---------- HR AND GSR ----------

In [1]:
```
import pydot
import pandas as pd
import numpy as np
import seaborn as sns
sns.set()
%matplotlib inline
import matplotlib
import matplotlib.pyplot as plt
# Ignore warnings
import warnings
warnings.filterwarnings('ignore')
import sklearn
from sklearn import metrics
from sklearn.svm import SVC
from sklearn.linear_model import LogisticRegression
from sklearn.ensemble import RandomForestClassifier
from sklearn.tree import export_graphviz, DecisionTreeClassifier
from sklearn.preprocessing import StandardScaler
from sklearn.model_selection import cross_val_score, train_test_split
from sklearn.exceptions import NotFittedError
import keras
from keras.models import Sequential
from keras.layers import Dense, Dropout
from keras import optimizers
from keras.wrappers.scikit_learn import KerasClassifier
from IPython.display import display
```

In [2]:
```
# Some useful functions we'll use in this notebook
def display_confusion_matrix(target, prediction, score=None):
    cm = metrics.confusion_matrix(target, prediction)
    plt.figure(figsize=(6,6))
    sns.heatmap(cm, annot=True, fmt=".4f", linewidths=.5, square=True, cmap='Blue
    plt.ylabel('Actual label')
    plt.xlabel('Predicted label')
    if score:
        score_title = 'Accuracy Score: {0}'.format(round(score, 5))
        plt.title(score_title, size = 25)

def visualize_tree(tree, feature_names):
    with open("dt.dot", 'w') as f:
        export_graphviz(tree, out_file=f, feature_names=feature_names)
    try:
        subprocess.check_call(["dot", "-Tpng", "dt.dot", "-o", "dt.png"])
    except:
        exit("Could not run dot, ie graphviz, to produce visualization")

def draw_missing_data_table(df):
    total = df.isnull().sum().sort_values(ascending=False)
    percent = (df.isnull().sum()/df.isnull().count()).sort_values(ascending=False
    missing_data = pd.concat([total, percent], axis=1, keys=['Total', 'Percent'])
    return missing_data
```

In [3]:
```
# Create dataframe for training dataset and print five first rows as preview
train_df_raw = pd.read_csv('hr_gsr.csv')
train_df_raw.head()
```

Out[3]:

	Condition	HR	RMSSD	SCL
0	0.0	61.0	0.061420	80.239727
1	0.0	61.0	0.061420	77.365127
2	0.0	64.0	0.049663	77.359559
3	0.0	60.0	0.052487	76.728772
4	0.0	61.0	0.051189	76.512877

In [4]:
```
train_df_raw=train_df_raw.dropna()
```

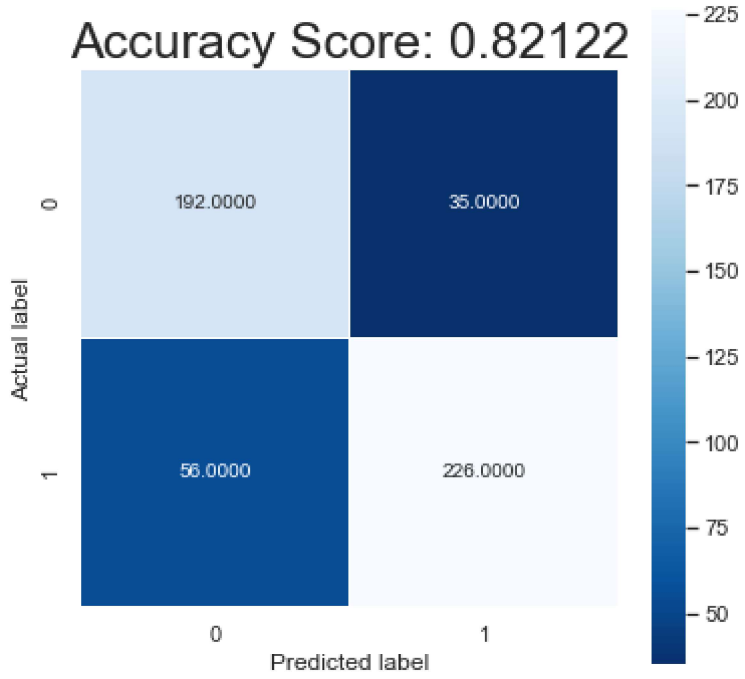
In [5]:
```
# Let's divide the train dataset in two datasets to evaluate perfomance of the mo
train_df = train_df_raw.copy()
X = train_df.drop(['Condition'], 1)
Y = train_df['Condition']
# We scale our data, it is essential for a smooth working of the models
# Scaling means that each columns as a 0 mean and a 1 variance
sc = StandardScaler()
X = pd.DataFrame(sc.fit_transform(X.values), index=X.index, columns=X.columns)
# Split dataset for model testing
X_train, X_test, Y_train, Y_test = train_test_split(X, Y, test_size=0.2, random_s
X_train.head()
```

Out[5]:

	HR	RMSSD	SCL
1653	1.315831	-0.950608	-0.511494
1782	-0.749653	-0.466227	0.049264
2752	-1.241434	-0.194360	-0.729176
814	0.233911	-0.721839	-0.387177
886	-1.241434	0.075152	0.470411

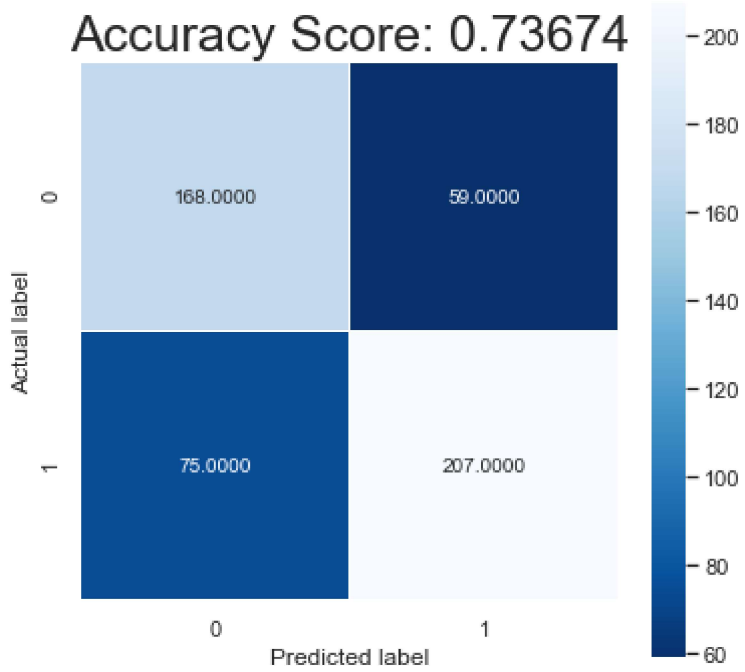
RANDOM FOREST

In [6]:
```
rf = RandomForestClassifier(n_estimators=200, random_state=42)
rf.fit(X_train, Y_train)
rf_prediction = rf.predict(X_test)
score = metrics.accuracy_score(Y_test, rf_prediction)
display_confusion_matrix(Y_test, rf_prediction, score=score)
rf_score=rf_prediction
```



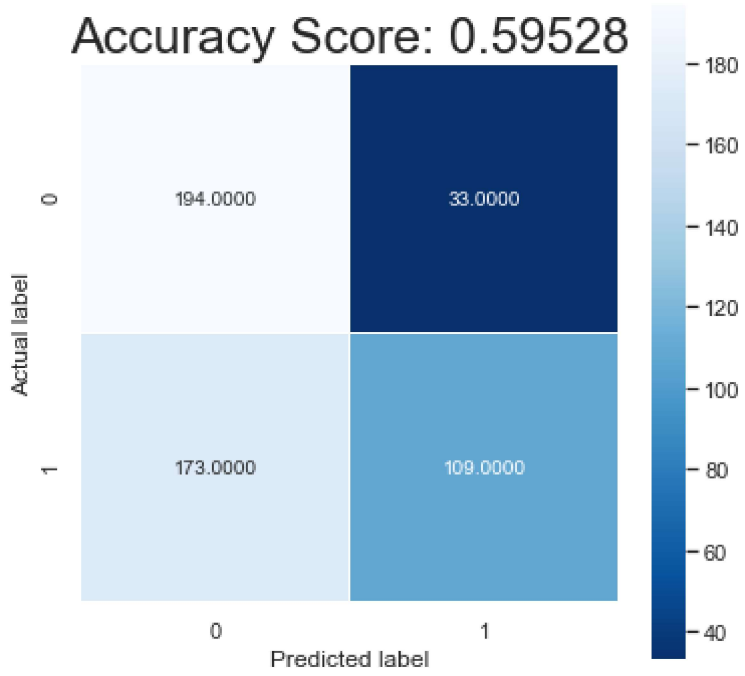
DECISION TREE

In [7]:
```
dt = DecisionTreeClassifier(min_samples_split=15, min_samples_leaf=20, random_sta
dt.fit(X_train, Y_train)
dt_prediction = dt.predict(X_test)

score = metrics.accuracy_score(Y_test, dt_prediction)
display_confusion_matrix(Y_test, dt_prediction, score=score)
```



SVM

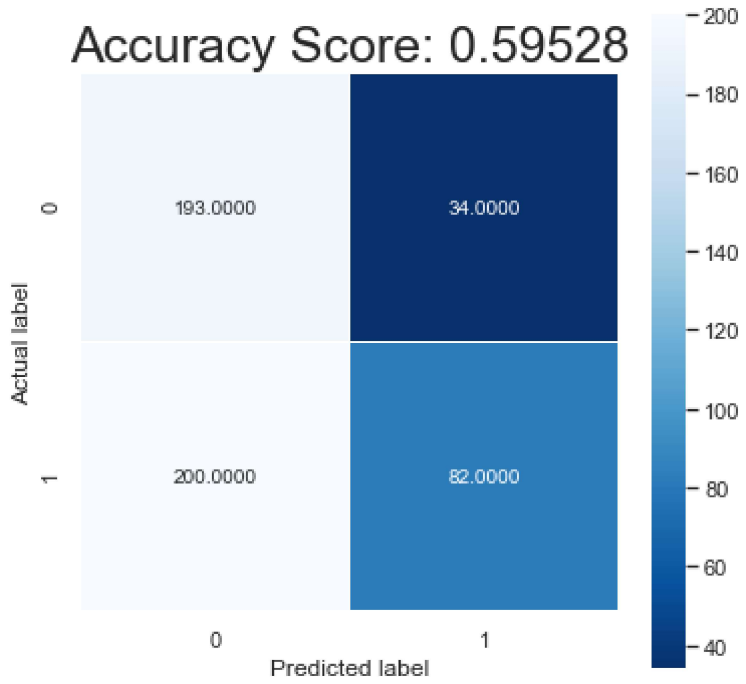
In [8]:
```
svm = SVC(gamma='auto', random_state=42)
svm.fit(X_train, Y_train)
svm_prediction = svm.predict(X_test)

score = metrics.accuracy_score(Y_test, svm_prediction)
display_confusion_matrix(Y_test, svm_prediction, score=score)
```



NAIVE BAYES

In [9]:
```
#train a Gaussian Naive Bayes classifier on the training set
from sklearn.naive_bayes import GaussianNB
# instantiate the model
gnb = GaussianNB()
# fit the model
gnb.fit(X_train, Y_train)
NB_y_pred = gnb.predict(X_test)
from sklearn.metrics import accuracy_score
y_pred_train = gnb.predict(X_train)
y_pred_train
# print the scores on training and test set
print('Training set score: {:.4f}'.format(gnb.score(X_train, Y_train)))
print('Test set score: {:.4f}'.format(gnb.score(X_test, Y_test)))
from sklearn.metrics import confusion_matrix

cm = confusion_matrix(Y_test, NB_y_pred)
display_confusion_matrix(Y_test, NB_y_pred, score=score)
```

```
Training set score: 0.6024
Test set score: 0.5403
```



K NEAREST NEIGHBORS

In [10]:
```
from sklearn.neighbors import KNeighborsClassifier
classifier = KNeighborsClassifier(n_neighbors=3)
classifier.fit(X_train, Y_train)
KNN_y_pred = classifier.predict(X_test)
from sklearn.metrics import classification_report, confusion_matrix
print(confusion_matrix(Y_test, KNN_y_pred))
print(classification_report(Y_test, KNN_y_pred))
```

```
[[172  55]
 [ 65 217]]
              precision    recall  f1-score   support

         0.0       0.73      0.76      0.74       227
         1.0       0.80      0.77      0.78       282

    accuracy                           0.76       509
   macro avg       0.76      0.76      0.76       509
weighted avg       0.77      0.76      0.76       509
```

In [11]:
```
print('********************* HR + GSR *********************')
print('SVM ---->',metrics.accuracy_score(Y_test, svm_prediction))
print('RF ---->',metrics.accuracy_score(Y_test, rf_prediction))
print('DT ---->',metrics.accuracy_score(Y_test, dt_prediction))
print('NB ---->',metrics.accuracy_score(Y_test, NB_y_pred))
print('KNN ---->',metrics.accuracy_score(Y_test, KNN_y_pred))
```

```
********************* HR + GSR *********************
SVM ----> 0.5952848722986247
RF ----> 0.8212180746561886
DT ----> 0.7367387033398821
NB ----> 0.5402750491159135
KNN ----> 0.7642436149312377
```

Confusion Matrix

As we can see from the table above:

True Positive(TP) : Values that the model predicted as yes, and is actually yes.

True Negative(TN) : Values that the model predicted as not, and is actually no.

False Positive(FP): Values that the model predicted as yes, but actually no.

False Negative(FN): Values that the model predicted as no, but actually yes.

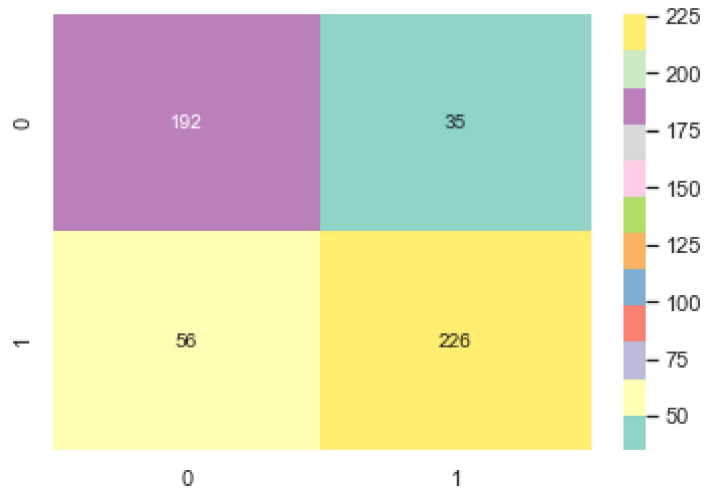
In [12]:
```
from sklearn.metrics import precision_score, recall_score, confusion_matrix, prec
cm = np.array(confusion_matrix(Y_test, rf_prediction, labels=[0,1]))
confusion_mat= pd.DataFrame(cm, index = ['NORMAL', 'STRESSED'],
                            columns =['NORMAL','STRESSED'])
confusion_mat
```

Out[12]:

	NORMAL	STRESSED
NORMAL	192	35
STRESSED	56	226

In [13]:
```
sns.heatmap(cm,annot=True,fmt='g',cmap='Set3')
```

Out[13]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x1a5821037f0>
```



Accuracy_Score

Accuracy_Score is the most intuitive performance measure and it is simply a ratio of correctly predicted observation to the total observations

In [14]:
```
from sklearn.metrics import accuracy_score
print(accuracy_score(Y_test, rf_prediction))
```

```
0.8212180746561886
```

Precision

Precision is the ratio of correctly predicted positive observations to the total predicted positive observations.

In [15]:
```
print(precision_score(Y_test, rf_prediction))
```

```
0.8659003831417624
```

Recall

Recall also called Sensitivity, is the ratio of positive instances that are correctly detected by the classifier to the all observations in actual class

In [16]:
```
print(recall_score(Y_test, rf_prediction))
```

```
0.8014184397163121
```

Classification Report

In [17]:
```
from sklearn.metrics import classification_report
print(classification_report(Y_test, rf_prediction))
```

```
              precision    recall  f1-score   support

         0.0       0.77      0.85      0.81       227
         1.0       0.87      0.80      0.83       282

    accuracy                           0.82       509
   macro avg       0.82      0.82      0.82       509
weighted avg       0.83      0.82      0.82       509
```

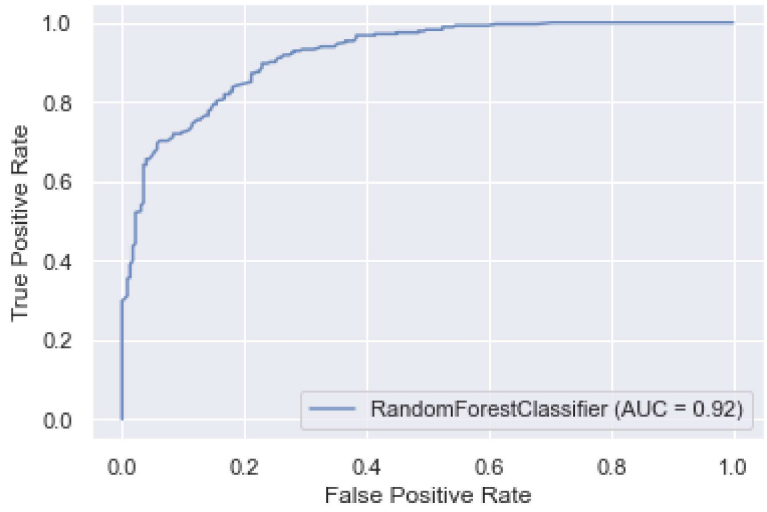
The ROC Curve

Area Under Curve

Area Under Curve is a common way to compare classifiers. A perfect classifier will have ROC AUC equal to 1

Sckit-Learn provides a function to compute the ROC AUC.

In [18]:
```
from sklearn.metrics import roc_auc_score,auc,f1_score
from sklearn.metrics import plot_roc_curve
ax = plt.gca()
rfc_disp = plot_roc_curve(rf, X_test, Y_test, ax=ax, alpha=0.8)
plt.show()
```



K FOLD VALIDATION

In [19]:
```
cv_score_rf1 = cross_val_score(estimator=rf, X=X_train, y=Y_train, cv=5, n_jobs=
cv_score_rf2 = cross_val_score(estimator=rf, X=X_train, y=Y_train, cv=10, n_jobs=
cv_score_rf3 = cross_val_score(estimator=rf, X=X_train, y=Y_train, cv=20, n_jobs=
cv_score_rf4 = cross_val_score(estimator=rf, X=X_train, y=Y_train, cv=50, n_jobs=
```

In [20]:
```
cv_result = { 'rf5': cv_score_rf1, 'rf10': cv_score_rf2, 'rf20': cv_score_rf3, 'r
cv_data = {model: [score.mean(), score.std()] for model, score in cv_result.items
cv_df = pd.DataFrame(cv_data, index=['Mean_accuracy', 'Variance'])
cv_df
```

Out[20]:

	rf5	rf10	rf20	rf50
Mean_accuracy	0.817902	0.824290	0.828194	0.819280
Variance	0.017638	0.019495	0.030666	0.061164

---------- GSR AND FACIAL IMAGE

DATA----------

In [21]:
```
# Create dataframe for training dataset and print five first rows as preview
train_df_raw = pd.read_csv('face_gsr.csv')
train_df_raw.head()
```

Out[21]:

	Condition	SCL	Unnamed: 2	Unnamed: 3	Unnamed: 4	Unnamed: 5	Unnamed: 6	Unnamed: 7	Unna
0	0.0	80.239727	0.968862	0.023946	-6.954147	-5.818151	-0.584952	0.0	0.0(
1	0.0	77.365127	0.884570	0.076952	-10.564172	-6.567912	-3.906502	0.0	0.02
2	0.0	77.359559	0.931965	0.031468	-10.721106	-7.055848	-2.452367	0.0	0.0(
3	0.0	76.728772	0.806947	0.105516	-10.782755	-5.616126	-4.669924	0.0	0.11
4	0.0	76.512877	0.951412	0.028358	-3.880091	-4.621940	-5.893645	0.0	0.03

5 rows × 24 columns

In [22]:
```
train_df_raw=train_df_raw.dropna()
```

In [23]:
```
# Let's divide the train dataset in two datasets to evaluate perfomance of the mo
train_df = train_df_raw.copy()
X = train_df.drop(['Condition'], 1)
Y = train_df['Condition']
# We scale our data, it is essential for a smooth working of the models
# Scaling means that each columns as a 0 mean and a 1 variance
sc = StandardScaler()
X = pd.DataFrame(sc.fit_transform(X.values), index=X.index, columns=X.columns)
# Split dataset for model testing
X_train, X_test, Y_train, Y_test = train_test_split(X, Y, test_size=0.2, random_s
X_train.head()
```

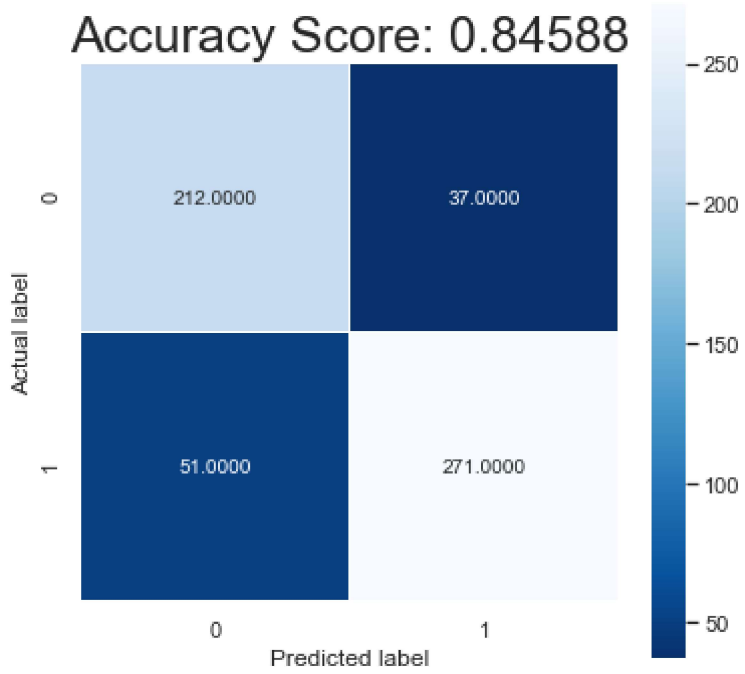
Out[23]:

	SCL	Unnamed: 2	Unnamed: 3	Unnamed: 4	Unnamed: 5	Unnamed: 6	Unnamed: 7	Unnamed: 8	U
1024	4.127854	0.913940	-0.414424	-1.725315	0.351406	0.601406	-0.627610	-0.669271	-(
673	-0.642822	-0.226861	-0.465262	-0.026317	-0.266536	-0.546780	-0.627610	-0.570223	:
773	-0.413888	0.589678	-0.063831	1.194307	-0.388965	-1.504441	-0.047468	0.599167	-(
2357	-0.463399	-0.935954	-0.132913	-0.813533	-0.405610	-0.186839	1.172464	-0.058425	-(
868	-0.335572	0.280199	1.172927	1.388406	-1.358499	-1.317352	1.518383	-0.219520	-(

5 rows × 23 columns

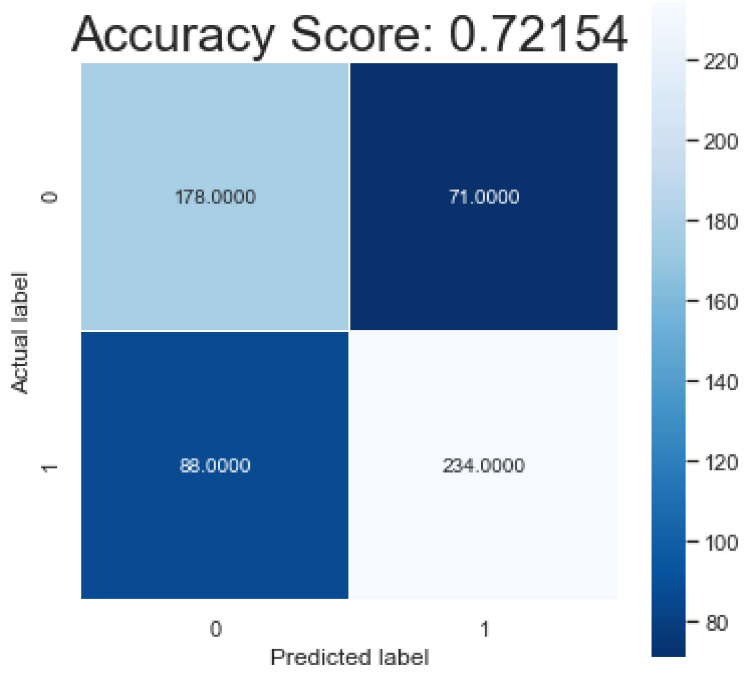
RANDOM FOREST

In [24]:
```
rf = RandomForestClassifier(n_estimators=200, random_state=42)
rf.fit(X_train, Y_train)
rf_prediction = rf.predict(X_test)
score = metrics.accuracy_score(Y_test, rf_prediction)
display_confusion_matrix(Y_test, rf_prediction, score=score)
rf_score=rf_prediction
```



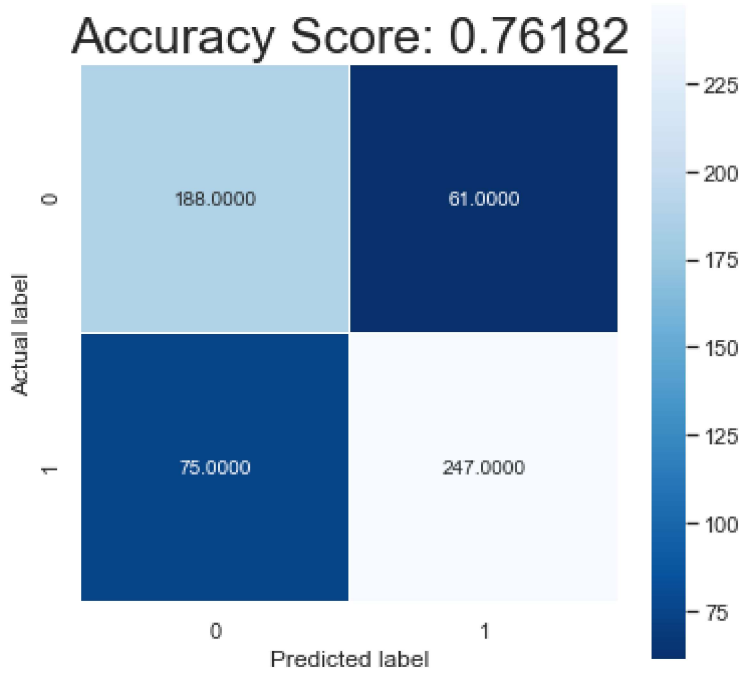
DECISION TREE

In [25]:
```
dt = DecisionTreeClassifier(min_samples_split=15, min_samples_leaf=20, random_sta
dt.fit(X_train, Y_train)
dt_prediction = dt.predict(X_test)

score = metrics.accuracy_score(Y_test, dt_prediction)
display_confusion_matrix(Y_test, dt_prediction, score=score)
```



SVM

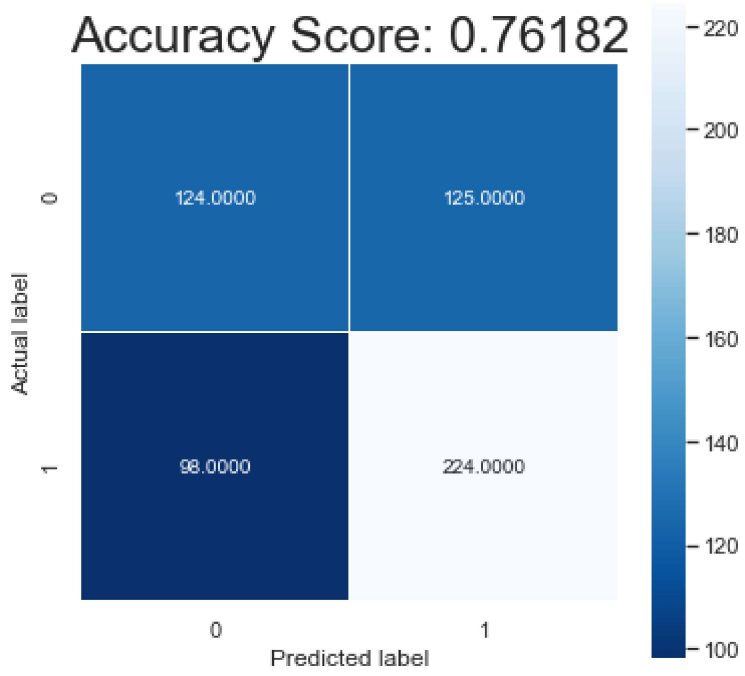
In [26]:
```
svm = SVC(gamma='auto', random_state=42)
svm.fit(X_train, Y_train)
svm_prediction = svm.predict(X_test)

score = metrics.accuracy_score(Y_test, svm_prediction)
display_confusion_matrix(Y_test, svm_prediction, score=score)
```



NAIVE BAYES

In [27]:
```
#train a Gaussian Naive Bayes classifier on the training set
from sklearn.naive_bayes import GaussianNB
# instantiate the model
gnb = GaussianNB()
# fit the model
gnb.fit(X_train, Y_train)
NB_y_pred = gnb.predict(X_test)
from sklearn.metrics import accuracy_score
y_pred_train = gnb.predict(X_train)
y_pred_train
# print the scores on training and test set
print('Training set score: {:.4f}'.format(gnb.score(X_train, Y_train)))
print('Test set score: {:.4f}'.format(gnb.score(X_test, Y_test)))
from sklearn.metrics import confusion_matrix

cm = confusion_matrix(Y_test, NB_y_pred)
display_confusion_matrix(Y_test, NB_y_pred, score=score)
```

```
Training set score: 0.6145
Test set score: 0.6095
```



K NEAREST NEIGHBORS

In [28]:
```
from sklearn.neighbors import KNeighborsClassifier
classifier = KNeighborsClassifier(n_neighbors=3)
classifier.fit(X_train, Y_train)
KNN_y_pred = classifier.predict(X_test)
from sklearn.metrics import classification_report, confusion_matrix
print(confusion_matrix(Y_test, KNN_y_pred))
print(classification_report(Y_test, KNN_y_pred))
```

```
[[177  72]
 [ 58 264]]
              precision    recall  f1-score   support

         0.0       0.75      0.71      0.73       249
         1.0       0.79      0.82      0.80       322

    accuracy                           0.77       571
   macro avg       0.77      0.77      0.77       571
weighted avg       0.77      0.77      0.77       571
```

In [29]:
```
print('********************* GSR + FACIAL IMAGE DATA *********************')
print('SVM ---->',metrics.accuracy_score(Y_test, svm_prediction))
print('RF ---->',metrics.accuracy_score(Y_test, rf_prediction))
print('DT ---->',metrics.accuracy_score(Y_test, dt_prediction))
print('NB ---->',metrics.accuracy_score(Y_test, NB_y_pred))
print('KNN ---->',metrics.accuracy_score(Y_test, KNN_y_pred))
```

```
******************** GSR + FACIAL IMAGE DATA ********************
SVM ----> 0.7618213660245184
RF ----> 0.8458844133099825
DT ----> 0.7215411558669002
NB ----> 0.6094570928196147
KNN ----> 0.7723292469352014
```

Confusion Matrix

In [30]:
```
from sklearn.metrics import precision_score, recall_score, confusion_matrix, prec
cm = np.array(confusion_matrix(Y_test, rf_prediction, labels=[0,1]))
confusion_mat= pd.DataFrame(cm, index = ['NORMAL', 'STRESSED'],
                            columns =['NORMAL','STRESSED'])
confusion_mat
```

Out[30]:

	NORMAL	STRESSED
NORMAL	212	37
STRESSED	51	271

In [31]:
```
sns.heatmap(cm,annot=True,fmt='g',cmap='Set3')
```

Out[31]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x1a5fff67190>
```

Accuracy_Score

In [32]:
```
from sklearn.metrics import accuracy_score
print(accuracy_score(Y_test, rf_prediction))
```

```
0.8458844133099825
```

Precision

In [33]:
```
print(precision_score(Y_test, rf_prediction))
```

```
0.8798701298701299
```

Recall

In [34]:
```
print(recall_score(Y_test, rf_prediction))
```

```
0.8416149068322981
```

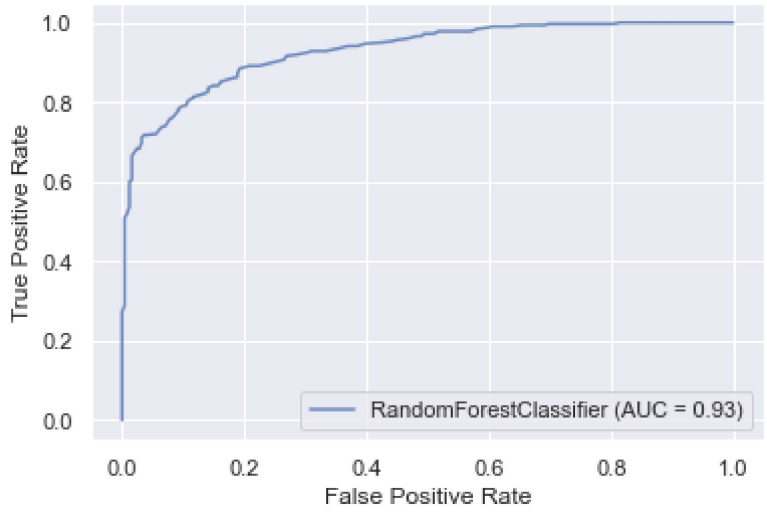
Classification Report

In [35]:
```
from sklearn.metrics import classification_report
print(classification_report(Y_test, rf_prediction))
```

```
              precision    recall  f1-score   support

         0.0       0.81      0.85      0.83       249
         1.0       0.88      0.84      0.86       322

    accuracy                           0.85       571
   macro avg       0.84      0.85      0.84       571
weighted avg       0.85      0.85      0.85       571
```

Area Under Curve

In [36]:
```
from sklearn.metrics import roc_auc_score,auc,f1_score
from sklearn.metrics import plot_roc_curve
ax = plt.gca()
rfc_disp = plot_roc_curve(rf, X_test, Y_test, ax=ax, alpha=0.8)
plt.show()
```



K FOLD VALIDATION

In [37]:
```
cv_score_rf1 = cross_val_score(estimator=rf, X=X_train, y=Y_train, cv=5, n_jobs=-
cv_score_rf2 = cross_val_score(estimator=rf, X=X_train, y=Y_train, cv=10, n_jobs=
cv_score_rf3 = cross_val_score(estimator=rf, X=X_train, y=Y_train, cv=20, n_jobs=
cv_score_rf4 = cross_val_score(estimator=rf, X=X_train, y=Y_train, cv=50, n_jobs=
```

In [38]:
```
cv_result = { 'rf5': cv_score_rf1, 'rf10': cv_score_rf2, 'rf20': cv_score_rf3, 'r
cv_data = {model: [score.mean(), score.std()] for model, score in cv_result.items
cv_df = pd.DataFrame(cv_data, index=['Mean_accuracy', 'Variance'])
cv_df
```

Out[38]:

	rf5	rf10	rf20	rf50
Mean_accuracy	0.837719	0.842544	0.840789	0.842957
Variance	0.012862	0.020984	0.029261	0.054493

----------HR AND FACE ----------

In [39]:
```
# Create dataframe for training dataset and print five first rows as preview
train_df_raw = pd.read_csv('face_hr.csv')
train_df_raw.head()
```

Out[39]:

	Condition	HR	RMSSD	Unnamed: 3	Unnamed: 4	Unnamed: 5	Unnamed: 6	Unnamed: 7	Unnamed: 8
0	0.0	61.0	0.061420	0.968862	0.023946	-6.954147	-5.818151	-0.584952	0.0
1	0.0	61.0	0.061420	0.884570	0.076952	-10.564172	-6.567912	-3.906502	0.0
2	0.0	64.0	0.049663	0.931965	0.031468	-10.721106	-7.055848	-2.452367	0.0
3	0.0	60.0	0.052487	0.806947	0.105516	-10.782755	-5.616126	-4.669924	0.0
4	0.0	61.0	0.051189	0.951412	0.028358	-3.880091	-4.621940	-5.893645	0.0

5 rows × 25 columns

In [40]:
```
train_df_raw=train_df_raw.dropna()
```

In [41]:
```
# Let's divide the train dataset in two datasets to evaluate perfomance of the mo
train_df = train_df_raw.copy()
X = train_df.drop(['Condition'], 1)
Y = train_df['Condition']
# We scale our data, it is essential for a smooth working of the models
# Scaling means that each columns as a 0 mean and a 1 variance
sc = StandardScaler()
X = pd.DataFrame(sc.fit_transform(X.values), index=X.index, columns=X.columns)
# Split dataset for model testing
X_train, X_test, Y_train, Y_test = train_test_split(X, Y, test_size=0.2, random_s
X_train.head()
```

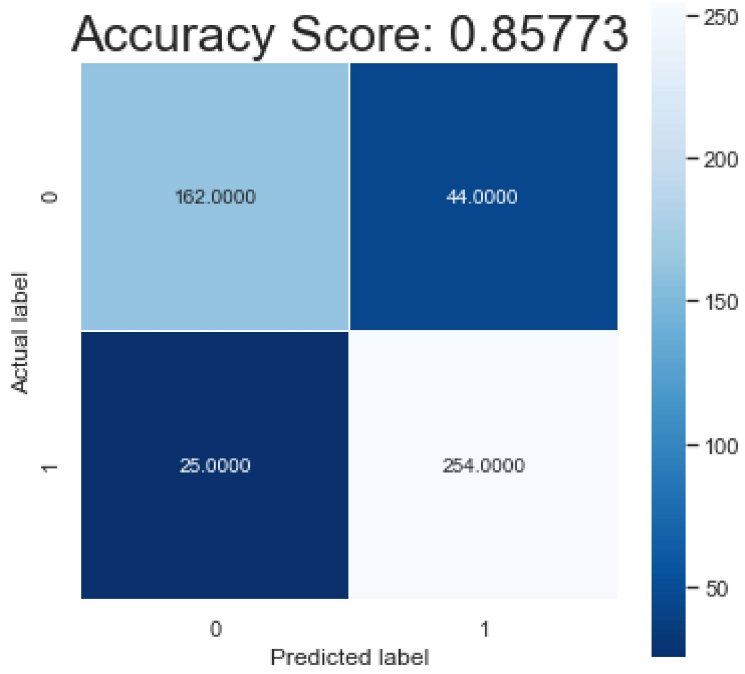
Out[41]:

	HR	RMSSD	Unnamed: 3	Unnamed: 4	Unnamed: 5	Unnamed: 6	Unnamed: 7	Unnamed: 8	Un
902	-0.374209	-0.531364	0.235220	-0.446981	0.887911	0.312497	0.718565	-0.452580	-0
327	-1.155800	0.952047	-2.640218	6.057871	1.454941	-0.250884	-0.251917	-0.338512	1
1675	1.091272	-0.350915	-0.103455	-0.513293	0.764261	0.563786	0.083545	-0.593063	1
2085	-0.081113	-0.977440	-0.100863	-0.534673	-0.651750	0.520750	-0.238795	1.859607	-0
2067	0.016586	-0.806410	-0.177677	-0.147487	-1.965639	-0.074883	-0.716510	-0.593063	-0

5 rows × 24 columns

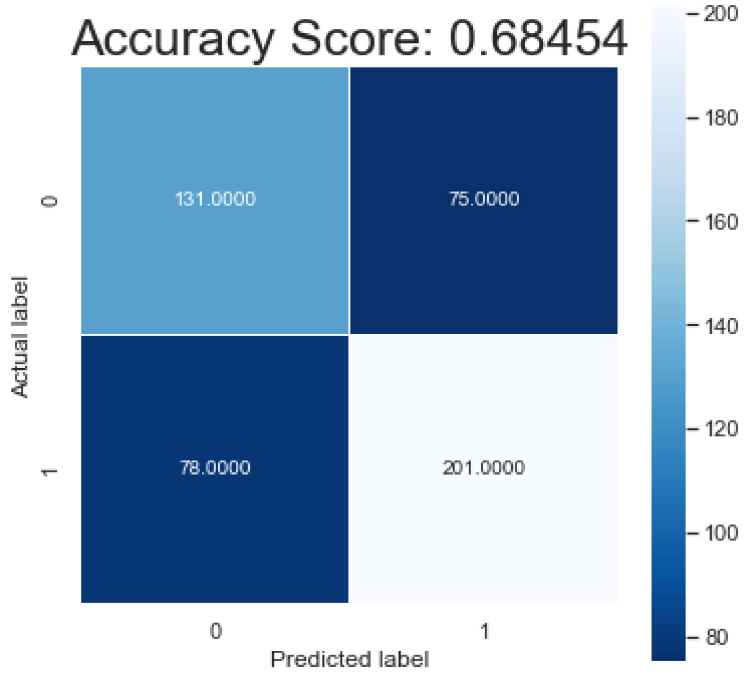
RANDOM FOREST

In [42]:
```
rf = RandomForestClassifier(n_estimators=200, random_state=42)
rf.fit(X_train, Y_train)
rf_prediction = rf.predict(X_test)
score = metrics.accuracy_score(Y_test, rf_prediction)
display_confusion_matrix(Y_test, rf_prediction, score=score)
rf_score=rf_prediction
```



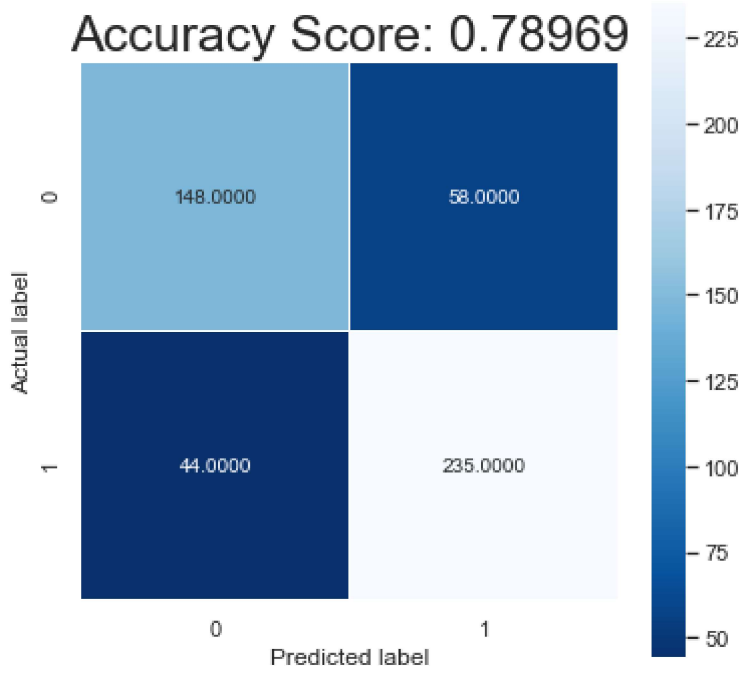
DECISION TREE

In [43]:
```
dt = DecisionTreeClassifier(min_samples_split=15, min_samples_leaf=20, random_sta
dt.fit(X_train, Y_train)
dt_prediction = dt.predict(X_test)

score = metrics.accuracy_score(Y_test, dt_prediction)
display_confusion_matrix(Y_test, dt_prediction, score=score)
```



SVM

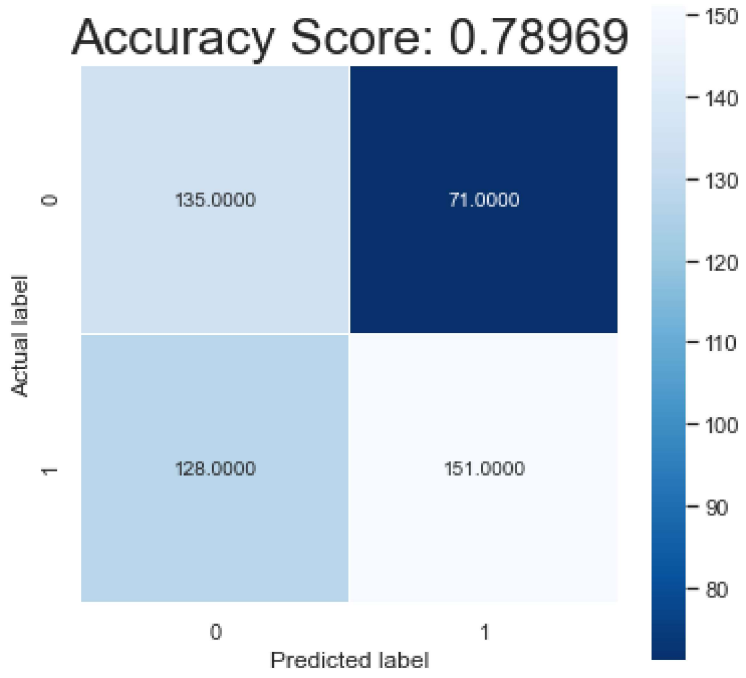
In [44]:
```
svm = SVC(gamma='auto', random_state=42)
svm.fit(X_train, Y_train)
svm_prediction = svm.predict(X_test)

score = metrics.accuracy_score(Y_test, svm_prediction)
display_confusion_matrix(Y_test, svm_prediction, score=score)
```



NAIVE BAYES

In [45]:
```
#train a Gaussian Naive Bayes classifier on the training set
from sklearn.naive_bayes import GaussianNB
# instantiate the model
gnb = GaussianNB()
# fit the model
gnb.fit(X_train, Y_train)
NB_y_pred = gnb.predict(X_test)
from sklearn.metrics import accuracy_score
y_pred_train = gnb.predict(X_train)
y_pred_train
# print the scores on training and test set
print('Training set score: {:.4f}'.format(gnb.score(X_train, Y_train)))
print('Test set score: {:.4f}'.format(gnb.score(X_test, Y_test)))
from sklearn.metrics import confusion_matrix

cm = confusion_matrix(Y_test, NB_y_pred)
display_confusion_matrix(Y_test, NB_y_pred, score=score)
```

```
Training set score: 0.6281
Test set score: 0.5897
```



K NEAREST NEIGHBORS

In [46]:
```
from sklearn.neighbors import KNeighborsClassifier
classifier = KNeighborsClassifier(n_neighbors=3)
classifier.fit(X_train, Y_train)
KNN_y_pred = classifier.predict(X_test)
from sklearn.metrics import classification_report, confusion_matrix
print(confusion_matrix(Y_test, KNN_y_pred))
print(classification_report(Y_test, KNN_y_pred))
```

```
[[156  50]
 [ 38 241]]
              precision    recall  f1-score   support

         0.0       0.80      0.76      0.78       206
         1.0       0.83      0.86      0.85       279

    accuracy                           0.82       485
   macro avg       0.82      0.81      0.81       485
weighted avg       0.82      0.82      0.82       485
```

In [47]:
```
print('********************** HR + FACIAL IMAGE DATA **********************')
print('SVM ---->',metrics.accuracy_score(Y_test, svm_prediction))
print('RF ---->',metrics.accuracy_score(Y_test, rf_prediction))
print('DT ---->',metrics.accuracy_score(Y_test, dt_prediction))
print('NB ---->',metrics.accuracy_score(Y_test, NB_y_pred))
print('KNN ---->',metrics.accuracy_score(Y_test, KNN_y_pred))
```

```
********************** HR + FACIAL IMAGE DATA **********************
SVM ----> 0.7896907216494845
RF ----> 0.8577319587628865
DT ----> 0.6845360824742268
NB ----> 0.5896907216494846
KNN ----> 0.8185567010309278
```

Confusion Matrix

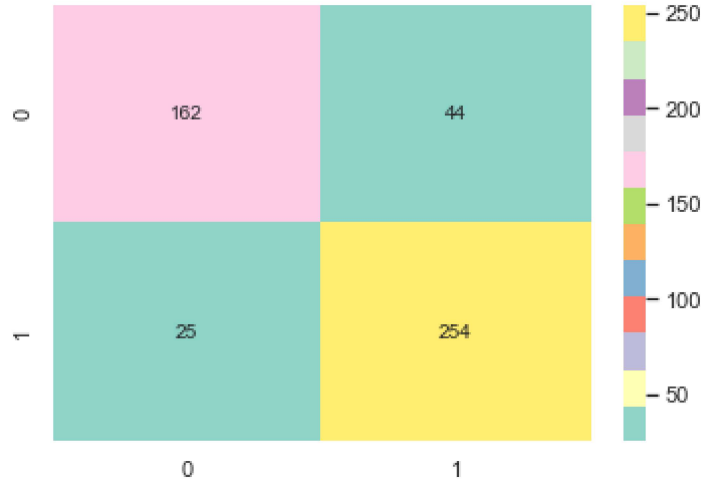
In [48]:
```
from sklearn.metrics import precision_score, recall_score, confusion_matrix, prec
cm = np.array(confusion_matrix(Y_test, rf_prediction, labels=[0,1]))
confusion_mat= pd.DataFrame(cm, index = ['NORMAL', 'STRESSED'],
                            columns =['NORMAL','STRESSED'])
confusion_mat
```

Out[48]:

	NORMAL	STRESSED
NORMAL	162	44
STRESSED	25	254

In [49]:
```
sns.heatmap(cm,annot=True,fmt='g',cmap='Set3')
```

Out[49]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x1a583580b50>
```



Accuracy_Score

In [50]:
```
from sklearn.metrics import accuracy_score
print(accuracy_score(Y_test, rf_prediction))
```

```
0.8577319587628865
```

Precision

In [51]:
```
print(precision_score(Y_test, rf_prediction))
```

```
0.8523489932885906
```

Recall

In [52]:
```
print(recall_score(Y_test, rf_prediction))
```

```
0.910394265232975
```

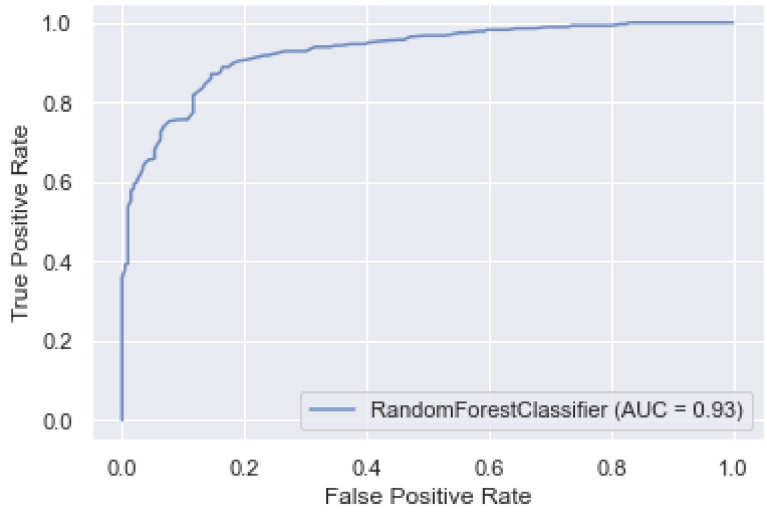
Classification Report

In [53]:
```
from sklearn.metrics import classification_report
print(classification_report(Y_test, rf_prediction))
```

```
              precision    recall  f1-score   support

         0.0       0.87      0.79      0.82       206
         1.0       0.85      0.91      0.88       279

    accuracy                           0.86       485
   macro avg       0.86      0.85      0.85       485
weighted avg       0.86      0.86      0.86       485
```

Area Under Curve

In [54]:
```
from sklearn.metrics import roc_auc_score,auc,f1_score
from sklearn.metrics import plot_roc_curve
ax = plt.gca()
rfc_disp = plot_roc_curve(rf, X_test, Y_test, ax=ax, alpha=0.8)
plt.show()
```



K FOLD VALIDATION

In [55]:
```
cv_score_rf1 = cross_val_score(estimator=rf, X=X_train, y=Y_train, cv=5, n_jobs=-
cv_score_rf2 = cross_val_score(estimator=rf, X=X_train, y=Y_train, cv=10, n_jobs=
cv_score_rf3 = cross_val_score(estimator=rf, X=X_train, y=Y_train, cv=20, n_jobs=
cv_score_rf4 = cross_val_score(estimator=rf, X=X_train, y=Y_train, cv=50, n_jobs=
```

In [56]:
```
cv_result = { 'rf5': cv_score_rf1, 'rf10': cv_score_rf2, 'rf20': cv_score_rf3, 'r
cv_data = {model: [score.mean(), score.std()] for model, score in cv_result.items
cv_df = pd.DataFrame(cv_data, index=['Mean_accuracy', 'Variance'])
cv_df
```

Out[56]:

	rf5	rf10	rf20	rf50
Mean_accuracy	0.808872	0.832090	0.818073	0.822686
Variance	0.022793	0.022946	0.051337	0.064534

----------HR GSR AND FACIAL IMAGE DATA----------

In [57]:
```
# Create dataframe for training dataset and print five first rows as preview
train_df_raw = pd.read_csv('face_phy.csv')
train_df_raw.head()
```

Out[57]:

	Condition	HR	RMSSD	SCL	Unnamed: 4	Unnamed: 5	Unnamed: 6	Unnamed: 7	Unnamed: 8
0	0.0	61.0	0.061420	80.239727	0.968862	0.023946	-6.954147	-5.818151	-0.584952
1	0.0	61.0	0.061420	77.365127	0.884570	0.076952	-10.564172	-6.567912	-3.906502
2	0.0	64.0	0.049663	77.359559	0.931965	0.031468	-10.721106	-7.055848	-2.452367
3	0.0	60.0	0.052487	76.728772	0.806947	0.105516	-10.782755	-5.616126	-4.669924
4	0.0	61.0	0.051189	76.512877	0.951412	0.028358	-3.880091	-4.621940	-5.893645

5 rows × 26 columns

In [58]:
```
train_df_raw=train_df_raw.dropna()
```

In [59]:
```
# Let's divide the train dataset in two datasets to evaluate perfomance of the mo
train_df = train_df_raw.copy()
X = train_df.drop(['Condition'], 1)
Y = train_df['Condition']
# We scale our data, it is essential for a smooth working of the models
# Scaling means that each columns as a 0 mean and a 1 variance
sc = StandardScaler()
X = pd.DataFrame(sc.fit_transform(X.values), index=X.index, columns=X.columns)
# Split dataset for model testing
X_train, X_test, Y_train, Y_test = train_test_split(X, Y, test_size=0.2, random_s
X_train.head()
```

Out[59]:

	HR	RMSSD	SCL	Unnamed: 4	Unnamed: 5	Unnamed: 6	Unnamed: 7	Unnamed: 8	Unn
882	-0.466880	-0.514140	-0.227917	0.495755	-0.119921	1.529137	-0.578054	-1.878399	0.
2845	-0.564016	-0.373841	-0.342219	0.951577	-0.268785	-1.596594	0.285085	-0.087922	-0.
444	1.670115	0.129043	-0.411088	1.027672	0.093078	0.234768	0.893334	-1.643508	-0.
1638	0.213073	-0.805802	-0.127388	0.898400	-0.528324	-0.823113	-1.053265	-1.471973	-0.
1457	0.310209	1.367904	1.465853	-0.015720	-0.374289	0.383245	-0.948984	0.039969	0.

5 rows × 25 columns

In [60]:
```
# Create dataframe for training dataset and print five first rows as preview
train_df_raw = pd.read_csv('face_phy.csv')
train_df_raw.head()
```

Out[60]:

	Condition	HR	RMSSD	SCL	Unnamed: 4	Unnamed: 5	Unnamed: 6	Unnamed: 7	Unnamed: 8
0	0.0	61.0	0.061420	80.239727	0.968862	0.023946	-6.954147	-5.818151	-0.584952
1	0.0	61.0	0.061420	77.365127	0.884570	0.076952	-10.564172	-6.567912	-3.906502
2	0.0	64.0	0.049663	77.359559	0.931965	0.031468	-10.721106	-7.055848	-2.452367
3	0.0	60.0	0.052487	76.728772	0.806947	0.105516	-10.782755	-5.616126	-4.669924
4	0.0	61.0	0.051189	76.512877	0.951412	0.028358	-3.880091	-4.621940	-5.893645

5 rows × 26 columns

In [61]:
```
train_df_raw=train_df_raw.dropna()
```

In [62]:
```
# PRE MODELING TASK
from sklearn.preprocessing import StandardScaler
from sklearn.model_selection import train_test_split, GridSearchCV
from sklearn.metrics import accuracy_score, confusion_matrix
from sklearn.neighbors import KNeighborsClassifier, NeighborhoodComponentsAnalysi
from sklearn.decomposition import PCA

X = train_df_raw.drop(['Condition'], 1)
Y = train_df_raw['Condition']

