StandardScaler()
X_train= scaler.fit_transform(X_train)
X_test=scaler.transform(X_test)

from sklearn.svm import SVC
svc = SVC()
svc.fit(X_train, y_train)
pred_data= svc.predict(X_test)
```

[32]:
```
# Calculating the Precision, Recall, Accuracy score
from sklearn.metrics import accuracy_score, recall_score, precision_score,␣
 ↪confusion_matrix, roc_auc_score, roc_curve
accuracy = accuracy_score(y_test, pred_data)
recall = recall_score(y_test, pred_data)
precision = precision_score(y_test, pred_data)
print('Accuracy score is: ',accuracy_score(y_test, pred_data))
print('Recall Score is : ',recall_score(y_test, pred_data))
print('Precision score is : ',precision_score(y_test, pred_data))
CM= confusion_matrix(y_test, pred_data)
print("Confusion Matrix is : ", CM)
F1_score = 2 * (recall * precision)/(recall + precision)
print("F1_score is : ", F1_score)
auc= roc_auc_score(y_test, pred_data)
print("auc is : ", auc)
```

```
Accuracy score is:  0.6923076923076923
Recall Score is :  0.7575757575757576
Precision score is :  0.7575757575757576
Confusion Matrix is :  [[11  8]
 [ 8 25]]
F1_score is :  0.7575757575757576
auc is :  0.6682615629984051
```

[33]:
```
# ROC
TPR, FPR, Treshold = roc_curve(y_test, pred_data)
plt.plot(TPR, FPR, label= "ROC", color= 'orange')
plt.plot([0,1], [0,1], color= 'blue', label= 'ROC curve (area = %0.2f)' % auc)
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('Receiver Operating Characteristic (ROC) Curve')
plt.legend()
plt.show()
```



3 Decision Tree

[34]:
```
#Importing and fiting the data in Decision Tree Classifier
from sklearn.tree  import DecisionTreeClassifier
regressor = DecisionTreeClassifier()
regressor.fit(X_train, y_train)
# Predicting the test data
pred_data = regressor.predict(X_test)
```

[35]:
```
# Predicting the training data
Training_data_Prediction= regressor.predict(X_train)
```

[36]:
```
# Calculating the Test data accuracy
Accuracy_test_data = accuracy_score(y_test, pred_data)
Accuracy_test_data
```

[36]: 0.7115384615384616

[37]:
```
# Calculating the Train data accuracy
Accuracy_training_data = accuracy_score(y_train, Training_data_Prediction)
Accuracy_training_data
```

[37]:
```
0.9038461538461539
```

We can clearly see that there is huge difference between train data accuracy score and test data accuracy score, this is a clear sign of overfitting data.

3.1 GridSearchCV

[38]:
```
## Hyperparameter tuning

hyperparameter = {
    'criterion' : ["gini", "entropy", "log_loss"],
    'splitter' : ["best", "random"],
    'max_depth' : [1,2,3,4,5,6,7,8,9,10,11,12],
    'max_features' : ["auto", "sqrt", "log2"]
}
regressor = DecisionTreeClassifier()
```

[39]:
```
# Using GridSearchCV
from sklearn.model_selection import GridSearchCV
from sklearn.metrics import accuracy_score, make_scorer
scoring = {"AUC": "roc_auc", "Accuracy": make_scorer(accuracy_score)}
regressorCV = GridSearchCV(regressor, param_grid=hyperparameter,␣
 ↪cv=5,scoring=scoring, refit="AUC", n_jobs=2,
                           return_train_score=True)
```

[40]:
```
regressorCV.fit(X_train, y_train)
```

[40]:
```
GridSearchCV(cv=5, estimator=DecisionTreeClassifier(), n_jobs=2,
             param_grid={'criterion': ['gini', 'entropy', 'log_loss'],
                         'max_depth': [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12],
                         'max_features': ['auto', 'sqrt', 'log2'],
                         'splitter': ['best', 'random']},
             refit='AUC', return_train_score=True,
             scoring={'AUC': 'roc_auc',
                      'Accuracy': make_scorer(accuracy_score)})
```

[41]:
```
# Getting the best parameters from GridSearchCV
regressorCV.best_params_
```

[41]:
```
{'criterion': 'log_loss',
 'max_depth': 5,
 'max_features': 'sqrt',
 'splitter': 'best'}
```

[42]:
```
# Applying the best parameters inside the Decision Tree Classifier model.
from sklearn.tree  import DecisionTreeClassifier
regressor = DecisionTreeClassifier(criterion = 'log_loss',
                                   max_depth = 4, max_features = 'log2',␣
 ↪splitter = 'best')
regressor.fit(X_train, y_train)
pred_data = regressor.predict(X_test)
```

[43]:
```
# Predicting the training data
Training_data_Prediction= regressor.predict(X_train)
```

[44]:
```
# Calculating the Test data accuracy
Accuracy_test_data = accuracy_score(y_test, pred_data)
Accuracy_test_data
```

[44]: 0.7115384615384616

[45]:
```
# Calculating the Train data accuracy
Accuracy_training_data = accuracy_score(y_train, Training_data_Prediction)
Accuracy_training_data
```

[45]: 0.8076923076923077

This model has imploved a lot, compared to the previous one. we can clearly see there is low bias and low variance. Hence we can consider these parameters of GridSearchCV

3.2 RandomSearchCV

[46]:
```
from sklearn.model_selection import RandomizedSearchCV
regressor = DecisionTreeClassifier()
hyperparameter = {
    'criterion' : ["gini", "entropy", "log_loss"],
    'splitter' : ["best", "random"],
    'max_depth' : [1,2,3,4,5,6,7,8,9,10,11,12],
    'max_features' : ["auto", "sqrt", "log2"]
}
```

[47]:
```
regressorCV = RandomizedSearchCV(regressor,hyperparameter, cv = 5)
```

[48]:
```
regressorCV.fit(X_train, y_train)
```

[48]:
```
RandomizedSearchCV(cv=5, estimator=DecisionTreeClassifier(),
                   param_distributions={'criterion': ['gini', 'entropy',
                                                      'log_loss'],
                                        'max_depth': [1, 2, 3, 4, 5, 6, 7, 8, 9,
                                                      10, 11, 12],
                                        'max_features': ['auto', 'sqrt',
                                                         'log2'],
```

```
                                                'splitter': ['best', 'random']})
```

[49]:
```
regressorCV.best_params_
```

[49]:
```
{'splitter': 'random',
 'max_features': 'sqrt',
 'max_depth': 6,
 'criterion': 'log_loss'}
```

[50]:
```
from sklearn.tree  import DecisionTreeClassifier
regressor = DecisionTreeClassifier(splitter = 'random', max_features = 'sqrt',␣
 ↪max_depth = 8, criterion = 'gini')
regressor.fit(X_train, y_train)
# Predicting the test data
pred_data = regressor.predict(X_test)
```

[51]:
```
# Predicting the training data
Training_data_Prediction= regressor.predict(X_train)
```

[52]:
```
# Calculating the Test data accuracy
Accuracy_test_data = accuracy_score(y_test, pred_data)
Accuracy_test_data
```

[52]:
```
0.6923076923076923
```

[53]:
```
# Calculating the Training data accuracy
Accuracy_training_data = accuracy_score(y_train, Training_data_Prediction)
Accuracy_training_data
```

[53]:
```
0.8461538461538461
```

In RandomSearchCV we can clearly see there is low bias and high variance. He we cannot consider these parameters of RandomSearchCV

4

[ ]:

[ ]:

[ ]: