```
import numpy as np
import pandas as pd
from sklearn.model_selection import train_test_split
from sklearn.metrics import accuracy_score, confusion_matrix,
classification_report
from sklearn import tree
from sklearn.tree import DecisionTreeClassifier
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn import metrics
%matplotlib inline

file_name =  "Dataset.xlsx"
sheet =  'Heart3'

df = pd.read_excel(io=file_name, sheet_name=sheet)
df.head()
```

```
  HeartDisease    BMI Smoking AlcoholDrinking Stroke
PhysicalHealth  \
0           No  16.60     Yes              No     No               3

1           No  20.34      No              No    Yes               0

2           No  26.58     Yes              No     No              20

3           No  24.21      No              No     No               0

4           No  23.71      No              No     No              28


   MentalHealth DiffWalking     Sex  AgeCategory   Race Diabetic  \
0            30          No  Female        55-59  White      Yes
1             0          No  Female  80 or older  White       No
2            30          No    Male        65-69  White      Yes
3             0          No  Female        75-79  White       No
4             0         Yes  Female        40-44  White       No

  PhysicalActivity  GenHealth  SleepTime Asthma KidneyDisease
SkinCancer
0              Yes  Very good          5    Yes            No
Yes
1              Yes  Very good          7     No            No
No
2              Yes       Fair          8    Yes            No
No
3               No       Good          6     No            No
Yes
4              Yes  Very good          8     No            No
No
```

```
df=df[['BMI', 'Smoking', 'Sex', 'GenHealth',
'SleepTime','SkinCancer']]
df
```

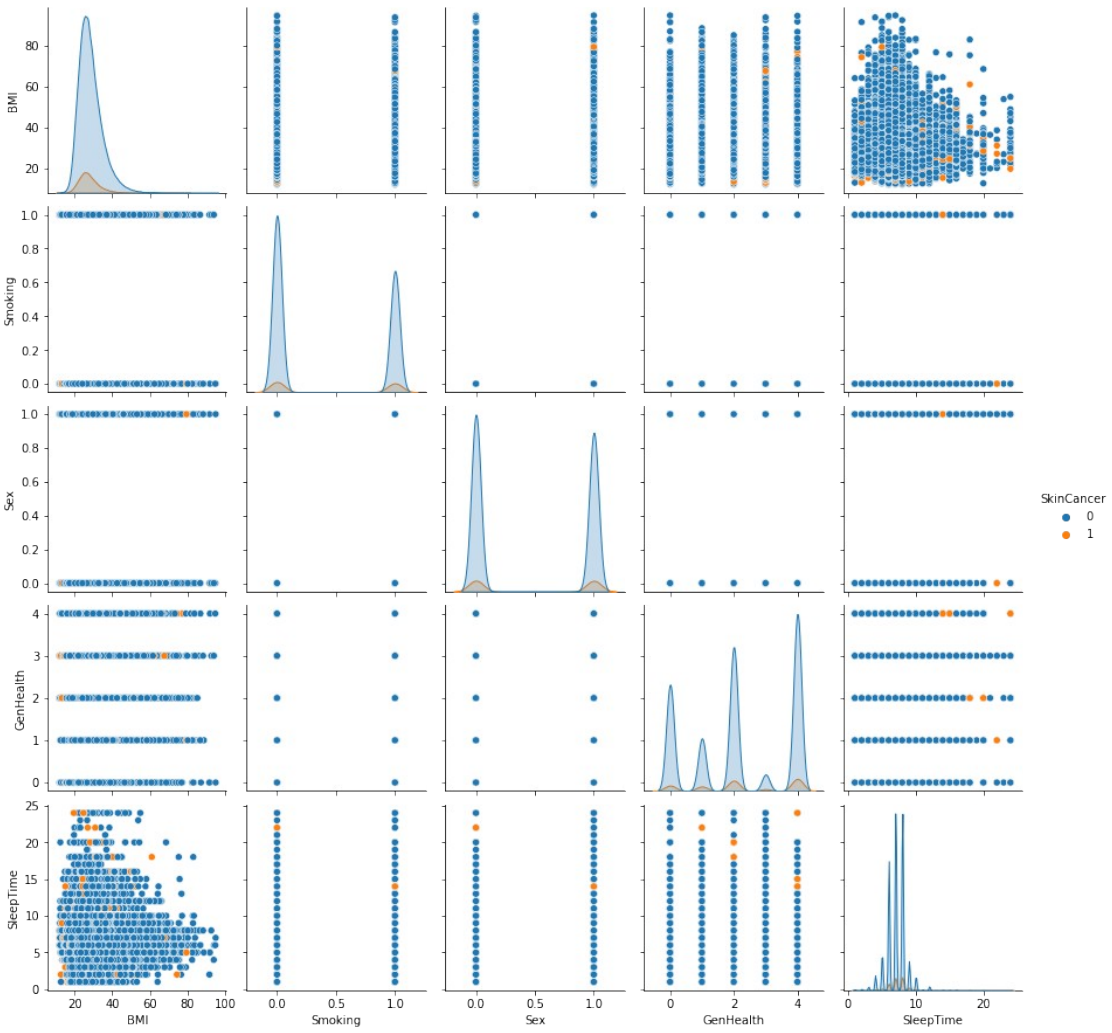
```
          BMI Smoking     Sex  GenHealth  SleepTime SkinCancer
0       16.60     Yes  Female  Very good          5        Yes
1       20.34      No  Female  Very good          7         No
2       26.58     Yes    Male       Fair          8         No
3       24.21      No  Female       Good          6        Yes
4       23.71      No  Female  Very good          8         No
...       ...     ...     ...        ...        ...        ...
319790  27.41     Yes    Male       Fair          6         No
319791  29.84     Yes    Male  Very good          5         No
319792  24.24      No  Female       Good          6         No
319793  32.81      No  Female       Good         12         No
319794  46.56      No  Female       Good          8         No

[319795 rows x 6 columns]
```

```
df.isnull().any()
```

```
BMI           False
Smoking       False
Sex           False
GenHealth     False
SleepTime     False
SkinCancer    False
dtype: bool
```

```
from sklearn.preprocessing import LabelEncoder

enc = LabelEncoder()

df['Sex'] = enc.fit_transform(df['Sex'])
df['GenHealth'] = enc.fit_transform(df['GenHealth'])
df['Smoking'] = enc.fit_transform(df['Smoking'])
df['SkinCancer'] = enc.fit_transform(df['SkinCancer'])

sns.pairplot(data=df, hue = 'SkinCancer')
```

```
<seaborn.axisgrid.PairGrid at 0x109e09310>
```




```
corr = df.corr()
plt.figure(figsize=(11,8))
sns.heatmap(corr, cmap="Blues",annot=True)
plt.show()
```


```
target = df['SkinCancer']
df = df.drop('SkinCancer', axis =1)


X = df
Y = target

X_train, X_test, y_train, y_test = train_test_split(X, Y, test_size =
0.2, random_state = 42)
```

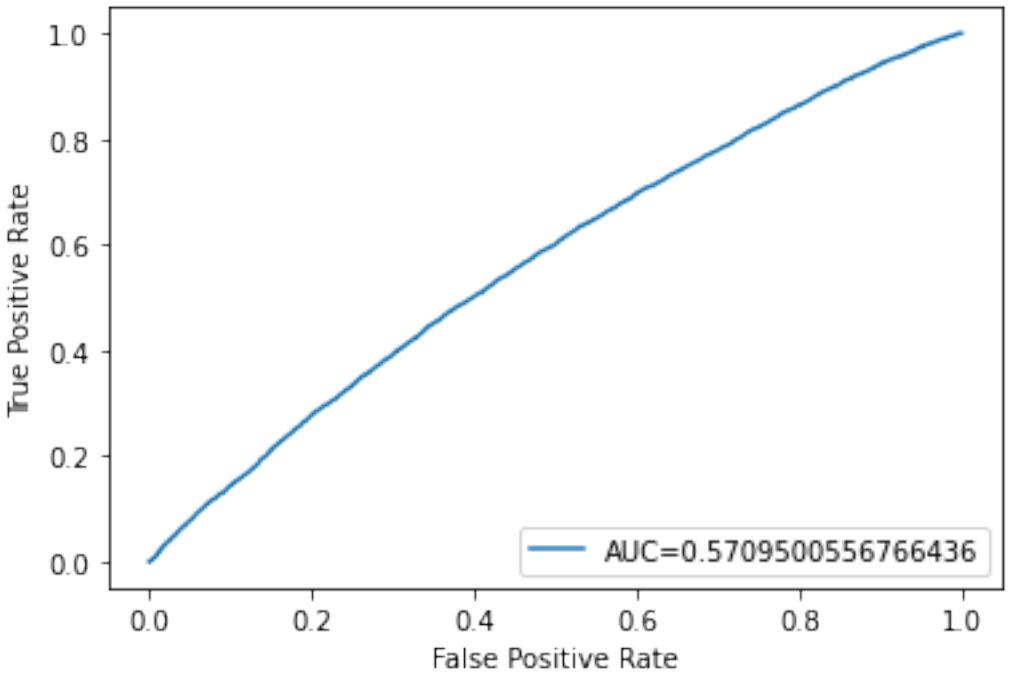
Logistic Regression

```
#logistic regression
from sklearn import linear_model

LRG = linear_model.LogisticRegression(random_state = 42,solver =
'liblinear').fit(X_train, y_train)
LRG.score(X_train, y_train)
```

```
0.9068153035538392
```

```
#AUC
y_pred_proba = LRG.predict_proba(X_test)[::,1]
fpr, tpr, _ = metrics.roc_curve(y_test,  y_pred_proba)
auc = metrics.roc_auc_score(y_test, y_pred_proba)
```

```
#create ROC curve
plt.plot(fpr,tpr,label="AUC="+str(auc))
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.legend(loc=4)
plt.show()
```




```
# https://stackoverflow.com/a/61517038/9848043
y_test.reset_index(drop=True)
```

```
0        0
1        1
2        0
3        0
4        1
       ..
63954    1
63955    0
63956    1
63957    0
63958    0
Name: SkinCancer, Length: 63959, dtype: int64
```

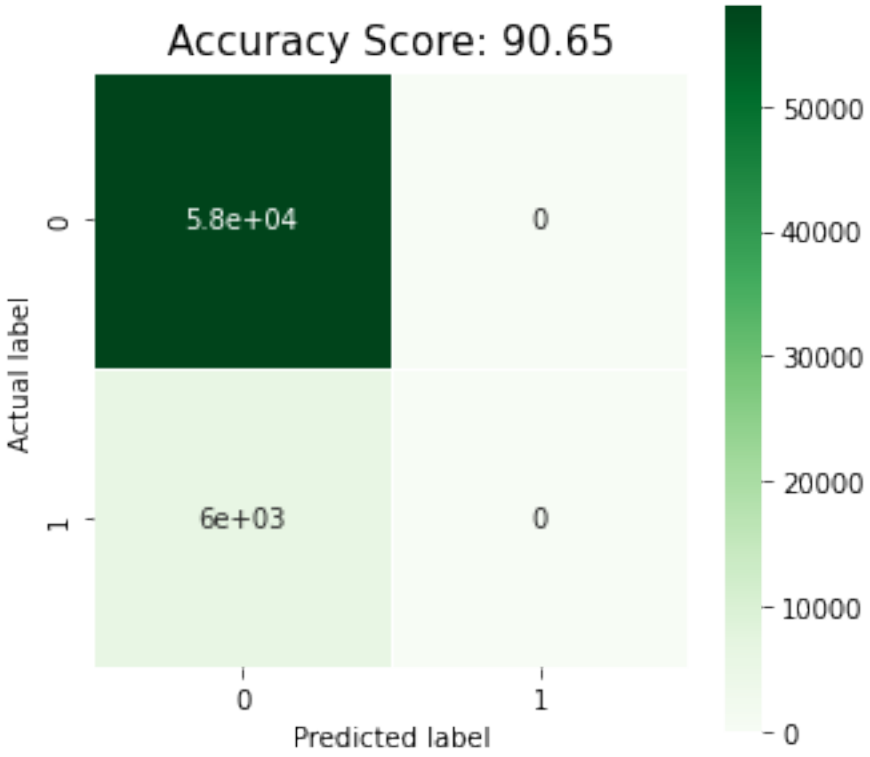
```
# confusion matrix in sklearn
from sklearn.metrics import confusion_matrix
from sklearn.metrics import classification_report
# actual values
actual = y_test
# predicted values
```

```
y_preds=LRG.predict(X_test)
predicted = y_preds
# confusion matrix
matrix = confusion_matrix(actual,predicted, labels=[1,0])
print('Confusion matrix : \n',matrix)
# outcome values order in sklearn
tp, fn, fp, tn =
confusion_matrix(actual,predicted,labels=[1,0]).reshape(-1)
print('Outcome values : \n', tp, fn, fp, tn)
# classification report for precision, recall f1-score and accuracy
matrix =
classification_report(actual,predicted,labels=[1,0],zero_division=1)
print('Classification report : \n',matrix)
```

```
Confusion matrix :
 [[    0  5979]
 [    0 57980]]
Outcome values :
 0 5979 0 57980
Classification report :
              precision    recall  f1-score   support

           1       1.00      0.00      0.00      5979
           0       0.91      1.00      0.95     57980

    accuracy                           0.91     63959
   macro avg       0.95      0.50      0.48     63959
weighted avg       0.92      0.91      0.86     63959
```

```
cm = confusion_matrix(actual, predicted)
plt.figure(figsize=(5,5))
sns.heatmap(data=cm,linewidths=.5, annot=True,square = True,  cmap =
'Greens')
plt.ylabel('Actual label')
plt.xlabel('Predicted label')
all_sample_title = 'Accuracy Score:
{:.2f}'.format(accuracy_score(actual,predicted)*100)
plt.title(all_sample_title, size = 15)
```

```
Text(0.5, 1.0, 'Accuracy Score: 90.65')
```



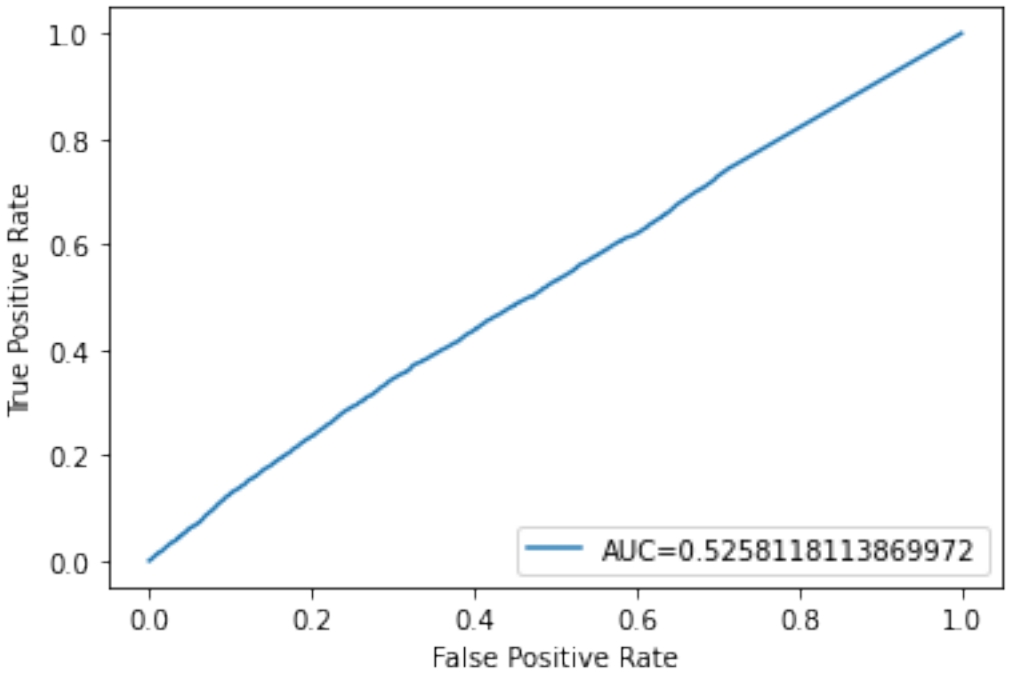
Random Forest Classifier

```
from sklearn.ensemble import RandomForestClassifier

clf = RandomForestClassifier(n_estimators = 100)

clf.fit(X_train, y_train)

# performing predictions on the test dataset
y_pred = clf.predict(X_test)

# metrics are used to find accuracy or error
from sklearn import metrics

# using metrics module for accuracy calculation
print("ACCURACY OF THE MODEL: ", metrics.accuracy_score(y_test,
y_pred))
```

```
ACCURACY OF THE MODEL:  0.8878656639409622
```

```
#AUC
y_pred_proba = clf.predict_proba(X_test)[::,1]
fpr, tpr, _ = metrics.roc_curve(y_test,  y_pred_proba)