X_train, X_test, Y_train, Y_test = train_test_split(X, Y, test_size = 0.20, randc
print("X_train",len(X_train))
print("X_test",len(X_test))
print("Y_train",len(Y_train))
print("Y_test",len(Y_test))
```

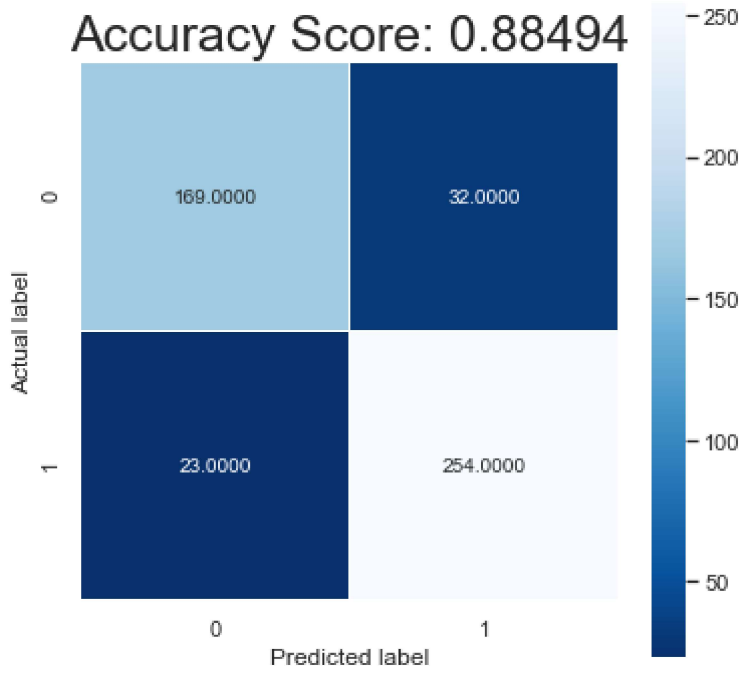
```
X_train 1909
X_test 478
Y_train 1909
Y_test 478
```

In [63]:
```
# to standardize the range
scaler = StandardScaler()
X_train = scaler.fit_transform(X_train)
X_test = scaler.transform(X_test)
```

In [ ]:
```

```

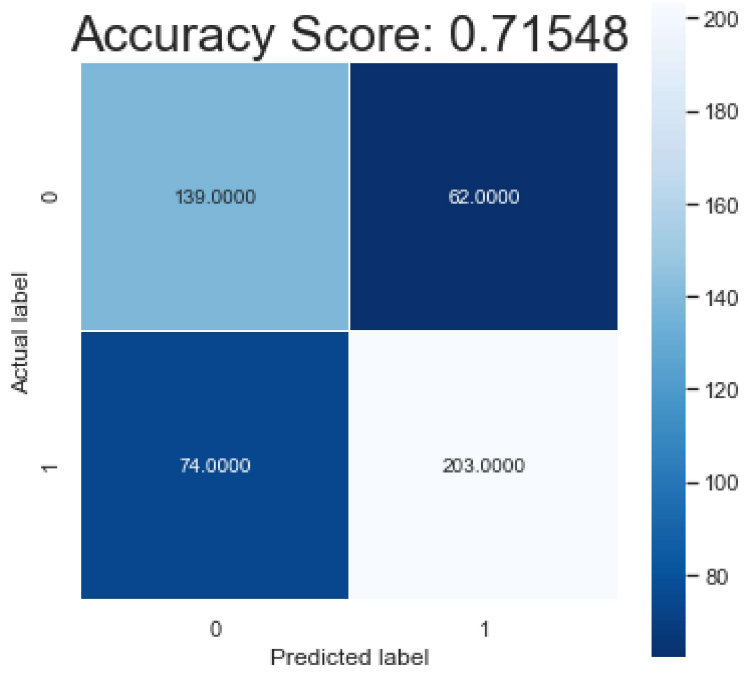
RANDOM FOREST

In [64]:
```
rf = RandomForestClassifier(n_estimators=200, random_state=42)
rf.fit(X_train, Y_train)
rf_prediction = rf.predict(X_test)
score = metrics.accuracy_score(Y_test, rf_prediction)
display_confusion_matrix(Y_test, rf_prediction, score=score)
rf_score=rf_prediction
```



DECISION TREE

In [65]:
```
dt = DecisionTreeClassifier(min_samples_split=15, min_samples_leaf=20, random_sta
dt.fit(X_train, Y_train)
dt_prediction = dt.predict(X_test)

score = metrics.accuracy_score(Y_test, dt_prediction)
display_confusion_matrix(Y_test, dt_prediction, score=score)
```



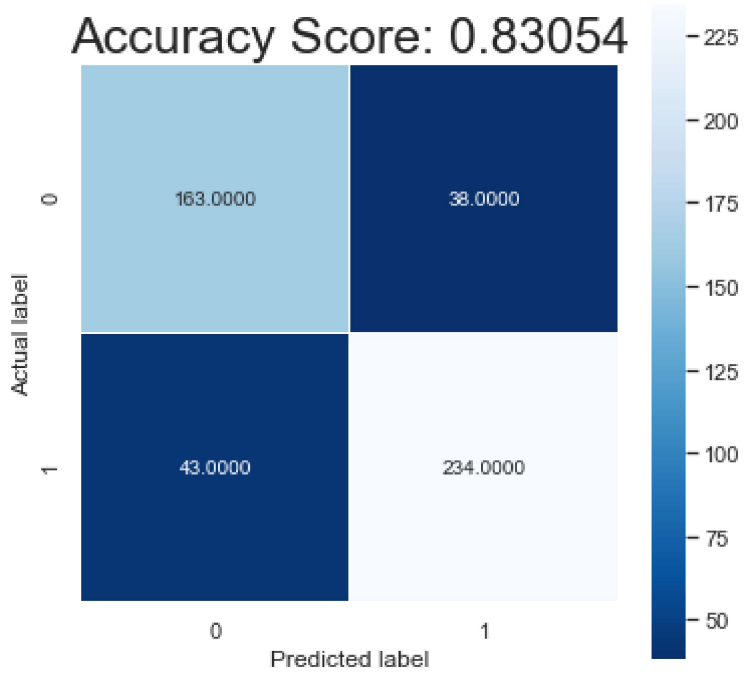
In [66]:
```
print(precision_score(Y_test, dt_prediction))
print(recall_score(Y_test, dt_prediction))
```

```
0.7660377358490567
0.7328519855595668
```

SVM

In [67]:
```
svm = SVC(gamma='auto', random_state=42)
svm.fit(X_train, Y_train)
svm_prediction = svm.predict(X_test)

score = metrics.accuracy_score(Y_test, svm_prediction)
display_confusion_matrix(Y_test, svm_prediction, score=score)
from sklearn.metrics import classification_report, confusion_matrix
print(confusion_matrix(Y_test, svm_prediction))
print(classification_report(Y_test, svm_prediction))
```

```
[[163  38]
 [ 43 234]]
              precision    recall  f1-score   support

         0.0       0.79      0.81      0.80       201
         1.0       0.86      0.84      0.85       277

    accuracy                           0.83       478
   macro avg       0.83      0.83      0.83       478
weighted avg       0.83      0.83      0.83       478
```



In [68]:
```
print(precision_score(Y_test, svm_prediction))
print(recall_score(Y_test, svm_prediction))
```

```
0.8602941176470589
0.8447653429602888
```

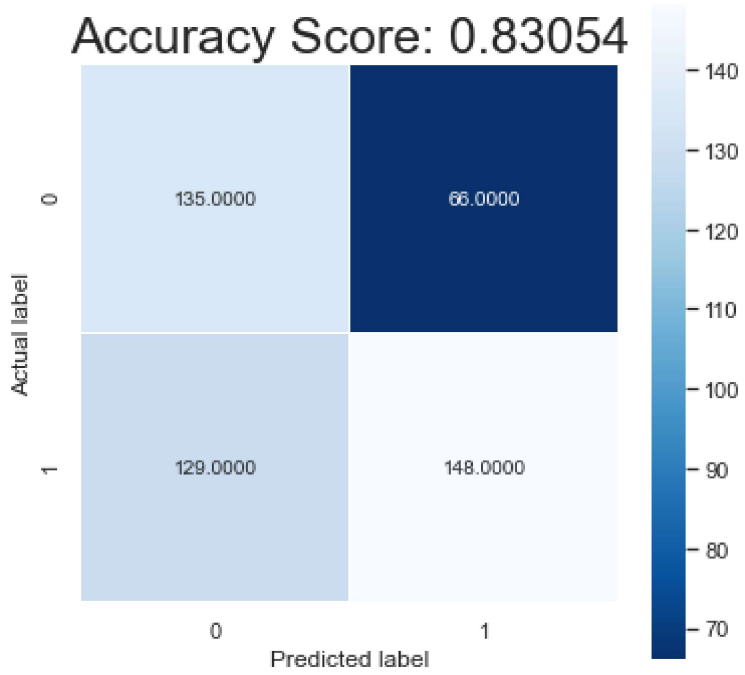
NAIVE BAYES

In [69]:
```
#train a Gaussian Naive Bayes classifier on the training set
from sklearn.naive_bayes import GaussianNB
# instantiate the model
gnb = GaussianNB()
# fit the model
gnb.fit(X_train, Y_train)
NB_y_pred = gnb.predict(X_test)
```

In [70]:
```
from sklearn.metrics import accuracy_score
y_pred_train = gnb.predict(X_train)
y_pred_train
# print the scores on training and test set
print('Training set score: {:.4f}'.format(gnb.score(X_train, Y_train)))
print('Test set score: {:.4f}'.format(gnb.score(X_test, Y_test)))
```

```
Training set score: 0.6286
Test set score: 0.5921
```

In [71]:
```
from sklearn.metrics import confusion_matrix

cm = confusion_matrix(Y_test, NB_y_pred)
display_confusion_matrix(Y_test, NB_y_pred, score=score)
```



In [72]:
```
print(precision_score(Y_test, NB_y_pred))
print(recall_score(Y_test, NB_y_pred))
```

