Decision Tree & Random Forest V3

November 19, 2021

Replace All zero features with mean

[1]:
```
import numpy as np # Import numpy for data preprocessing
import pandas as pd # Import pandas for data frame read
import matplotlib.pyplot as plt # Import matplotlib for data visualisation
import seaborn as sns # Import seaborn for data visualisation
import plotly.express as px # Import plotly for data visualisation
from sklearn.model_selection import train_test_split # Import train_test_split␣
↪for data split
from sklearn.tree import DecisionTreeClassifier # Import Decision Tree␣
↪Classifier
from sklearn.ensemble import RandomForestClassifier # Import Random Forest␣
↪Classifier
from sklearn.model_selection import train_test_split # Import train_test_split␣
↪function
from sklearn import metrics #Import scikit-learn metrics module for accuracy␣
↪calculation
from sklearn import tree # Import export_graphviz for visualizing Decision Trees
```

0.1 Data read

[2]:
```
df = pd.read_csv("data/diabetes.csv") # Data read
```

[3]:
```
df.head() # print data
```

[3]:

	Pregnancies	Glucose	BloodPressure	SkinThickness	Insulin	BMI	DiabetesPedigreeFunction	Age	Outcome
0	6	148	72	35	0	33.6	0.627	50	1
1	1	85	66	29	0	26.6	0.351	31	0
2	8	183	64	0	0	23.3	0.672	32	1
3	1	89	66	23	94	28.1	0.167	21	0
4	0	137	40	35	168	43.1	2.288	33	1

[4]:
```
df.isna().sum() # check for null value
```

[4]:
```
Pregnancies                 0
Glucose                     0
BloodPressure               0
SkinThickness               0
Insulin                     0
BMI                         0
DiabetesPedigreeFunction    0
Age                         0
Outcome                     0
dtype: int64
```

[5]:
```
df.describe()
```

[5]:

	Pregnancies	Glucose	BloodPressure	SkinThickness	Insulin
count	768.000000	768.000000	768.000000	768.000000	768.000000
mean	3.845052	120.894531	69.105469	20.536458	79.799479
std	3.369578	31.972618	19.355807	15.952218	115.244002
min	0.000000	0.000000	0.000000	0.000000	0.000000
25%	1.000000	99.000000	62.000000	0.000000	0.000000
50%	3.000000	117.000000	72.000000	23.000000	30.500000
75%	6.000000	140.250000	80.000000	32.000000	127.250000
max	17.000000	199.000000	122.000000	99.000000	846.000000

	BMI	DiabetesPedigreeFunction	Age	Outcome
count	768.000000	768.000000	768.000000	768.000000
mean	31.992578	0.471876	33.240885	0.348958
std	7.884160	0.331329	11.760232	0.476951
min	0.000000	0.078000	21.000000	0.000000
25%	27.300000	0.243750	24.000000	0.000000
50%	32.000000	0.372500	29.000000	0.000000
75%	36.600000	0.626250	41.000000	1.000000
max	67.100000	2.420000	81.000000	1.000000

[6]:
```
# replace zero bmi value with it's mean
print("Before BMI mean : ",round(df['BMI'].mean(),1))
df['BMI'] = df['BMI'].replace(0, df['BMI'].mean())
print("After BMI mean : ",round(df['BMI'].mean(),1))
```

```
Before BMI mean :  32.0
After BMI mean :  32.5
```

[7]:
```
# replace zero skinthickness value with it's mean
print("Before SkinThickness mean : ",round(df['SkinThickness'].mean(),1))
df['SkinThickness'] = df['SkinThickness'].replace(0, df['SkinThickness'].mean())
print("After SkinThickness mean : ",round(df['SkinThickness'].mean(),1))
```

```
Before SkinThickness mean :  20.5
After SkinThickness mean :  26.6
```

[8]:
```
# replace zero bloodpressure value with it's mean
print("Before BloodPressure mean : ",round(df['BloodPressure'].mean(),1))
df['BloodPressure'] = df['BloodPressure'].replace(0, df['BloodPressure'].mean())
print("After BloodPressure mean : ",round(df['BloodPressure'].mean(),1))
```

```
Before BloodPressure mean :  69.1
After BloodPressure mean :  72.3
```

[9]:
```
# replace zero Glucose value with it's mean
print("Before Glucose mean : ",round(df['Glucose'].mean(),1))
df['Glucose'] = df['Glucose'].replace(0, df['Glucose'].mean())
print("After Glucose mean : ",round(df['Glucose'].mean(),1))
```

```
Before Glucose mean :  120.9
After Glucose mean :  121.7
```

[10]:
```
# replace zero Insulin value with it's mean
print("Before Insulin mean : ",round(df['Insulin'].mean(),1))
df['Insulin'] = df['Insulin'].replace(0, df['Insulin'].mean())
print("After Insulin mean : ",round(df['Insulin'].mean(),1))
```

```
Before Insulin mean :  79.8
After Insulin mean :  118.7
```

[11]:
```
df.describe()
```

[11]:

	Pregnancies	Glucose	BloodPressure	SkinThickness	Insulin	\
count	768.000000	768.000000	768.000000	768.000000	768.000000	
mean	3.845052	121.681605	72.254807	26.606479	118.660163	
std	3.369578	30.436016	12.115932	9.631241	93.080358	
min	0.000000	44.000000	24.000000	7.000000	14.000000	
25%	1.000000	99.750000	64.000000	20.536458	79.799479	
50%	3.000000	117.000000	72.000000	23.000000	79.799479	
75%	6.000000	140.250000	80.000000	32.000000	127.250000	
max	17.000000	199.000000	122.000000	99.000000	846.000000	

	BMI	DiabetesPedigreeFunction	Age	Outcome
count	768.000000	768.000000	768.000000	768.000000
mean	32.450805	0.471876	33.240885	0.348958
std	6.875374	0.331329	11.760232	0.476951
min	18.200000	0.078000	21.000000	0.000000
25%	27.500000	0.243750	24.000000	0.000000
50%	32.000000	0.372500	29.000000	0.000000
75%	36.600000	0.626250	41.000000	1.000000
max	67.100000	2.420000	81.000000	1.000000

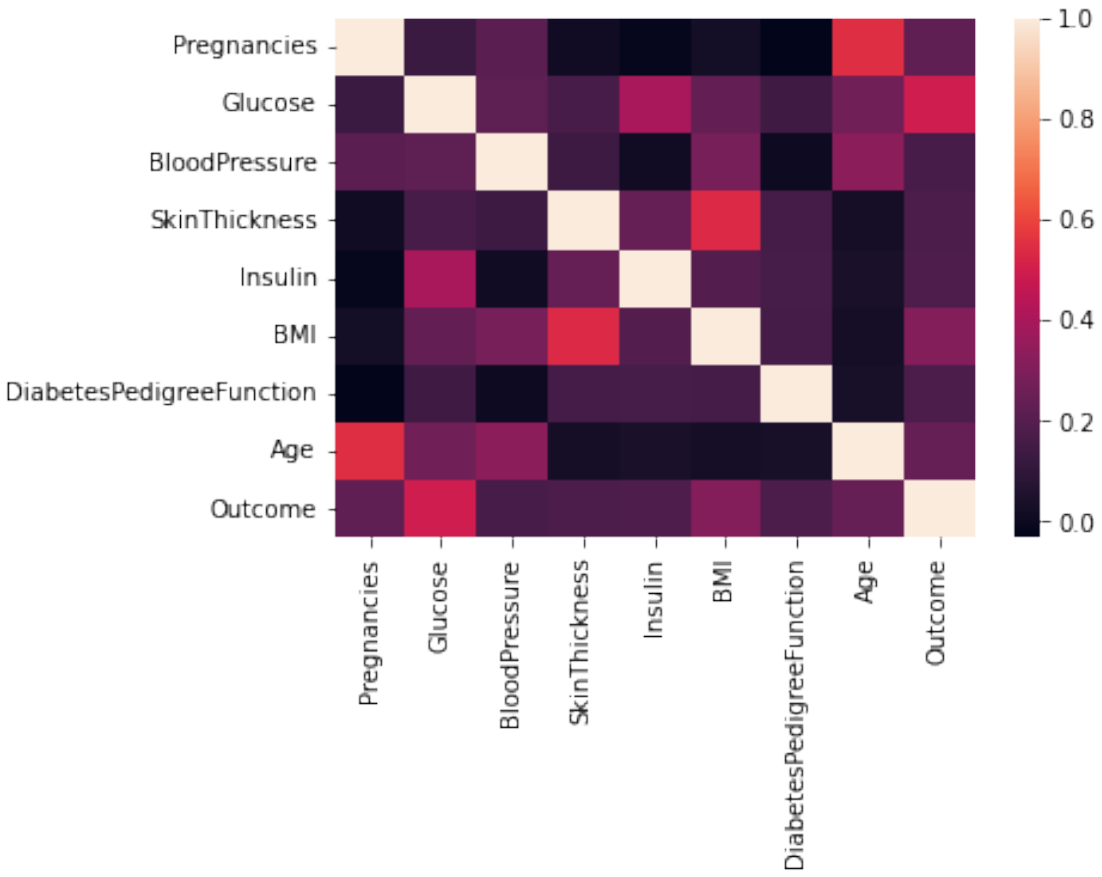
[12]:
```
df.corr()
```

[12]:

	Pregnancies	Glucose	BloodPressure	SkinThickness	Insulin	BMI	DiabetesPedigreeFunction	Age	Outcome
Pregnancies	1.000000	0.127964	0.208984	0.013376	-0.018082	0.021546	-0.033523	0.544341	0.221898
Glucose	0.127964	1.000000	0.219666	0.160766	0.396597	0.231478	0.137106	0.266600	0.492908
BloodPressure	0.208984	0.219666	1.000000	0.134155	0.010926	0.281231	0.000371	0.326740	0.162986
SkinThickness	0.013376	0.160766	0.134155	1.000000	0.240361	0.535703	0.154961	0.026423	0.175026
Insulin	-0.018082	0.396597	0.010926	0.240361	1.000000	0.189856	0.157806	0.038652	0.179185
BMI	0.021546	0.231478	0.281231	0.535703	0.189856	1.000000	0.153508	0.025748	0.312254
DiabetesPedigreeFunction	-0.033523	0.137106	0.000371	0.154961	0.157806	0.153508	1.000000	0.033561	0.173844
Age	0.544341	0.266600	0.326740	0.026423	0.038652	0.025748	0.033561	1.000000	0.238356
Outcome	0.221898	0.492908	0.162986	0.175026	0.179185	0.312254	0.173844	0.238356	1.000000

[13]:
```
sns.heatmap(df.corr())
```

[13]:
```
<AxesSubplot:>
```



1 Data split

[14]:
```
X = df.iloc[:,0:-1] # All features
Y = df.iloc[:,-1] # Target
```

[15]:
```
X.head()
```

[15]:

	Pregnancies	Glucose	BloodPressure	SkinThickness	Insulin	BMI	DiabetesPedigreeFunction	Age
0	6	148.0	72.0	35.000000	79.799479	33.6	0.627	50
1	1	85.0	66.0	29.000000	79.799479	26.6	0.351	31
2	8	183.0	64.0	20.536458	79.799479	23.3	0.672	32
3	1	89.0	66.0	23.000000	94.000000	28.1		
4	0	137.0	40.0	35.000000	168.000000	43.1		

```
3                       0.167   21
4                       2.288   33
```

[16]:
```
Y.head()
```

[16]:
```
0    1
1    0
2    1
3    0
4    1
Name: Outcome, dtype: int64
```

[17]:
```
# Data split
x_train, x_test, y_train, y_test = train_test_split(X, Y, test_size=0.2,␣
 ↪random_state=1)
# x_dev, x_test, y_dev, y_test = train_test_split(x_test, y_test, test_size= 0.
 ↪5)
```

[18]:
```
print("Original data size : ", X.shape, Y.shape)
print("Train data size : ", x_train.shape, y_train.shape)
# print("Dev data size : ", x_dev.shape, y_dev.shape)
print("Test data size : ", x_test.shape, y_test.shape)
```

```
Original data size :  (768, 8) (768,)
Train data size :  (614, 8) (614,)
Test data size :  (154, 8) (154,)
```

2 Decision Tree

[19]:
```
accuracy = {}
```

2.0.1 criterion="gini", splitter="best"

[20]:
```
# Define and build model
clf = DecisionTreeClassifier(criterion="gini", splitter="best")
clf = clf.fit(x_train,y_train)
y_pred = clf.predict(x_test)
```

[21]:
```
print(y_pred)
```

```
[0 0 0 1 0 0 1 0 0 0 1 0 0 1 0 0 0 1 0 1 0 0 1 0 0 0 0 1 1 1 0 0 0 1 0 1 0
 0 0 0 0 0 0 1 0 0 0 1 0 0 0 0 1 0 1 0 0 0 0 1 1 0 1 0 1 0 0 0 1 1 1 1 0 0
 0 0 1 1 0 1 1 0 0 0 0 1 0 1 1 1 0 0 0 0 1 0 0 0 0 0 0 0 1 0 0 0 0 1 0 0 1
 0 0 1 1 0 0 1 0 1 0 1 0 1 0 0 0 0 0 1 1 0 1 0 0 0 0 1 0 0 1 1 0 1 1 0 0 0
 0 0 0 1 1 0]
```

[22]:
```
print(np.array(y_test))
```

```
[0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 1 1 0 0 0 1 1 1 1 0 0 0 1 0 1 1 0 0 1 0 1 0
 0 0 0 0 0 0 1 0 0 1 1 0 1 0 0 1 0 1 0 1 0 0 0 0 0 0 1 0 1 0 1 1 0 1 1 0 0 0
 1 1 1 0 0 1 1 0 1 1 0 0 1 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 1 0 0 0 1 0 1 0 1
 0 0 0 1 0 0 1 0 1 0 1 1 0 0 0 0 1 0 0 1 0 1 0 0 0 0 0 1 0 1 0 0 1 1 1 0 0
 1 0 0 1 0 0]
```

[23]:
```
accuracy["dt_gini_best"] = metrics.accuracy_score(y_test, y_pred);
print("Accuracy:",metrics.accuracy_score(y_test, y_pred))
```

```
Accuracy: 0.6948051948051948
```

[24]:
```
print(metrics.confusion_matrix(y_test, y_pred))
```

```
[[77 22]
 [25 30]]
```

[25]:
```
print(metrics.classification_report(y_test, y_pred))
```

```
              precision    recall  f1-score   support

           0       0.75      0.78      0.77        99
           1       0.58      0.55      0.56        55

    accuracy                           0.69       154
   macro avg       0.67      0.66      0.66       154
weighted avg       0.69      0.69      0.69       154
```

2.0.2 criterion="gini", splitter="best", max_depth=8

[26]:
```
# Define and build model
clf = DecisionTreeClassifier(criterion="gini", splitter="best", max_depth=8)
clf = clf.fit(x_train,y_train)
y_pred = clf.predict(x_test)
```

[27]:
```
print(y_pred)
```

```
[0 0 0 1 0 0 1 0 0 0 1 0 0 0 0 1 0 0 0 0 0 0 1 0 0 1 0 1 1 0 0 0 0 1 0 1 0
 0 0 0 0 0 0 1 0 0 0 1 0 0 0 0 0 1 0 1 0 0 0 0 1 1 0 1 0 1 0 0 1 1 1 1 0 0 0
 0 0 1 1 0 1 1 0 0 0 0 0 0 1 1 1 0 0 0 0 1 1 0 0 0 0 0 0 1 0 0 0 0 1 0 0 0
 0 0 0 0 0 0 0 0 1 0 1 0 0 0 0 1 0 0 0 1 0 1 0 0 0 0 1 0 0 1 1 0 0 0 0 0 0
 0 0 0 0 1 0]
```

[28]:
```
print(np.array(y_test))
```

```
[0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 1 1 0 0 0 1 1 1 1 0 0 0 1 0 1 1 0 0 1 0 1 0
 0 0 0 0 0 0 1 0 0 1 1 0 1 0 0 1 0 1 0 1 0 0 0 0 0 0 1 0 1 0 1 1 0 1 1 0 0 0
 1 1 1 0 0 1 1 0 1 1 0 0 1 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 1 0 0 0 1 0 1 0 1
 0 0 0 1 0 0 1 0 1 0 1 1 0 0 0 0 1 0 0 1 0 1 0 0 0 0 0 1 0 1 0 0 1 1 1 0 0
 1 0 0 1 0 0]
```

[29]:
```
accuracy["dt_gini_best_8"] = metrics.accuracy_score(y_test, y_pred);
print("Accuracy:",metrics.accuracy_score(y_test, y_pred))
```

```
Accuracy: 0.6818181818181818
```

[30]:
```
print(metrics.confusion_matrix(y_test, y_pred))
```

```
[[81 18]
 [31 24]]
```

[31]:
```
print(metrics.classification_report(y_test, y_pred))
```

```
              precision    recall  f1-score   support

           0       0.72      0.82      0.77        99
           1       0.57      0.44      0.49        55

    accuracy                           0.68       154
   macro avg       0.65      0.63      0.63       154
weighted avg       0.67      0.68      0.67       154
```

2.0.3 criterion="entropy", splitter="best"

[32]:
```
# Define and build model
clf = DecisionTreeClassifier(criterion="entropy", splitter="best")
clf = clf.fit(x_train,y_train)
y_pred = clf.predict(x_test)
```

[33]:
```
print(y_pred)
```

```
[1 0 0 0 0 0 0 0 0 0 1 0 1 1 0 1 0 0 0 0 1 0 1 0 0 1 0 1 0 0 0 1 0 1 1 0 0
 1 0 0 0 0 0 1 0 0 1 0 0 0 0 1 1 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 1 1 1 1 0 0
 1 1 1 1 0 1 1 0 0 0 0 0 0 1 1 1 0 0 1 0 1 1 0 1 1 0 0 0 1 0 0 0 1 0 0 0 1
 0 0 1 1 0 1 0 1 1 0 1 0 0 0 0 0 1 0 0 1 0 1 1 0 0 0 0 0 0 1 0 0 1 1 1 0 0
 0 0 0 1 1 1]
```

[34]:
```
print(np.array(y_test))
```

```
[0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 1 1 0 0 0 1 1 1 1 0 0 0 1 0 1 1 0 0 1 0 1 0
 0 0 0 0 0 0 1 0 0 1 1 0 1 0 0 1 0 1 0 1 0 0 0 0 0 1 0 1 0 1 1 0 1 1 0 0 0
 1 1 1 0 0 1 1 0 1 1 0 0 1 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 1 0 0 0 1 0 1 0 1
 0 0 0 1 0 0 1 0 1 0 1 1 0 0 0 0 1 0 0 1 0 1 0 0 0 0 0 1 0 1 0 0 1 1 1 0 0
 1 0 0 1 0 0]
```

[35]:
```
accuracy["dt_entropy_best"] = metrics.accuracy_score(y_test, y_pred);
print("Accuracy:",metrics.accuracy_score(y_test, y_pred))
```

```
Accuracy: 0.7142857142857143
```

[36]:
```
print(metrics.confusion_matrix(y_test, y_pred))
```

```
[[76 23]
 [21 34]]
```

[37]:
```
print(metrics.classification_report(y_test, y_pred))
```

```
              precision    recall  f1-score   support

           0       0.78      0.77      0.78        99
           1       0.60      0.62      0.61        55

    accuracy                           0.71       154
   macro avg       0.69      0.69      0.69       154
weighted avg       0.72      0.71      0.72       154
```

2.0.4 criterion="entropy", splitter="best", max_depth=8

[38]:
```
# Define and build model
clf = DecisionTreeClassifier(criterion="entropy", splitter="best", max_depth=8)
clf = clf.fit(x_train,y_train)
y_pred = clf.predict(x_test)
```

[39]:
```
print(y_pred)
```

```
[1 0 0 0 0 0 1 0 1 0 1 0 1 1 0 0 1 0 0 0 1 0 1 0 0 0 0 1 0 0 0 1 0 1 1 0 0
 0 0 0 0 0 0 1 0 0 1 0 0 0 0 0 1 0 1 0 0 0 0 0 1 0 1 0 1 0 1 1 0 1 1 1 0 0
 1 1 1 0 0 1 1 0 0 0 0 0 1 1 1 1 0 0 0 0 1 1 0 1 1 0 0 0 1 0 0 0 0 0 0 0 1
 0 0 0 1 0 1 0 0 1 0 1 1 1 0 0 0 1 1 0 1 0 1 1 0 0 0 1 0 0 1 0 0 0 1 1 0 0
 1 0 0 1 1 1]
```

[40]:
```
print(np.array(y_test))
```

```
[0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 1 1 0 0 0 1 1 1 1 0 0 0 1 0 1 1 0 0 1 0 1 0
 0 0 0 0 0 0 1 0 0 1 1 0 1 0 0 1 0 1 0 1 0 0 0 0 0 1 0 1 0 1 1 0 1 1 0 0 0
 1 1 1 0 0 1 1 0 1 1 0 0 1 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 1 0 0 0 1 0 1 0 1
 0 0 0 1 0 0 1 0 1 0 1 1 0 0 0 0 1 0 0 1 0 1 0 0 0 0 0 1 0 1 0 0 1 1 1 0 0
 1 0 0 1 0 0]
```

[41]:
```
accuracy["dt_entropy_best_8"] = metrics.accuracy_score(y_test, y_pred);
print("Accuracy:",metrics.accuracy_score(y_test, y_pred))
```

```
Accuracy: 0.7662337662337663
```

[42]:
```
print(metrics.confusion_matrix(y_test, y_pred))
```

```
[[79 20]
 [16 39]]
```

[43]:
```
print(metrics.classification_report(y_test, y_pred))
```

```
              precision    recall  f1-score   support

           0       0.83      0.80      0.81        99
           1       0.66      0.71      0.68        55

    accuracy                           0.77       154
   macro avg       0.75      0.75      0.75       154
weighted avg       0.77      0.77      0.77       154
```

2.0.5 criterion="entropy", splitter="random"

[44]:
```
# Define and build model
clf = DecisionTreeClassifier(criterion="entropy", splitter="random")
clf = clf.fit(x_train,y_train)
y_pred = clf.predict(x_test)
```

[45]:
```
print(y_pred)
```

```
[0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 1 1 1 0 0 1 0 1 1 0 1 0 1 0 1 0 1 0 1 0
 0 0 0 0 0 0 1 0 0 0 0 0 0 0 1 1 0 1 0 1 0 0 1 1 0 0 1 1 0 1 0 1 0 1 1 0 0
 1 0 1 1 0 1 1 0 1 0 0 0 1 0 0 1 0 0 0 0 0 1 1 0 1 0 0 1 1 0 0 0 1 0 0 0 1
 0 1 0 0 0 0 0 0 1 1 1 1 0 0 0 0 0 0 0 1 0 1 1 1 0 0 1 0 0 1 1 1 1 1 0 0 0
 1 1 1 1 1 0]
```

[46]:
```
print(np.array(y_test))
```

```
[0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 1 1 0 0 0 1 1 1 1 0 0 0 1 0 1 1 0 0 1 0 1 0
 0 0 0 0 0 0 1 0 0 1 1 0 1 0 0 1 0 1 0 1 0 0 0 0 0 0 1 0 1 0 1 1 0 1 1 0 0 0
 1 1 1 0 0 1 1 0 1 1 0 0 1 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 1 0 0 0 1 0 1 0 1
 0 0 0 1 0 0 1 0 1 0 1 1 0 0 0 0 1 0 0 1 0 1 0 0 0 0 0 0 1 0 1 0 0 1 1 1 0 0
 1 0 0 1 0 0]
```

[47]:
```
accuracy["dt_entropy_random"] = metrics.accuracy_score(y_test, y_pred);
print("Accuracy:",metrics.accuracy_score(y_test, y_pred))
```

```
Accuracy: 0.7337662337662337
```

[48]:
```
print(metrics.confusion_matrix(y_test, y_pred))
```

```
[[75 24]
 [17 38]]
```

[49]:
```
print(metrics.classification_report(y_test, y_pred))
```

```
              precision    recall  f1-score   support

           0       0.82      0.76      0.79        99
```

```
           1       0.61      0.69      0.65        55

    accuracy                           0.73       154
   macro avg       0.71      0.72      0.72       154
weighted avg       0.74      0.73      0.74       154
```

2.0.6 criterion="entropy", splitter="random", max_depth=8

[50]:
```
# Define and build model
clf = DecisionTreeClassifier(criterion="entropy", splitter="random",␣
 ↪max_depth=8)
clf = clf.fit(x_train,y_train)
y_pred = clf.predict(x_test)
```

[51]:
```
print(y_pred)
```

```
[1 0 0 0 0 1 0 0 0 0 1 0 1 1 0 1 0 1 0 0 1 0 1 1 0 1 0 1 0 0 0 1 0 1 1 1 0
 0 0 0 0 0 0 0 0 0 1 1 0 0 0 1 1 0 0 0 0 0 0 0 1 0 1 0 0 0 1 0 1 1 1 1 0 0
 1 0 1 1 0 1 1 0 1 0 0 1 1 0 0 0 0 0 1 0 1 1 0 0 1 0 0 0 1 0 0 0 1 1 0 0 0
 0 0 0 1 0 1 0 0 1 0 1 1 0 0 0 0 0 0 0 1 0 0 0 0 0 0 1 0 1 0 0 0 1 1 0 0 0
 0 1 0 1 0 1]
```

[52]:
```
print(np.array(y_test))
```

```
[0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 1 1 0 0 0 1 1 1 1 0 0 0 1 0 1 1 0 0 1 0 1 0
 0 0 0 0 0 0 1 0 0 1 1 0 1 0 0 1 0 1 0 1 0 0 0 0 0 1 0 1 0 1 1 0 1 1 0 0 0
 1 1 1 0 0 1 1 0 1 1 0 0 1 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 1 0 0 0 1 0 1 0 1
 0 0 0 1 0 0 1 0 1 0 1 1 0 0 0 0 1 0 0 1 0 1 0 0 0 0 0 1 0 1 0 0 1 1 1 0 0
 1 0 0 1 0 0]
```

[53]:
```
accuracy["dt_entropy_random_8"] = metrics.accuracy_score(y_test, y_pred);
print("Accuracy:",metrics.accuracy_score(y_test, y_pred))
```

```
Accuracy: 0.7272727272727273
```

[54]:
```
print(metrics.confusion_matrix(y_test, y_pred))
```

```
[[78 21]
 [21 34]]
```

[55]:
```
print(metrics.classification_report(y_test, y_pred))
```

```
              precision    recall  f1-score   support

           0       0.79      0.79      0.79        99
           1       0.62      0.62      0.62        55

    accuracy                           0.73       154
   macro avg       0.70      0.70      0.70       154
```

```
weighted avg       0.73      0.73      0.73       154
```

2.0.7 criterion="entropy", splitter="best", max_depth=3

[56]:
```
# Define and build model
clf = DecisionTreeClassifier(criterion="entropy", splitter="best", max_depth=3)
clf = clf.fit(x_train,y_train)
y_pred = clf.predict(x_test)
```

[57]:
```
print(y_pred)
```

```
[0 0 0 0 0 0 0 0 0 0 1 0 1 1 0 1 0 0 0 0 0 0 1 0 0 1 0 1 0 1 0 0 0 1 0 1 0
 0 0 0 0 0 0 1 0 0 1 1 0 0 0 0 1 0 0 0 1 0 0 0 1 0 1 0 0 0 0 0 1 1 1 1 0 0
 1 0 1 0 0 1 1 0 0 1 0 1 1 0 1 0 0 0 0 0 1 0 0 0 1 0 0 0 1 0 0 0 1 1 0 0 1
 0 1 0 0 0 0 0 0 1 0 1 0 0 0 0 0 0 0 0 1 0 1 1 0 0 0 1 0 0 1 0 0 1 1 0 0 0
 0 0 0 1 1 0]
```

[58]:
```
print(np.array(y_test))
```

```
[0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 1 1 0 0 0 1 1 1 1 0 0 0 1 0 1 1 0 0 1 0 1 0
 0 0 0 0 0 0 1 0 0 1 1 0 1 0 0 1 0 1 0 1 0 0 0 0 0 0 1 0 1 0 1 1 0 1 1 0 0 0
 1 1 1 0 0 1 1 0 1 1 0 0 1 0 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 1 0 0 0 1 0 1 0 1
 0 0 0 1 0 0 1 0 1 0 1 1 0 0 0 0 0 1 0 0 1 0 1 0 0 0 0 0 0 1 0 1 0 0 1 1 1 0 0
 1 0 0 1 0 0]
```

[59]:
```
accuracy["dt_entropy_best_3"] = metrics.accuracy_score(y_test, y_pred);
print("Accuracy:",metrics.accuracy_score(y_test, y_pred))
```

```
Accuracy: 0.7922077922077922
```

[60]:
```
print(metrics.confusion_matrix(y_test, y_pred))
```

```
[[87 12]
 [20 35]]
```

[61]:
```
print(metrics.classification_report(y_test, y_pred))
```

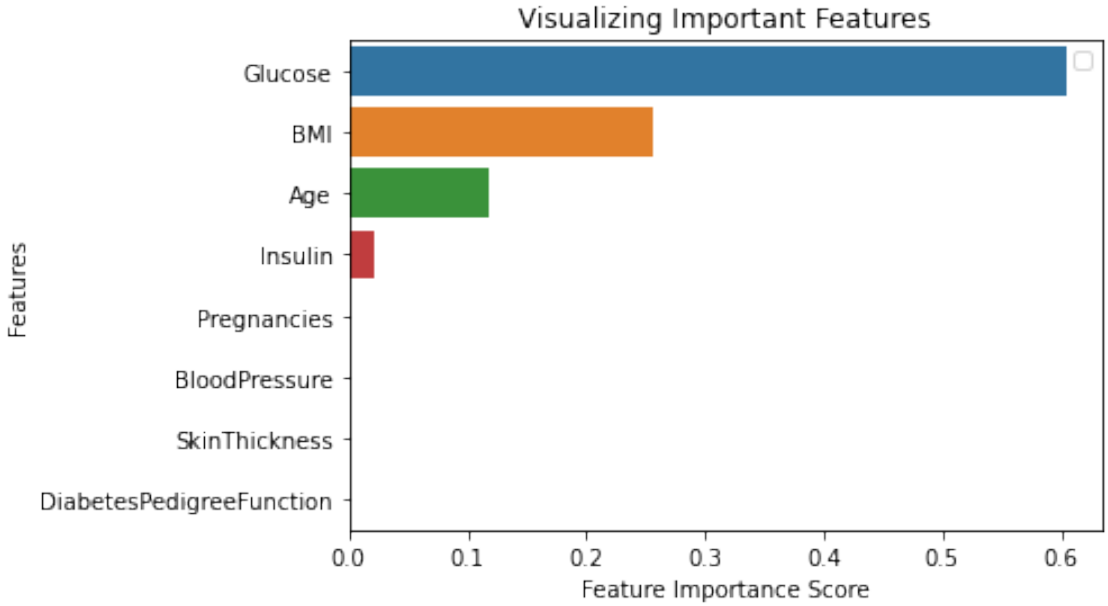
```
              precision    recall  f1-score   support

           0       0.81      0.88      0.84        99
           1       0.74      0.64      0.69        55

    accuracy                           0.79       154
   macro avg       0.78      0.76      0.77       154
weighted avg       0.79      0.79      0.79       154
```

[62]:
```
feature_imp = pd.Series(clf.feature_importances_,index=X.columns).
↪sort_values(ascending=False)
```

```
print(feature_imp)
# Creating a bar plot
sns.barplot(x=feature_imp, y=feature_imp.index)
# Add labels to your graph
plt.xlabel('Feature Importance Score')
plt.ylabel('Features')
plt.title("Visualizing Important Features")
plt.legend()
plt.show()
```

```
Glucose                     0.603648
BMI                         0.257027
Age                         0.117798
Insulin                     0.021527
Pregnancies                 0.000000
BloodPressure               0.000000
SkinThickness               0.000000
DiabetesPedigreeFunction    0.000000
dtype: float64
```

```
No handles with labels found to put in legend.
```



2.0.8 criterion="entropy", splitter="random", max_depth=3

[63]:
```
# Define and build model
clf = DecisionTreeClassifier(criterion="entropy", splitter="random",␣
 ↪max_depth=3)
```

```
clf = clf.fit(x_train,y_train)
y_pred = clf.predict(x_test)
```

[64]:
```
print(y_pred)
```

```
[1 0 0 0 0 0 0 0 0 0 1 0 1 1 0 1 1 1 0 0 1 0 1 1 0 1 0 1 0 0 0 0 0 1 1 1 0
 0 0 1 0 0 0 1 0 0 1 0 0 0 0 0 1 0 1 0 0 1 1 0 1 0 1 0 1 0 1 1 1 1 1 1 1 0
 1 0 1 0 0 0 1 0 1 0 1 1 1 0 0 1 0 0 0 0 1 0 1 0 1 0 0 0 1 0 0 0 1 1 0 0 1
 0 0 0 1 0 0 1 0 1 0 1 1 1 0 0 0 0 1 0 1 0 1 0 0 0 0 1 0 1 1 0 1 1 1 0 0 0
 1 0 0 1 1 0]
```

[65]:
```
print(np.array(y_test))
```

```
[0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 1 1 0 0 0 1 1 1 1 0 0 0 1 0 1 1 0 0 1 0 1 0
 0 0 0 0 0 0 1 0 0 1 1 0 1 0 0 1 0 1 0 1 0 0 0 0 0 1 0 1 0 1 1 0 1 1 0 0 0
 1 1 1 1 0 0 1 1 0 1 1 0 0 1 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 1 0 0 0 1 0 1 0 1
 0 0 0 1 0 0 1 0 1 0 1 1 0 0 0 0 1 0 0 1 0 1 0 0 0 0 0 1 0 1 0 0 1 1 1 0 0
 1 0 0 1 0 0]
```

[66]:
```
accuracy["dt_entropy_random_3"] = metrics.accuracy_score(y_test, y_pred);
print("Accuracy:",metrics.accuracy_score(y_test, y_pred))
```

```
Accuracy: 0.7662337662337663
```

[67]:
```
print(metrics.confusion_matrix(y_test, y_pred))
```

```
[[76 23]
 [13 42]]
```

[68]:
```
print(metrics.classification_report(y_test, y_pred))
```

```
              precision    recall  f1-score   support

           0       0.85      0.77      0.81        99
           1       0.65      0.76      0.70        55

    accuracy                           0.77       154
   macro avg       0.75      0.77      0.75       154
weighted avg       0.78      0.77      0.77       154
```