auc = metrics.roc_auc_score(y_test, y_pred_proba)

#create ROC curve
plt.plot(fpr,tpr,label="AUC="+str(auc))
```

```
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.legend(loc=4)
plt.show()
```



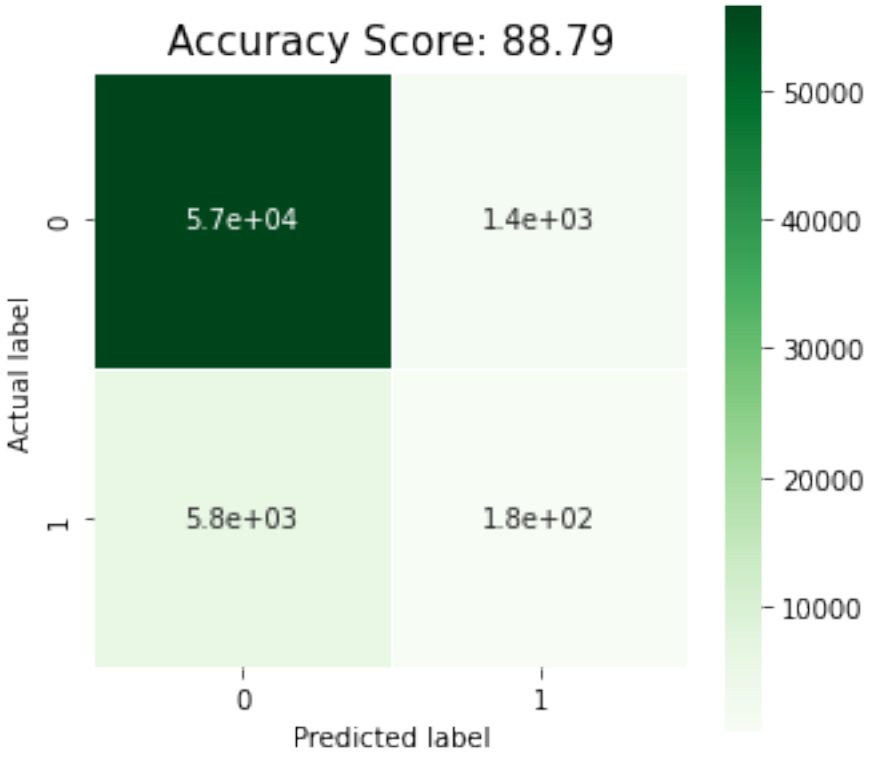

```
# confusion matrix in sklearn
from sklearn.metrics import confusion_matrix
from sklearn.metrics import classification_report
# actual values
actual = y_test
# predicted values
y_preds=clf.predict(X_test)
predicted = y_preds
# confusion matrix
matrix = confusion_matrix(actual,predicted, labels=[1,0])
print('Confusion matrix : \n',matrix)
# outcome values order in sklearn
tp, fn, fp, tn =
confusion_matrix(actual,predicted,labels=[1,0]).reshape(-1)
print('Outcome values : \n', tp, fn, fp, tn)
# classification report for precision, recall f1-score and accuracy
matrix =
classification_report(actual,predicted,labels=[1,0],zero_division=1)
print('Classification report : \n',matrix)
```

```
Confusion matrix :
 [[  175  5804]
 [ 1368 56612]]
Outcome values :
```

```
 175 5804 1368 56612
Classification report :
              precision    recall  f1-score   support

           1       0.11      0.03      0.05      5979
           0       0.91      0.98      0.94     57980

    accuracy                           0.89     63959
   macro avg       0.51      0.50      0.49     63959
weighted avg       0.83      0.89      0.86     63959
```

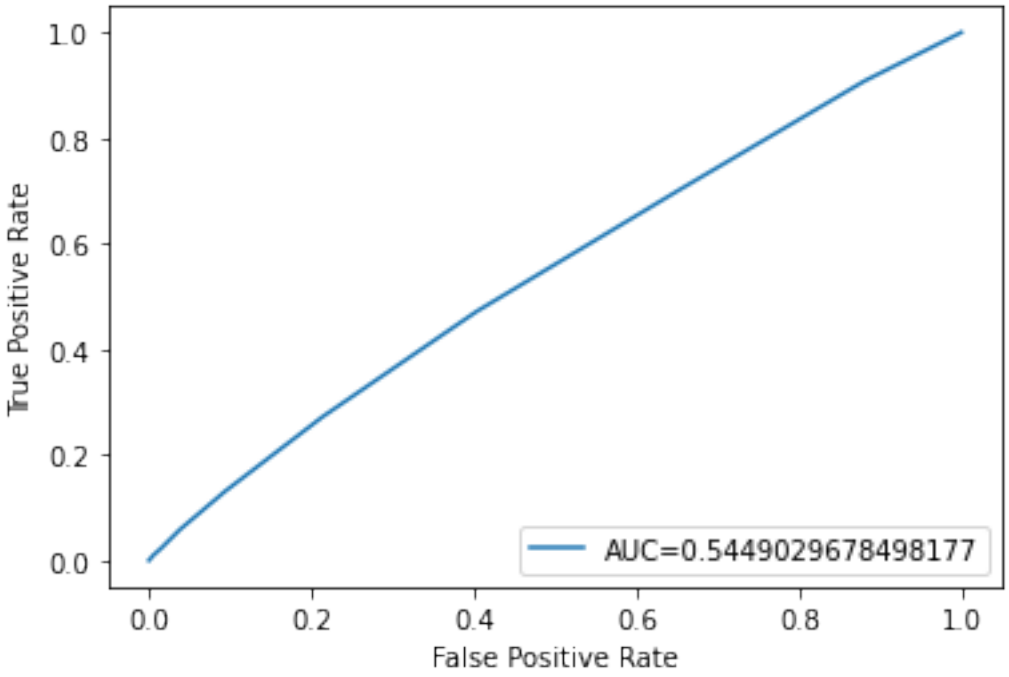
```
cm = confusion_matrix(actual, predicted)
plt.figure(figsize=(5,5))
sns.heatmap(data=cm,linewidths=.5, annot=True,square = True,  cmap =
'Greens')
plt.ylabel('Actual label')
plt.xlabel('Predicted label')
all_sample_title = 'Accuracy Score:
{:.2f}'.format(accuracy_score(actual,predicted)*100)
plt.title(all_sample_title, size = 15)
```

```
Text(0.5, 1.0, 'Accuracy Score: 88.79')
```



K-Nearest Neighbours

```
from sklearn.neighbors import KNeighborsClassifier

K = []
training = []
test = []
scores = {}

for k in range(2, 26):
    clf = KNeighborsClassifier(n_neighbors = k)
    clf.fit(X_train, y_train)

    training_score = clf.score(X_train, y_train)
    test_score = clf.score(X_test, y_test)
    K.append(k)

    training.append(training_score)
    test.append(test_score)
    scores[k] = [training_score, test_score]

#AUC
y_pred_proba = clf.predict_proba(X_test)[::,1]
fpr, tpr, _ = metrics.roc_curve(y_test,  y_pred_proba)
auc = metrics.roc_auc_score(y_test, y_pred_proba)

#create ROC curve
plt.plot(fpr,tpr,label="AUC="+str(auc))
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.legend(loc=4)
plt.show()
```




```
for keys, values in scores.items():
    print(keys, ':', values)
```

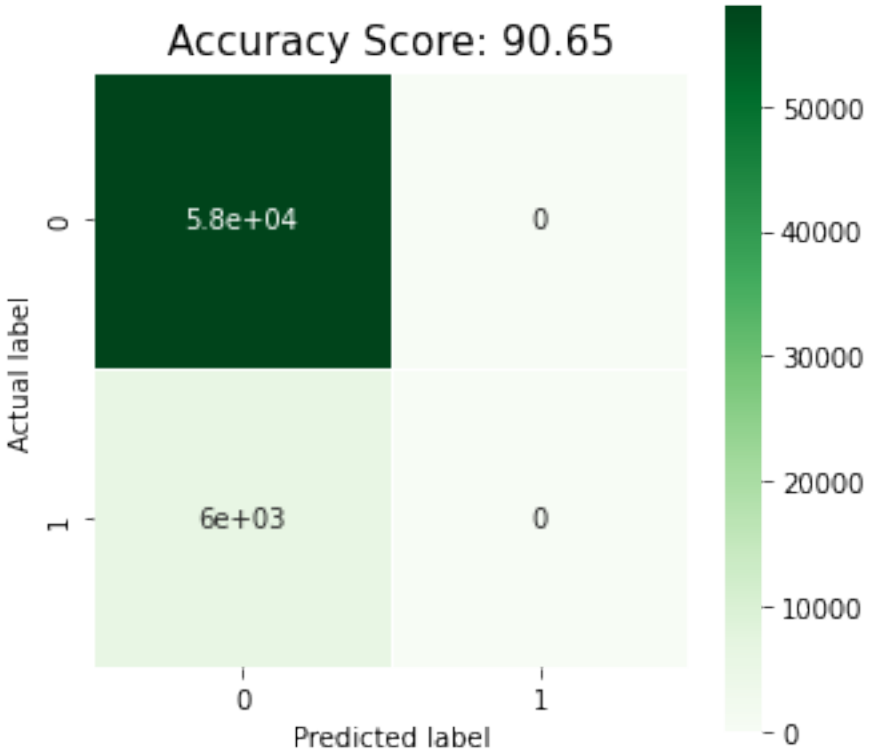
```
2 : [0.9068231210619303, 0.8979658843946904]
3 : [0.9007020122265826, 0.8838474647821261]
4 : [0.9068231210619303, 0.9032974249128348]
5 : [0.9052947982301162, 0.8989352553979894]
6 : [0.9068113947997937, 0.9057208524210822]
7 : [0.9066003220813333, 0.9042042558514048]
8 : [0.9068426648321581, 0.9060335527447271]
9 : [0.9068270298159758, 0.9055801372754421]
10 : [0.9068622086023859, 0.9063306180521897]
11 : [0.9068348473240669, 0.9060804577932738]
12 : [0.9068270298159758, 0.9064556981816476]
13 : [0.9068543910942948, 0.9063775231007364]
14 : [0.9068113947997937, 0.9064869682140121]
15 : [0.9067918510295658, 0.9064713331978299]
16 : [0.906807486045748, 0.9065182382463766]
17 : [0.9067996685376569, 0.9064713331978299]
18 : [0.9068153035538392, 0.9065182382463766]
19 : [0.9068113947997937, 0.9065026032301944]
20 : [0.9068153035538392, 0.9065182382463766]
21 : [0.906807486045748, 0.9065182382463766]
22 : [0.9068153035538392, 0.9065182382463766]
23 : [0.9068153035538392, 0.9065182382463766]
24 : [0.9068153035538392, 0.9065182382463766]
25 : [0.9068153035538392, 0.9065182382463766]
```

```
# confusion matrix in sklearn
from sklearn.metrics import confusion_matrix
from sklearn.metrics import classification_report
# actual values
actual = y_test
# predicted values
y_preds=clf.predict(X_test)
predicted = y_preds
# confusion matrix
matrix = confusion_matrix(actual,predicted, labels=[1,0])
print('Confusion matrix : \n',matrix)
# outcome values order in sklearn
tp, fn, fp, tn =
confusion_matrix(actual,predicted,labels=[1,0]).reshape(-1)