3 Accuracy visulization of Decision Tree

[69]:
```
accuracy_df_dt = pd.DataFrame(list(zip(accuracy.keys(), accuracy.values())),␣
↪columns =['Arguments', 'Accuracy'])
accuracy_df_dt
```

[69]:

	Arguments	Accuracy
0	dt_gini_best	0.694805

```
1       dt_gini_best_8  0.681818
2      dt_entropy_best  0.714286
3    dt_entropy_best_8  0.766234
4    dt_entropy_random  0.733766
5  dt_entropy_random_8  0.727273
6    dt_entropy_best_3  0.792208
7  dt_entropy_random_3  0.766234
```

[70]:
```
fig = px.bar(accuracy_df_dt, x='Arguments', y='Accuracy')
fig.show()
```

4 Random Forest

[71]:
```
accuracy_rf = {}
```

4.0.1 n_estimators = 1000, criterion='entropy'

[72]:
```
# Instantiate model with 1000 decision trees
rf = RandomForestClassifier(n_estimators = 1000, criterion='entropy')
# Train the model on training data
rf.fit(x_train,y_train)
# Use the forest's predict method on the test data
y_pred = rf.predict(x_test)
```

[73]:
```
print(y_pred)
```

```
[1 0 0 0 0 0 0 0 0 0 1 0 1 1 0 1 0 0 0 0 1 0 1 0 0 0 0 1 0 1 0 0 0 1 0 1 0
 0 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 1 0 1 0 0 0 0 0 1 0 1 0 1 0 0 1 1 1 1 1 0 0
 1 1 1 0 0 1 1 0 0 0 0 1 0 0 1 0 0 0 0 0 1 1 0 0 1 0 0 0 1 0 0 0 1 1 0 0 1
 0 0 0 0 0 0 0 0 1 0 1 0 1 0 0 0 1 1 0 1 0 1 0 0 0 0 1 0 0 1 0 0 1 1 0 0 0
 0 0 0 1 1 0]
```

[74]:
```
print(np.array(y_test))
```

```
[0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 1 1 0 0 0 1 1 1 1 0 0 0 1 0 1 1 0 0 1 0 1 0
 0 0 0 0 0 0 1 0 0 1 1 0 1 0 0 1 0 1 0 1 0 0 0 0 0 1 0 1 0 1 1 0 1 1 0 0 0
 1 1 1 0 0 1 1 0 1 1 0 0 1 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 1 0 0 0 1 0 1 0 1
 0 0 0 1 0 0 1 0 1 0 1 1 0 0 0 0 1 0 0 1 0 1 0 0 0 0 0 1 0 1 0 0 1 1 1 0 0
 1 0 0 1 0 0]
```

[75]:
```
accuracy_rf["rf_entropy_1000"] = metrics.accuracy_score(y_test, y_pred);
print("Accuracy:",metrics.accuracy_score(y_test, y_pred))
```

```
Accuracy: 0.7987012987012987
```

[76]:
```
print(metrics.confusion_matrix(y_test, y_pred))
```

```
[[86 13]
 [18 37]]
```

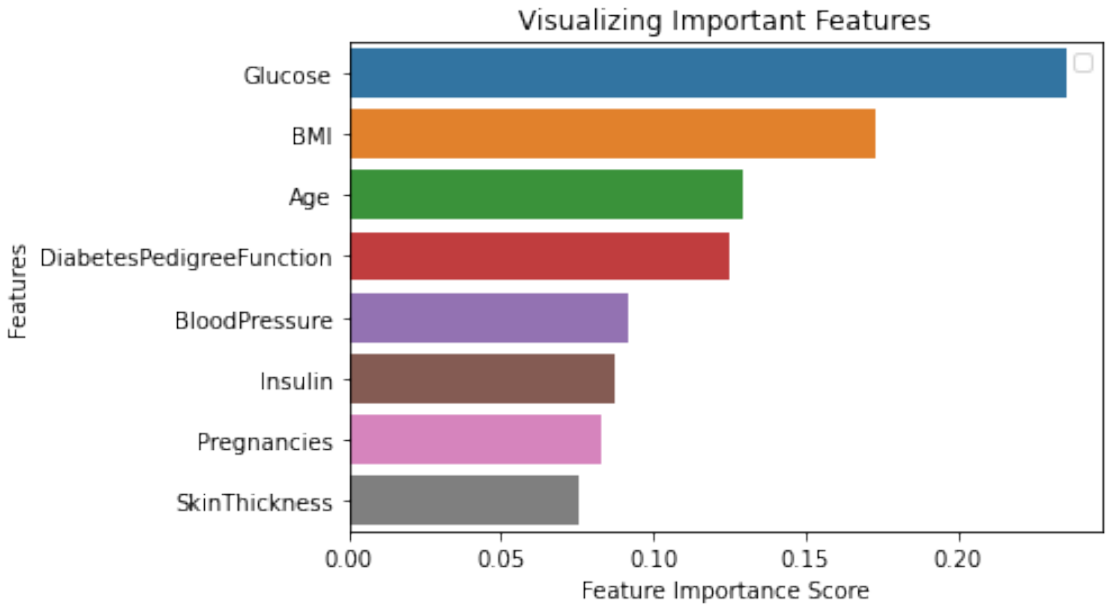
[77]:
```
print(metrics.classification_report(y_test, y_pred))
```

```
              precision    recall  f1-score   support

           0       0.83      0.87      0.85        99
           1       0.74      0.67      0.70        55

    accuracy                           0.80       154
   macro avg       0.78      0.77      0.78       154
weighted avg       0.80      0.80      0.80       154
```

[78]:
```
feature_imp = pd.Series(rf.feature_importances_,index=X.columns).
 ↪sort_values(ascending=False)
print(feature_imp)
# Creating a bar plot
sns.barplot(x=feature_imp, y=feature_imp.index)
# Add labels to your graph
plt.xlabel('Feature Importance Score')
plt.ylabel('Features')
plt.title("Visualizing Important Features")
plt.legend()
plt.show()
```

```
No handles with labels found to put in legend.
```

```
Glucose                     0.235444
BMI                         0.173068
Age                         0.129225
DiabetesPedigreeFunction    0.125376
BloodPressure               0.091730
Insulin                     0.087149
Pregnancies                 0.082769
SkinThickness               0.075239
dtype: float64
```



4.0.2 n_estimators = 100, criterion='entropy'

[79]:
```
# Instantiate model with 100 decision trees
rf = RandomForestClassifier(n_estimators = 100, criterion='entropy')
# Train the model on training data
rf.fit(x_train,y_train)
# Use the forest's predict method on the test data
y_pred = rf.predict(x_test)
```

[80]:
```
print(y_pred)
```

```
[0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 1 0 0 0 0 0 0 1 0 0 1 0 1 0 1 0 0 0 1 0 1 0
 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 1 0 1 0 0 0 0 0 1 0 1 0 1 0 0 0 1 1 1 1 0 0
 1 1 1 0 0 1 1 0 0 0 0 1 0 0 1 0 0 0 0 0 1 1 0 0 1 0 0 0 1 0 0 0 1 1 0 0 1
 0 1 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1 0 0 1 0 1 0 0 0 0 1 0 0 1 0 0 1 1 1 0 0
 0 0 0 1 1 0]
```

[81]:
```
print(np.array(y_test))
```

```
[0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 1 1 0 0 0 1 1 1 1 0 0 0 1 0 1 1 0 0 1 0 1 0
 0 0 0 0 0 0 1 0 0 1 1 0 1 0 0 1 0 1 0 1 0 0 0 0 0 1 0 1 0 1 1 0 1 1 0 0 0
 1 1 1 0 0 1 1 0 1 1 0 0 1 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 1 0 0 0 1 0 1 0 1
 0 0 0 1 0 0 1 0 1 0 1 1 0 0 0 0 1 0 0 1 0 1 0 0 0 0 0 1 0 1 0 0 1 1 1 0 0
 1 0 0 1 0 0]
```

[82]:
```
accuracy_rf["rf_entropy_100"] = metrics.accuracy_score(y_test, y_pred);
print("Accuracy:",metrics.accuracy_score(y_test, y_pred))
```

```
Accuracy: 0.7987012987012987
```

[83]:
```
print(metrics.confusion_matrix(y_test, y_pred))
```

```
[[88 11]
 [20 35]]
```

[84]:
```
print(metrics.classification_report(y_test, y_pred))
```

```
              precision    recall  f1-score   support

           0       0.81      0.89      0.85        99
           1       0.76      0.64      0.69        55

    accuracy                           0.80       154
   macro avg       0.79      0.76      0.77       154
weighted avg       0.80      0.80      0.79       154
```

4.0.3 n_estimators = 1000, random_state = 42, criterion='entropy'

[85]:
```
# Instantiate model with 1000 decision trees
rf = RandomForestClassifier(n_estimators = 1000, random_state = 42,␣
 ↪criterion='entropy')
# Train the model on training data
rf.fit(x_train,y_train)
# Use the forest's predict method on the test data
y_pred = rf.predict(x_test)
```