print('Outcome values : \n', tp, fn, fp, tn)
# classification report for precision, recall f1-score and accuracy
matrix =
classification_report(actual,predicted,labels=[1,0],zero_division=1)
print('Classification report : \n',matrix)
```

```
Confusion matrix :
 [[    0  5979]
 [    0 57980]]
Outcome values :
 0 5979 0 57980
Classification report :
              precision    recall  f1-score   support

           1       1.00      0.00      0.00      5979
           0       0.91      1.00      0.95     57980

    accuracy                           0.91     63959
   macro avg       0.95      0.50      0.48     63959
weighted avg       0.92      0.91      0.86     63959
```

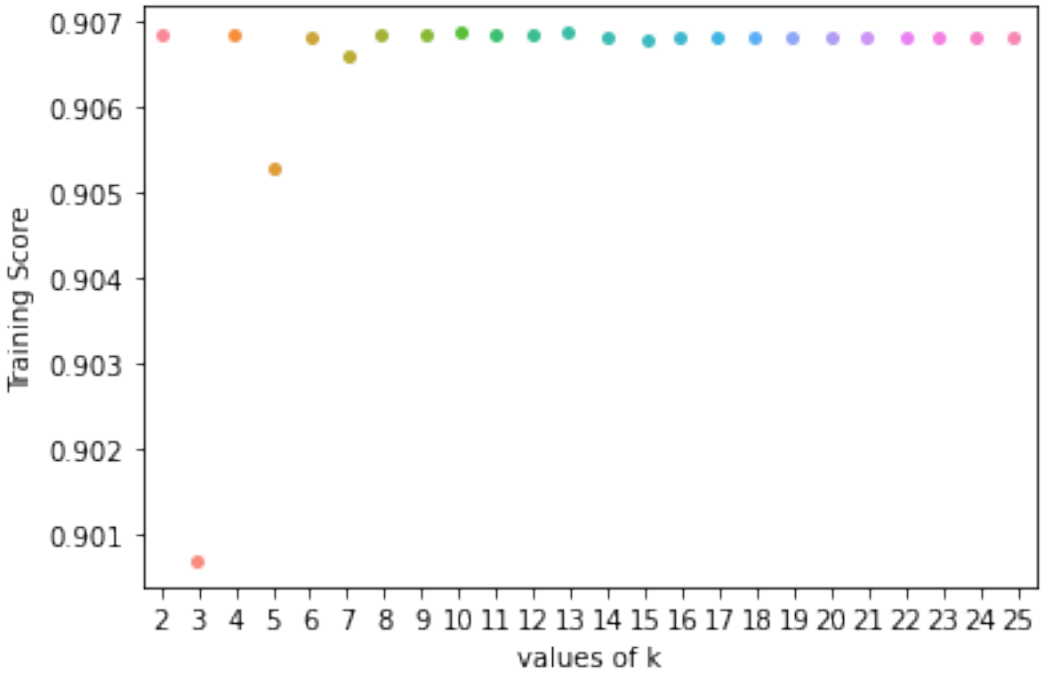
```
cm = confusion_matrix(actual, predicted)
plt.figure(figsize=(5,5))
sns.heatmap(data=cm,linewidths=.5, annot=True,square = True,  cmap =
'Greens')
plt.ylabel('Actual label')
plt.xlabel('Predicted label')
all_sample_title = 'Accuracy Score:
{:.2f}'.format(accuracy_score(actual,predicted)*100)
plt.title(all_sample_title, size = 15)
```

```
Text(0.5, 1.0, 'Accuracy Score: 90.65')
```



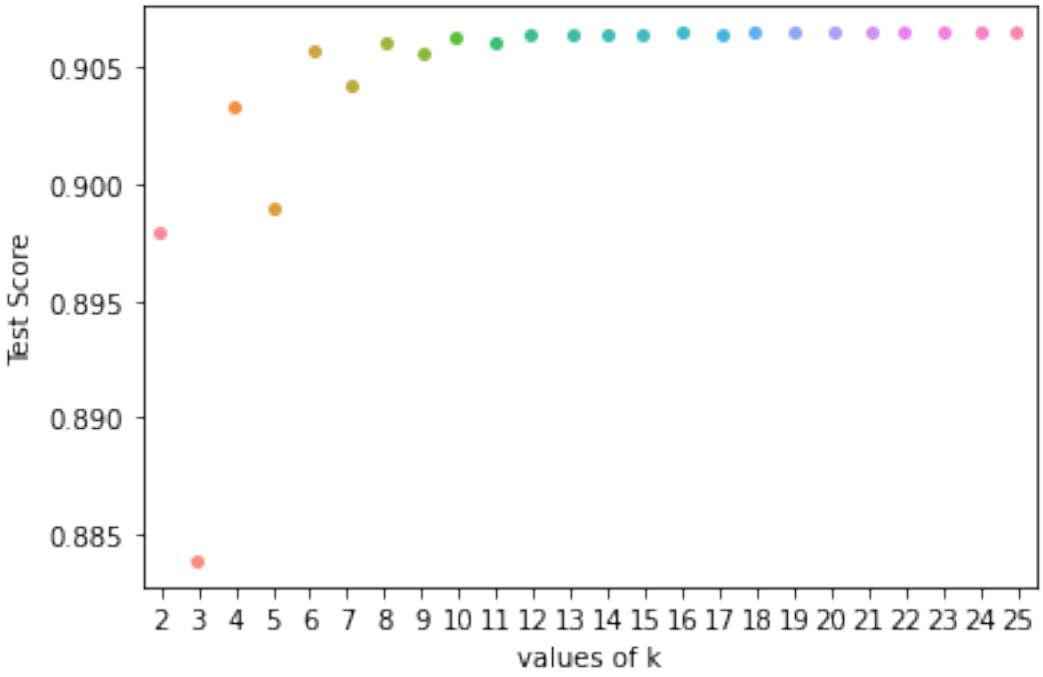

```
ax = sns.stripplot(K, training);
ax.set(xlabel ='values of k', ylabel ='Training Score')

plt.show()
```

```
/Users/joyanta/miniforge3/envs/tensorflow_3/lib/python3.8/site-
packages/seaborn/_decorators.py:36: FutureWarning: Pass the following
variables as keyword args: x, y. From version 0.12, the only valid
positional argument will be `data`, and passing other arguments
without an explicit keyword will result in an error or
misinterpretation.
  warnings.warn(
```

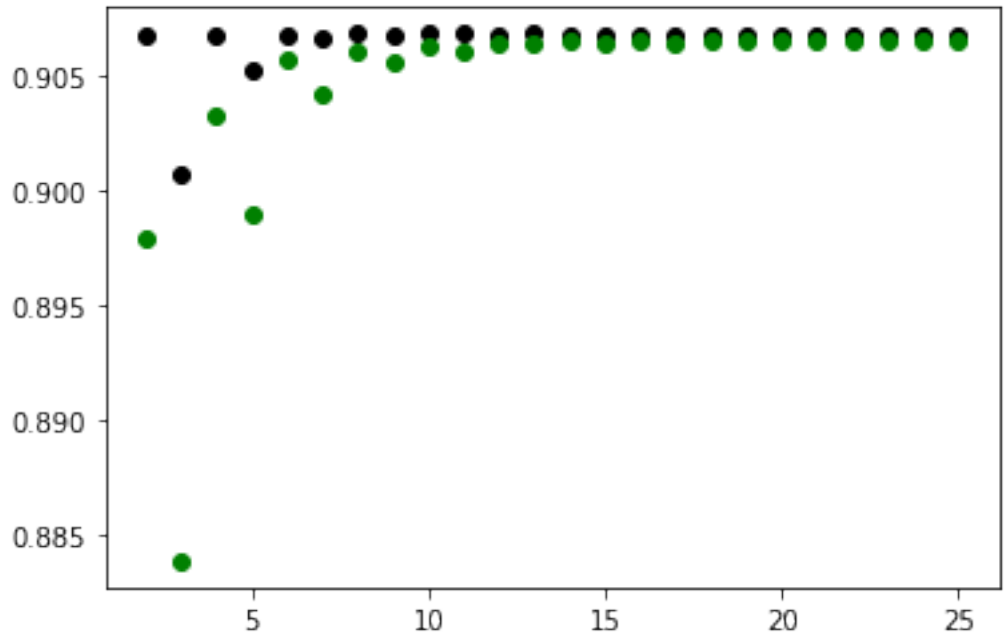



```
ax = sns.stripplot(K, test);
ax.set(xlabel ='values of k', ylabel ='Test Score')
plt.show()
```

```
/Users/joyanta/miniforge3/envs/tensorflow_3/lib/python3.8/site-
packages/seaborn/_decorators.py:36: FutureWarning: Pass the following
variables as keyword args: x, y. From version 0.12, the only valid
positional argument will be `data`, and passing other arguments
without an explicit keyword will result in an error or
misinterpretation.