[86]:
```
print(y_pred)
```

```
[0 0 0 0 0 0 0 0 0 0 1 0 1 1 0 1 0 0 0 0 1 0 1 0 0 0 0 1 0 1 0 0 0 1 0 1 0
 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 1 0 1 0 0 0 0 0 1 0 1 0 1 0 0 0 1 1 1 1 0 0
 1 1 1 0 0 1 1 0 0 0 0 1 1 0 1 0 0 0 0 0 1 1 0 0 1 0 0 0 1 0 0 0 1 1 0 0 0
 0 0 0 0 0 0 0 0 1 0 1 0 1 0 0 0 1 1 0 1 0 1 0 0 0 0 1 0 0 1 0 0 1 1 0 0 0
 0 0 0 1 1 0]
```

[87]:
```
print(np.array(y_test))
```

```
[0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 1 1 0 0 0 1 1 1 1 0 0 0 1 0 1 1 0 0 1 0 1 0
 0 0 0 0 0 0 1 0 0 1 1 0 1 0 0 1 0 1 0 1 0 0 0 0 0 1 0 1 0 1 1 0 1 1 0 0 0
 1 1 1 0 0 1 1 0 1 1 0 0 1 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 1 0 0 0 1 0 1 0 1
 0 0 0 1 0 0 1 0 1 0 1 1 0 0 0 0 1 0 0 1 0 1 0 0 0 0 0 1 0 1 0 0 1 1 1 0 0
 1 0 0 1 0 0]
```

[88]:
```
accuracy_rf["rf_entropy_1000_42"] = metrics.accuracy_score(y_test, y_pred);
print("Accuracy:",metrics.accuracy_score(y_test, y_pred))
```

```
Accuracy: 0.7987012987012987
```

[89]:
```
print(metrics.confusion_matrix(y_test, y_pred))
```

```
[[87 12]
 [19 36]]
```

[90]:
```
print(metrics.classification_report(y_test, y_pred))
```

```
              precision    recall  f1-score   support

           0       0.82      0.88      0.85        99
           1       0.75      0.65      0.70        55

    accuracy                           0.80       154
   macro avg       0.79      0.77      0.77       154
weighted avg       0.80      0.80      0.80       154
```

4.0.4 n_estimators = 100, random_state = 42, criterion='entropy'

[91]:
```
# Instantiate model with 100 decision trees
rf = RandomForestClassifier(n_estimators = 100, random_state = 42, max_depth =␣
↪8, criterion='entropy')
# Train the model on training data
rf.fit(x_train,y_train)
# Use the forest's predict method on the test data
y_pred = rf.predict(x_test)
```

[92]:
```
print(y_pred)
```

```
[0 0 0 0 0 0 0 0 0 0 1 0 1 1 0 1 0 0 0 0 1 0 1 0 0 0 0 1 0 1 0 0 0 1 0 1 0
 0 0 1 0 0 0 0 0 0 1 1 0 0 0 0 1 0 1 0 0 0 0 0 1 0 1 0 1 0 0 0 1 1 1 1 0 0
 1 0 1 0 0 1 1 0 0 0 0 1 1 0 1 0 0 0 0 0 1 1 0 0 1 0 0 0 1 0 0 0 1 0 0 0 1
 0 1 0 1 0 0 1 0 1 0 1 0 0 0 0 0 1 1 0 1 0 1 0 0 0 0 1 0 0 1 0 0 1 1 1 0 0
 0 0 0 1 1 0]
```

[93]:
```
print(np.array(y_test))
```

```
[0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 1 1 0 0 0 1 1 1 1 0 0 0 1 0 1 1 0 0 1 0 1 0
 0 0 0 0 0 0 1 0 0 1 1 0 1 0 0 1 0 1 0 1 0 0 0 0 0 1 0 1 0 1 1 0 1 1 0 0 0
 1 1 1 0 0 1 1 0 1 1 0 0 1 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 1 0 0 0 1 0 1 0 1
 0 0 0 1 0 0 1 0 1 0 1 1 0 0 0 0 1 0 0 1 0 1 0 0 0 0 0 1 0 1 0 0 1 1 1 0 0
 1 0 0 1 0 0]
```

[94]:
```
accuracy_rf["rf_entropy_100_42"] = metrics.accuracy_score(y_test, y_pred);
print("Accuracy:",metrics.accuracy_score(y_test, y_pred))
```

```
Accuracy: 0.8181818181818182
```

[95]:
```
print(metrics.confusion_matrix(y_test, y_pred))
```

```
[[87 12]
 [16 39]]
```

[96]:
```
print(metrics.classification_report(y_test, y_pred))
```

```
              precision    recall  f1-score   support

           0       0.84      0.88      0.86        99
           1       0.76      0.71      0.74        55

    accuracy                           0.82       154
   macro avg       0.80      0.79      0.80       154
weighted avg       0.82      0.82      0.82       154
```

4.0.5 n_estimators = 1000, random_state = 42, max_depth = 8, criterion='entropy'

[97]:
```
# Instantiate model with 1000 decision trees
rf = RandomForestClassifier(n_estimators = 1000, random_state = 42, max_depth =␣
↪8, criterion='entropy')
# Train the model on training data
rf.fit(x_train,y_train)
# Use the forest's predict method on the test data
y_pred = rf.predict(x_test)
```

[98]:
```
print(y_pred)
```

```
[0 0 0 0 0 0 0 0 0 0 1 0 1 1 0 1 0 0 0 0 1 0 1 0 0 0 0 1 0 1 0 0 0 1 0 1 0
 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 1 0 1 0 0 0 0 0 1 0 1 0 1 0 0 0 1 1 1 1 0 0
 1 0 1 0 0 1 1 0 0 0 0 1 1 0 1 0 0 0 0 0 1 1 0 0 1 0 0 0 1 0 0 0 1 1 0 0 0
 0 1 0 0 0 0 1 0 1 0 1 0 1 0 0 0 1 1 0 1 0 1 0 0 0 0 1 0 0 1 0 0 1 1 0 0 0
 0 0 0 1 1 0]
```

[99]:
```
print(np.array(y_test))
```

```
[0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 1 1 0 0 0 1 1 1 1 0 0 0 1 0 1 1 0 0 1 0 1 0
 0 0 0 0 0 0 1 0 0 1 1 0 1 0 0 1 0 1 0 1 0 0 0 0 0 1 0 1 0 1 1 0 1 1 0 0 0
 1 1 1 0 0 1 1 0 1 1 0 0 1 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 1 0 0 0 1 0 1 0 1
 0 0 0 1 0 0 1 0 1 0 1 1 0 0 0 0 1 0 0 1 0 1 0 0 0 0 0 1 0 1 0 0 1 1 1 0 0
 1 0 0 1 0 0]
```

[100]:
```
accuracy_rf["rf_entropy_1000_42_8"] = metrics.accuracy_score(y_test, y_pred);
print("Accuracy:",metrics.accuracy_score(y_test, y_pred))
```

```
Accuracy: 0.7922077922077922
```

[101]:
```
print(metrics.confusion_matrix(y_test, y_pred))
```

```
[[86 13]
 [19 36]]
```

[102]:
```
print(metrics.classification_report(y_test, y_pred))
```

```
              precision    recall  f1-score   support

           0       0.82      0.87      0.84        99
           1       0.73      0.65      0.69        55

    accuracy                           0.79       154
   macro avg       0.78      0.76      0.77       154
weighted avg       0.79      0.79      0.79       154
```

4.0.6 n_estimators = 100, random_state = 42, max_depth = 8, criterion='entropy'

[103]:
```
# Instantiate model with 100 decision trees
rf = RandomForestClassifier(n_estimators = 100, random_state = 42, max_depth =␣
 ↪8, criterion='entropy')
# Train the model on training data
rf.fit(x_train,y_train)
# Use the forest's predict method on the test data
y_pred = rf.predict(x_test)
```

[104]:
```
print(y_pred)
```

```
[0 0 0 0 0 0 0 0 0 0 1 0 1 1 0 1 0 0 0 0 1 0 1 0 0 0 0 1 0 1 0 0 0 1 0 1 0
 0 0 1 0 0 0 0 0 0 1 1 0 0 0 0 1 0 1 0 0 0 0 0 1 0 1 0 1 0 0 0 1 1 1 1 0 0
 1 0 1 0 0 1 1 0 0 0 0 1 1 0 1 0 0 0 0 0 1 1 0 0 1 0 0 0 1 0 0 0 1 0 0 0 1
 0 1 0 1 0 0 1 0 1 0 1 0 0 0 0 0 1 1 0 1 0 1 0 0 0 0 1 0 0 1 0 0 1 1 1 0 0
 0 0 0 1 1 0]
```