  warnings.warn(
```




```
plt.scatter(K, training, color ='k')
plt.scatter(K, test, color ='g')
plt.show()
```



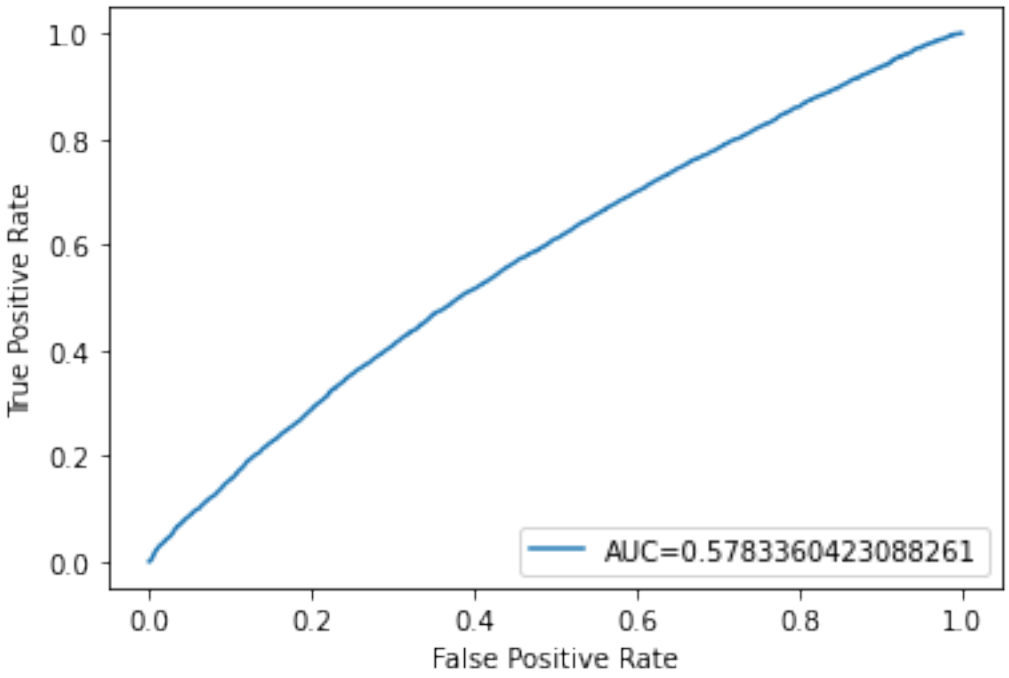
Naive Bayes

```
from sklearn.naive_bayes import GaussianNB
gnb = GaussianNB()
gnb.fit(X_train, y_train)
```

```
# making predictions on the testing set
y_pred = gnb.predict(X_test)

# comparing actual response values (y_test) with predicted response
values (y_pred)
from sklearn import metrics
print("Gaussian Naive Bayes model accuracy(in %):",
metrics.accuracy_score(y_test, y_pred)*100)
```

```
Gaussian Naive Bayes model accuracy(in %): 90.65182382463766
```

```
#AUC
y_pred_proba = gnb.predict_proba(X_test)[::,1]
fpr, tpr, _ = metrics.roc_curve(y_test,  y_pred_proba)
auc = metrics.roc_auc_score(y_test, y_pred_proba)

#create ROC curve
plt.plot(fpr,tpr,label="AUC="+str(auc))
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.legend(loc=4)
plt.show()
```



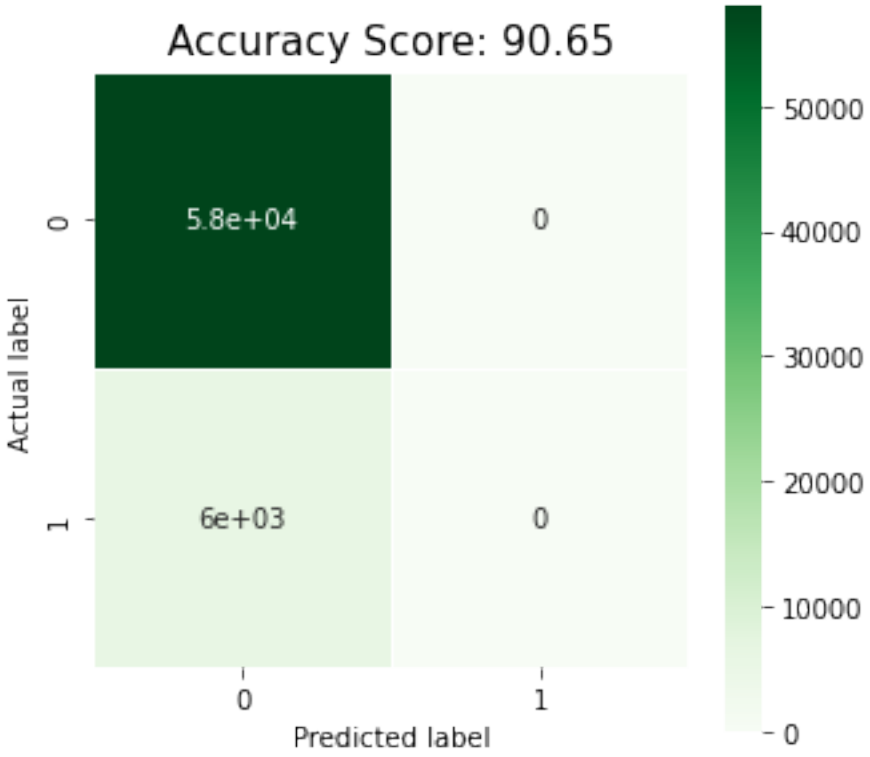

```
# confusion matrix in sklearn
from sklearn.metrics import confusion_matrix
from sklearn.metrics import classification_report
# actual values
actual = y_test
# predicted values
y_preds=gnb.predict(X_test)
```

```
predicted = y_preds
# confusion matrix
matrix = confusion_matrix(actual,predicted, labels=[1,0])
print('Confusion matrix : \n',matrix)
# outcome values order in sklearn
tp, fn, fp, tn =
confusion_matrix(actual,predicted,labels=[1,0]).reshape(-1)
print('Outcome values : \n', tp, fn, fp, tn)
# classification report for precision, recall f1-score and accuracy
matrix =
classification_report(actual,predicted,labels=[1,0],zero_division=1)
print('Classification report : \n',matrix)
```

```
Confusion matrix :
 [[    0  5979]
 [    0 57980]]
Outcome values :
 0 5979 0 57980
Classification report :
              precision    recall  f1-score   support

           1       1.00      0.00      0.00      5979
           0       0.91      1.00      0.95     57980

    accuracy                           0.91     63959
   macro avg       0.95      0.50      0.48     63959
weighted avg       0.92      0.91      0.86     63959
```

```
cm = confusion_matrix(actual, predicted)
plt.figure(figsize=(5,5))
sns.heatmap(data=cm,linewidths=.5, annot=True,square = True,  cmap =
'Greens')
plt.ylabel('Actual label')
plt.xlabel('Predicted label')
all_sample_title = 'Accuracy Score:
{:.2f}'.format(accuracy_score(actual,predicted)*100)
plt.title(all_sample_title, size = 15)
```

```
Text(0.5, 1.0, 'Accuracy Score: 90.65')
```



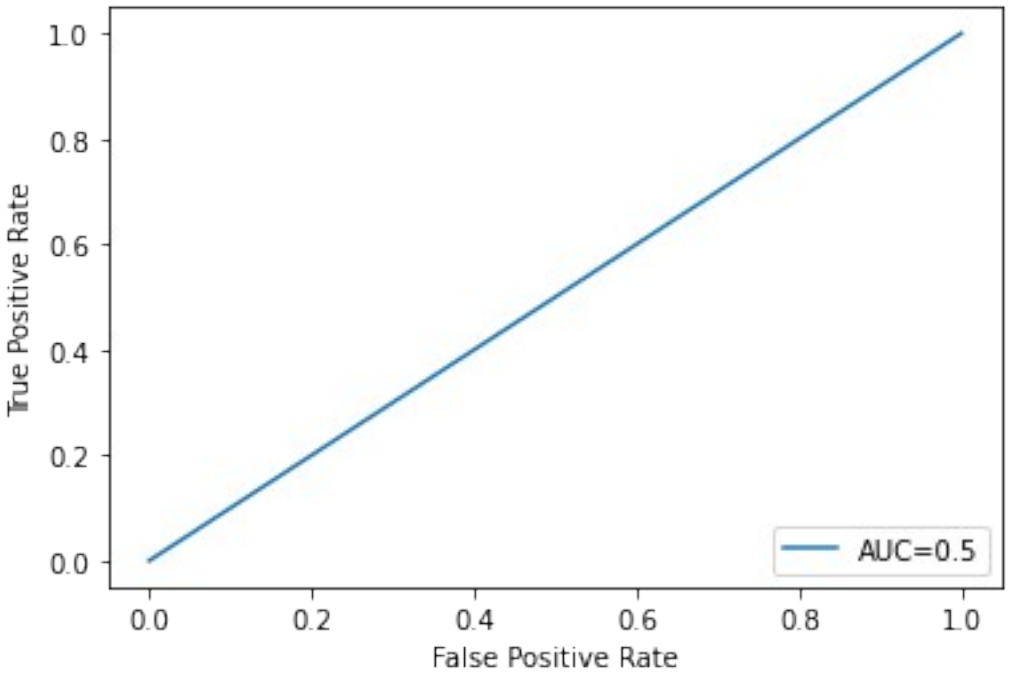
Support Vector Machine

```
# import support vector classifier
from sklearn.svm import SVC
from sklearn.svm import LinearSVC
# clf = SVC(kernel='linear') #it takes too much time to train up
clf = LinearSVC(random_state=42, tol=1e-5)
# fitting x samples and y classes
clf.fit(X_train, y_train)

y_pred = clf.predict(X_test)

print("SVM model accuracy(in %):", metrics.accuracy_score(y_test,
y_pred)*100)
```

```
SVM model accuracy(in %): 90.65182382463766

/Users/joyanta/miniforge3/envs/tensorflow_3/lib/python3.8/site-
packages/sklearn/svm/_base.py:1206: ConvergenceWarning: Liblinear
failed to converge, increase the number of iterations.
  warnings.warn(
```

```
#AUC
y_pred_proba = clf.predict(X_test)
fpr, tpr, _ = metrics.roc_curve(y_test,  y_pred_proba)
auc = metrics.roc_auc_score(y_test, y_pred_proba)

#create ROC curve
```

```
plt.plot(fpr,tpr,label="AUC="+str(auc))
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.legend(loc=4)
plt.show()
```




```
# confusion matrix in sklearn
from sklearn.metrics import confusion_matrix
from sklearn.metrics import classification_report
# actual values
actual = y_test
# predicted values
y_preds=clf.predict(X_test)
predicted = y_preds
# confusion matrix
matrix = confusion_matrix(actual,predicted, labels=[1,0])
print('Confusion matrix : \n',matrix)
# outcome values order in sklearn
tp, fn, fp, tn =
confusion_matrix(actual,predicted,labels=[1,0]).reshape(-1)
print('Outcome values : \n', tp, fn, fp, tn)
# classification report for precision, recall f1-score and accuracy
matrix =
classification_report(actual,predicted,labels=[1,0],zero_division=1)
print('Classification report : \n',matrix)
```

```
Confusion matrix :
 [[    0  5979]
 [    0 57980]]
```

```
Outcome values :
 0 5979 0 57980
Classification report :
               precision    recall  f1-score   support

           1       1.00      0.00      0.00      5979
           0       0.91      1.00      0.95     57980

    accuracy                           0.91     63959
   macro avg       0.95      0.50      0.48     63959
weighted avg       0.92      0.91      0.86     63959
```

```
cm = confusion_matrix(actual, predicted)
plt.figure(figsize=(5,5))
sns.heatmap(data=cm,linewidths=.5, annot=True,square = True,  cmap =
'Greens')
plt.ylabel('Actual label')
plt.xlabel('Predicted label')
all_sample_title = 'Accuracy Score:
{:.2f}'.format(accuracy_score(actual,predicted)*100)
plt.title(all_sample_title, size = 15)
```

```
Text(0.5, 1.0, 'Accuracy Score: 90.65')
```