[105]:
```
print(np.array(y_test))
```

```
[0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 1 1 0 0 0 1 1 1 1 0 0 0 1 0 1 1 0 0 1 0 1 0
 0 0 0 0 0 0 1 0 0 1 1 0 1 0 0 1 0 1 0 1 0 0 0 0 0 0 1 0 1 0 1 1 0 1 1 0 0 0
 1 1 1 0 0 1 1 0 1 1 0 0 1 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 1 0 0 0 1 0 1 0 1
 0 0 0 1 0 0 1 0 1 0 1 1 0 0 0 0 1 0 0 1 0 1 0 0 0 0 0 1 0 1 0 0 1 1 1 0 0
 1 0 0 1 0 0]
```

[106]:
```
accuracy_rf["rf_entropy_100_42_8"] = metrics.accuracy_score(y_test, y_pred);
print("Accuracy:",metrics.accuracy_score(y_test, y_pred))
```

```
Accuracy: 0.8181818181818182
```

[107]:
```
print(metrics.confusion_matrix(y_test, y_pred))
```

```
[[87 12]
 [16 39]]
```

[108]:
```
print(metrics.classification_report(y_test, y_pred))
```

```
              precision    recall  f1-score   support

           0       0.84      0.88      0.86        99
           1       0.76      0.71      0.74        55

    accuracy                           0.82       154
   macro avg       0.80      0.79      0.80       154
weighted avg       0.82      0.82      0.82       154
```

4.0.7 n_estimators = 1000

[109]:
```
# Instantiate model with 1000 decision trees
rf = RandomForestClassifier(n_estimators = 1000)
# Train the model on training data
rf.fit(x_train,y_train)
# Use the forest's predict method on the test data
y_pred = rf.predict(x_test)
```

[110]:
```
print(y_pred)
```

```
[1 0 0 0 0 0 0 0 0 0 1 0 1 1 0 1 0 0 0 0 1 0 1 0 0 0 0 1 0 1 0 0 0 1 0 1 0
 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 1 0 1 0 0 0 0 0 1 0 1 0 1 0 0 1 1 1 1 1 0 0
 1 1 1 0 0 1 1 0 0 0 0 1 1 0 1 0 0 0 0 0 1 1 0 0 1 0 0 0 1 0 0 0 1 1 0 0 1
 0 1 0 0 0 0 0 0 1 0 1 0 0 0 0 0 1 1 0 1 0 1 0 0 0 0 1 0 0 1 0 0 1 1 0 0 0
 0 0 0 1 1 0]
```

[111]:
```
print(np.array(y_test))
```

```
[0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 1 1 0 0 0 1 1 1 1 0 0 0 1 0 1 1 0 0 1 0 1 0
 0 0 0 0 0 0 1 0 0 1 1 0 1 0 0 1 0 1 0 1 0 0 0 0 0 1 0 1 0 1 1 0 1 1 0 0 0
 1 1 1 0 0 1 1 0 1 1 0 0 1 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 1 0 0 0 1 0 1 0 1
 0 0 0 1 0 0 1 0 1 0 1 1 0 0 0 0 1 0 0 1 0 1 0 0 0 0 0 1 0 1 0 0 1 1 1 0 0
 1 0 0 1 0 0]
```

[112]:
```
accuracy_rf["rf_gini_1000"] = metrics.accuracy_score(y_test, y_pred);
print("Accuracy:",metrics.accuracy_score(y_test, y_pred))
```

```
Accuracy: 0.8051948051948052
```

[113]:
```
print(metrics.confusion_matrix(y_test, y_pred))
```

```
[[86 13]
 [17 38]]
```

[114]:
```
print(metrics.classification_report(y_test, y_pred))
```

```
              precision    recall  f1-score   support

           0       0.83      0.87      0.85        99
```

```
           1       0.75      0.69      0.72        55

    accuracy                           0.81       154
   macro avg       0.79      0.78      0.78       154
weighted avg       0.80      0.81      0.80       154
```

4.0.8 n_estimators = 100

[115]:
```
# Instantiate model with 100 decision trees
rf = RandomForestClassifier(n_estimators = 100)
# Train the model on training data
rf.fit(x_train,y_train)
# Use the forest's predict method on the test data
y_pred = rf.predict(x_test)
```

[116]:
```
print(y_pred)
```

```
[1 0 0 0 0 0 0 0 0 0 1 0 1 1 0 1 0 0 0 0 0 0 1 0 0 0 0 1 0 1 0 0 0 1 0 1 0
 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 1 0 1 0 0 0 0 0 1 0 1 0 1 0 0 0 1 1 1 1 0 0
 1 0 1 0 0 1 1 0 1 0 0 1 1 0 1 0 0 0 0 0 1 1 0 0 1 0 0 0 1 0 0 0 1 1 0 0 1
 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1 0 0 1 0 1 0 0 0 0 1 0 0 1 0 0 1 1 0 0 0
 0 0 0 1 1 0]
```

[117]:
```
print(np.array(y_test))
```

```
[0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 1 1 0 0 0 1 1 1 1 0 0 0 1 0 1 1 0 0 1 0 1 0
 0 0 0 0 0 0 1 0 0 1 1 0 1 0 0 1 0 1 0 1 0 0 0 0 0 1 0 1 0 1 1 0 1 1 0 0 0
 1 1 1 0 0 1 1 0 1 1 0 0 1 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 1 0 0 0 1 0 1 0 1
 0 0 0 1 0 0 1 0 1 0 1 1 0 0 0 0 1 0 0 1 0 1 0 0 0 0 0 1 0 1 0 0 1 1 1 0 0
 1 0 0 1 0 0]
```

[118]:
```
accuracy_rf["rf_gini_100"] = metrics.accuracy_score(y_test, y_pred);
print("Accuracy:",metrics.accuracy_score(y_test, y_pred))
```

```
Accuracy: 0.7987012987012987
```

[119]:
```
print(metrics.confusion_matrix(y_test, y_pred))
```

```
[[88 11]
 [20 35]]
```

[120]:
```
print(metrics.classification_report(y_test, y_pred))
```

```
              precision    recall  f1-score   support

           0       0.81      0.89      0.85        99
           1       0.76      0.64      0.69        55

    accuracy                           0.80       154
```

```
   macro avg       0.79      0.76      0.77       154
weighted avg       0.80      0.80      0.79       154
```

4.0.9 n_estimators = 1000, random_state = 42

[121]:
```
# Instantiate model with 1000 decision trees
rf = RandomForestClassifier(n_estimators = 1000, random_state = 42)
# Train the model on training data
rf.fit(x_train,y_train)
# Use the forest's predict method on the test data
y_pred = rf.predict(x_test)
```

[122]:
```
print(y_pred)
```

```
[1 0 0 0 0 0 0 0 0 0 1 0 1 1 0 1 0 0 0 0 1 0 1 0 0 0 0 1 0 1 0 0 0 1 0 1 0
 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 1 0 1 0 0 0 0 0 1 0 1 0 1 0 0 0 1 1 1 1 0 0
 1 1 1 0 0 1 1 0 0 0 0 1 1 0 1 0 0 0 0 0 1 1 1 0 1 0 0 0 1 0 0 0 1 1 0 0 1
 0 1 0 0 0 0 0 0 1 0 1 0 0 0 0 0 1 1 0 1 0 1 0 0 0 0 1 0 0 1 0 0 1 1 0 0 0
 0 0 0 1 1 0]
```

[123]:
```
print(np.array(y_test))
```

```
[0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 1 1 0 0 0 1 1 1 1 0 0 0 1 0 1 1 0 0 1 0 1 0
 0 0 0 0 0 0 1 0 0 1 1 0 1 0 0 1 0 1 0 1 0 0 0 0 0 0 1 0 1 0 1 1 0 1 1 0 0 0
 1 1 1 0 0 1 1 0 1 1 0 0 1 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 1 0 0 0 1 0 1 0 1
 0 0 0 1 0 0 1 0 1 0 1 1 0 0 0 0 1 0 0 1 0 1 0 0 0 0 0 0 1 0 1 0 0 1 1 1 0 0
 1 0 0 1 0 0]
```

[124]:
```
accuracy_rf["rf_gini_1000_42"] = metrics.accuracy_score(y_test, y_pred);
print("Accuracy:",metrics.accuracy_score(y_test, y_pred))
```

```
Accuracy: 0.7922077922077922
```

[125]:
```
print(metrics.confusion_matrix(y_test, y_pred))
```

```
[[85 14]
 [18 37]]
```

[126]:
```
print(metrics.classification_report(y_test, y_pred))
```

```
              precision    recall  f1-score   support

           0       0.83      0.86      0.84        99
           1       0.73      0.67      0.70        55

    accuracy                           0.79       154
   macro avg       0.78      0.77      0.77       154
weighted avg       0.79      0.79      0.79       154
```

4.0.10 n_estimators = 100, random_state = 42

[127]:
```
# Instantiate model with 100 decision trees
rf = RandomForestClassifier(n_estimators = 100, random_state = 42, max_depth =␣
↪8)
# Train the model on training data
rf.fit(x_train,y_train)
# Use the forest's predict method on the test data
y_pred = rf.predict(x_test)
```

[128]:
```
print(y_pred)
```

```
[0 0 0 0 0 0 0 0 0 0 1 0 1 1 0 1 0 0 0 0 1 0 1 0 0 0 0 1 0 1 0 0 0 1 0 1 0
 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 1 0 1 0 0 0 0 0 1 0 1 0 1 0 0 0 1 1 1 1 0 0
 1 1 1 0 0 1 1 0 0 0 0 1 1 0 1 0 0 0 0 0 1 1 1 0 1 0 0 0 1 0 0 0 1 1 0 0 1
 0 0 0 0 0 0 1 0 1 0 1 0 0 0 0 0 1 1 0 1 0 1 0 0 0 0 1 0 0 1 0 0 1 1 0 0 0
 0 0 0 1 1 0]
```

[129]:
```
print(np.array(y_test))
```

```
[0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 1 1 0 0 0 1 1 1 1 0 0 0 1 0 1 1 0 0 1 0 1 0
 0 0 0 0 0 0 1 0 0 1 1 0 1 0 0 1 0 1 0 1 0 0 0 0 0 1 0 1 0 1 1 0 1 1 0 0 0
 1 1 1 0 0 1 1 0 1 1 0 0 1 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 1 0 0 0 1 0 1 0 1
 0 0 0 1 0 0 1 0 1 0 1 1 0 0 0 0 1 0 0 1 0 1 0 0 0 0 0 1 0 1 0 0 1 1 1 0 0
 1 0 0 1 0 0]
```

[130]:
```
accuracy_rf["rf_gini_100_42"] = metrics.accuracy_score(y_test, y_pred);
print("Accuracy:",metrics.accuracy_score(y_test, y_pred))
```

```
Accuracy: 0.8116883116883117
```

[131]:
```
print(metrics.confusion_matrix(y_test, y_pred))
```

```
[[87 12]
 [17 38]]
```

[132]:
```
print(metrics.classification_report(y_test, y_pred))
```

```
              precision    recall  f1-score   support

           0       0.84      0.88      0.86        99
           1       0.76      0.69      0.72        55

    accuracy                           0.81       154
   macro avg       0.80      0.78      0.79       154
weighted avg       0.81      0.81      0.81       154
```

4.0.11 n_estimators = 1000, random_state = 42, max_depth = 8

[133]:
```
# Instantiate model with 1000 decision trees
rf = RandomForestClassifier(n_estimators = 1000, random_state = 42, max_depth =␣
↪8)
# Train the model on training data
rf.fit(x_train,y_train)
# Use the forest's predict method on the test data
y_pred = rf.predict(x_test)
```

[134]:
```
print(y_pred)
```

```
[1 0 0 0 0 0 0 0 0 0 1 0 1 1 0 1 0 0 0 0 1 0 1 0 0 0 0 1 0 0 0 0 0 1 0 1 0
 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 1 0 1 0 0 0 0 0 1 0 1 0 1 0 0 0 1 1 1 1 0 0
 1 0 1 0 0 1 1 0 0 0 0 1 1 0 1 0 0 0 0 0 1 1 0 0 1 0 0 0 1 0 0 0 1 1 0 0 1
 0 0 0 0 0 0 0 0 1 0 1 0 0 0 0 0 1 1 0 1 0 1 0 0 0 0 1 0 0 1 0 0 1 1 0 0 0
 0 0 0 1 1 0]
```

[135]:
```
print(np.array(y_test))
```

```
[0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 1 1 0 0 0 1 1 1 1 0 0 0 1 0 1 1 0 0 1 0 1 0
 0 0 0 0 0 0 1 0 0 1 1 0 1 0 0 1 0 1 0 1 0 0 0 0 0 1 0 1 0 1 1 0 1 1 0 0 0
 1 1 1 0 0 1 1 0 1 1 0 0 1 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 1 0 0 0 1 0 1 0 1
 0 0 0 1 0 0 1 0 1 0 1 1 0 0 0 0 1 0 0 1 0 1 0 0 0 0 0 1 0 1 0 0 1 1 1 0 0
 1 0 0 1 0 0]
```

[136]:
```
accuracy_rf["rf_gini_1000_42_8"] = metrics.accuracy_score(y_test, y_pred);
print("Accuracy:",metrics.accuracy_score(y_test, y_pred))
```

```
Accuracy: 0.7922077922077922
```

[137]:
```
print(metrics.confusion_matrix(y_test, y_pred))
```

```
[[87 12]
 [20 35]]
```

[138]:
```
print(metrics.classification_report(y_test, y_pred))
```

```
              precision    recall  f1-score   support

           0       0.81      0.88      0.84        99
           1       0.74      0.64      0.69        55

    accuracy                           0.79       154
   macro avg       0.78      0.76      0.77       154
weighted avg       0.79      0.79      0.79       154
```

4.0.12 n_estimators = 100, random_state = 42, max_depth = 8

[139]:
```
# Instantiate model with 100 decision trees
rf = RandomForestClassifier(n_estimators = 100, random_state = 42, max_depth =␣
↪8)
# Train the model on training data
rf.fit(x_train,y_train)
# Use the forest's predict method on the test data
y_pred = rf.predict(x_test)
```

[140]:
```
print(y_pred)
```

```
[0 0 0 0 0 0 0 0 0 0 1 0 1 1 0 1 0 0 0 0 1 0 1 0 0 0 0 1 0 1 0 0 0 1 0 1 0
 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 1 0 1 0 0 0 0 0 1 0 1 0 1 0 0 0 1 1 1 1 0 0
 1 1 1 0 0 1 1 0 0 0 0 1 1 0 1 0 0 0 0 0 1 1 1 0 1 0 0 0 1 0 0 0 1 1 0 0 1
 0 0 0 0 0 0 1 0 1 0 1 0 0 0 0 0 1 1 0 1 0 1 0 0 0 0 1 0 0 1 0 0 1 1 0 0 0
 0 0 0 1 1 0]
```

[141]:
```
print(np.array(y_test))
```

```
[0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 1 1 0 0 0 1 1 1 1 0 0 0 1 0 1 1 0 0 1 0 1 0
 0 0 0 0 0 0 1 0 0 1 1 0 1 0 0 1 0 1 0 1 0 0 0 0 0 1 0 1 0 1 1 0 1 1 0 0 0
 1 1 1 0 0 1 1 0 1 1 0 0 1 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 1 0 0 0 1 0 1 0 1
 0 0 0 1 0 0 1 0 1 0 1 1 0 0 0 0 1 0 0 1 0 1 0 0 0 0 0 1 0 1 0 0 1 1 1 0 0
 1 0 0 1 0 0]
```

[142]:
```
accuracy_rf["rf_gini_100_42_8"] = metrics.accuracy_score(y_test, y_pred);
print("Accuracy:",metrics.accuracy_score(y_test, y_pred))
```

```
Accuracy: 0.8116883116883117
```

[143]:
```
print(metrics.confusion_matrix(y_test, y_pred))
```

```
[[87 12]
 [17 38]]
```

[144]:
```
print(metrics.classification_report(y_test, y_pred))
```

```
              precision    recall  f1-score   support

           0       0.84      0.88      0.86        99
           1       0.76      0.69      0.72        55

    accuracy                           0.81       154
   macro avg       0.80      0.78      0.79       154
weighted avg       0.81      0.81      0.81       154
```

5 Accuracy visulization of Random Forest

[145]:
```
accuracy_df_rf = pd.DataFrame(list(zip(accuracy_rf.keys(), accuracy_rf.
↪values())), columns =['Arguments', 'Accuracy'])
accuracy_df_rf
```

[145]:

	Arguments	Accuracy
0	rf_entropy_1000	0.798701
1	rf_entropy_100	0.798701
2	rf_entropy_1000_42	0.798701
3	rf_entropy_100_42	0.818182
4	rf_entropy_1000_42_8	0.792208
5	rf_entropy_100_42_8	0.818182
6	rf_gini_1000	0.805195
7	rf_gini_100	0.798701
8	rf_gini_1000_42	0.792208
9	rf_gini_100_42	0.811688
10	rf_gini_1000_42_8	0.792208
11	rf_gini_100_42_8	0.811688

[146]:
```
fig = px.bar(accuracy_df_rf, x='Arguments', y='Accuracy')
fig.show()
```

[147]:
```
accuracy_df = pd.concat([accuracy_df_dt, accuracy_df_rf])
accuracy_df['Accuracy'] = round(accuracy_df['Accuracy'] * 100, 2)
fig = px.bar(accuracy_df, x='Arguments', y='Accuracy')
print(accuracy_df['Accuracy'].max())
fig.show()
```

```
81.82
```