```
0.6915887850467289
0.5342960288808665
```

K NEAREST NEIGHBORS

In [73]:
```
from sklearn.neighbors import KNeighborsClassifier
classifier = KNeighborsClassifier(n_neighbors=3)
classifier.fit(X_train, Y_train)
KNN_y_pred = classifier.predict(X_test)
```

In [74]:
```
print(precision_score(Y_test, KNN_y_pred))
print(recall_score(Y_test, KNN_y_pred))
```

```
0.8415492957746479
0.8628158844765343
```

In [75]:
```
print('******************** HR + GSR + FACIAL IMAGE DATA ********************')
print('SVM ---->',metrics.accuracy_score(Y_test, svm_prediction))
print('RF ---->',metrics.accuracy_score(Y_test, rf_prediction))
print('DT ---->',metrics.accuracy_score(Y_test, dt_prediction))
print('NB ---->',metrics.accuracy_score(Y_test, NB_y_pred))
print('KNN ---->',metrics.accuracy_score(Y_test, KNN_y_pred))
```

```
******************** HR + GSR + FACIAL IMAGE DATA ********************
SVM ----> 0.8305439330543933
RF ----> 0.8849372384937239
DT ----> 0.7154811715481172
NB ----> 0.5920502092050209
KNN ----> 0.8263598326359832
```

Confusion Matrix

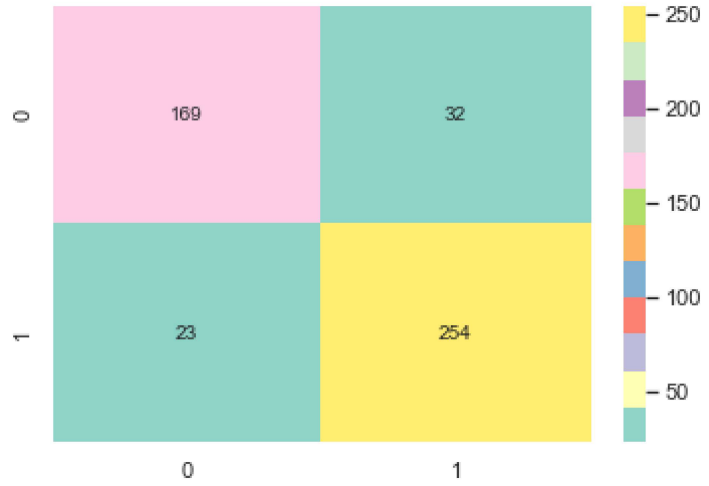
In [76]:
```
from sklearn.metrics import precision_score, recall_score, confusion_matrix, prec
cm = np.array(confusion_matrix(Y_test, rf_prediction, labels=[0,1]))
confusion_mat= pd.DataFrame(cm, index = ['NORMAL', 'STRESSED'],
                            columns =['NORMAL','STRESSED'])
confusion_mat
```

Out[76]:

	NORMAL	STRESSED
NORMAL	169	32
STRESSED	23	254

In [77]:
```
sns.heatmap(cm,annot=True,fmt='g',cmap='Set3')
```

Out[77]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x1a583878490>
```



Accuracy_Score

In [78]:
```
from sklearn.metrics import accuracy_score
print(accuracy_score(Y_test, rf_prediction))
```

```
0.8849372384937239
```

Precision

In [79]:
```
rf_pre=precision_score(Y_test, rf_prediction)
rf_pre
```

Out[79]:
```
0.8881118881118881
```

In [80]:
```
# calculate score
score = f1_score(Y_test, rf_prediction, average='binary')
print('F-Measure: %.4f' % score)
```

```
F-Measure: 0.9023
```

Recall

In [81]:
```
rf_recall=recall_score(Y_test, rf_prediction)
rf_recall
```

Out[81]:
```
0.9169675090252708
```

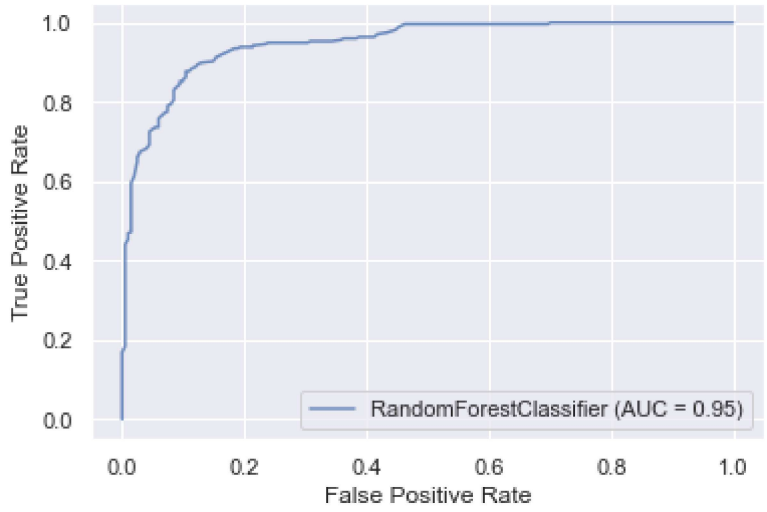
Classification Report

In [82]:
```
from sklearn.metrics import classification_report
print(classification_report(Y_test, rf_prediction))
```

```
              precision    recall  f1-score   support

         0.0       0.88      0.84      0.86       201
         1.0       0.89      0.92      0.90       277

    accuracy                           0.88       478
   macro avg       0.88      0.88      0.88       478
weighted avg       0.88      0.88      0.88       478
```

Area Under Curve

In [83]:
```
from sklearn.metrics import roc_auc_score,auc,f1_score
from sklearn.metrics import plot_roc_curve
ax = plt.gca()
rfc_disp = plot_roc_curve(rf, X_test, Y_test, ax=ax, alpha=0.8)
plt.show()
```



K FOLD VALIDATION

In [84]:
```
cv_score_rf1 = cross_val_score(estimator=rf, X=X_train, y=Y_train, cv=5, n_jobs=
cv_score_rf2 = cross_val_score(estimator=rf, X=X_train, y=Y_train, cv=10, n_jobs=
cv_score_rf3 = cross_val_score(estimator=rf, X=X_train, y=Y_train, cv=20, n_jobs=
cv_score_rf4 = cross_val_score(estimator=rf, X=X_train, y=Y_train, cv=50, n_jobs=
```

In [85]:
```
cv_result = { 'rf5': cv_score_rf1, 'rf10': cv_score_rf2, 'rf20': cv_score_rf3, 'r
cv_data = {model: [score.mean(), score.std()] for model, score in cv_result.items
cv_df = pd.DataFrame(cv_data, index=['Mean_accuracy', 'Variance'])
cv_df
```

Out[85]:

	rf5	rf10	rf20	rf50
Mean_accuracy	0.871665	0.873748	0.880016	0.878516
Variance	0.012461	0.022806	0.037503	0.055084

In [86]:
```
cv_score_dt1 = cross_val_score(estimator=dt, X=X_train, y=Y_train, cv=5, n_jobs=
cv_score_dt2 = cross_val_score(estimator=dt, X=X_train, y=Y_train, cv=10, n_jobs=
cv_score_dt3 = cross_val_score(estimator=dt, X=X_train, y=Y_train, cv=20, n_jobs=
cv_score_dt4 = cross_val_score(estimator=dt, X=X_train, y=Y_train, cv=50, n_jobs=
```

In [87]:
```
cv_result = { 'rf5': cv_score_dt1, 'rf10': cv_score_dt2, 'rf20': cv_score_dt3, 'r
cv_data = {model: [score.mean(), score.std()] for model, score in cv_result.items
cv_df = pd.DataFrame(cv_data, index=['Mean_accuracy', 'Variance'])
cv_df
```

Out[87]:

	rf5	rf10	rf20	rf50
Mean_accuracy	0.733373	0.722373	0.733432	0.724507
Variance	0.023499	0.020612	0.035718	0.071758

In [88]:
```
cv_score_svm1 = cross_val_score(estimator=svm, X=X_train, y=Y_train, cv=5, n_jobs
cv_score_svm2 = cross_val_score(estimator=svm, X=X_train, y=Y_train, cv=10, n_job
cv_score_svm3 = cross_val_score(estimator=svm, X=X_train, y=Y_train, cv=20, n_job
cv_score_svm4 = cross_val_score(estimator=svm, X=X_train, y=Y_train, cv=50, n_job
```

In [89]:
```
cv_result = { 'rf5': cv_score_svm1, 'rf10': cv_score_svm2, 'rf20': cv_score_svm3,
cv_data = {model: [score.mean(), score.std()] for model, score in cv_result.items
cv_df = pd.DataFrame(cv_data, index=['Mean_accuracy', 'Variance'])
cv_df
```

Out[89]:

	rf5	rf10	rf20	rf50
Mean_accuracy	0.803548	0.807746	0.811930	0.810864
Variance	0.018381	0.023710	0.036918	0.064591

In [90]:
```
cv_score_knn1 = cross_val_score(estimator=classifier, X=X_train, y=Y_train, cv=5,
cv_score_knn2 = cross_val_score(estimator=classifier, X=X_train, y=Y_train, cv=10
cv_score_knn3 = cross_val_score(estimator=classifier, X=X_train, y=Y_train, cv=20
cv_score_knn4 = cross_val_score(estimator=classifier, X=X_train, y=Y_train, cv=50
```

In [91]:
```
cv_result = { 'knn5': cv_score_knn1, 'knn10': cv_score_knn2, 'knn20': cv_score_kn
cv_data = {model: [score.mean()] for model, score in cv_result.items()}
cv_df = pd.DataFrame(cv_data, index=['Mean_accuracy'])
cv_df
```

Out[91]:

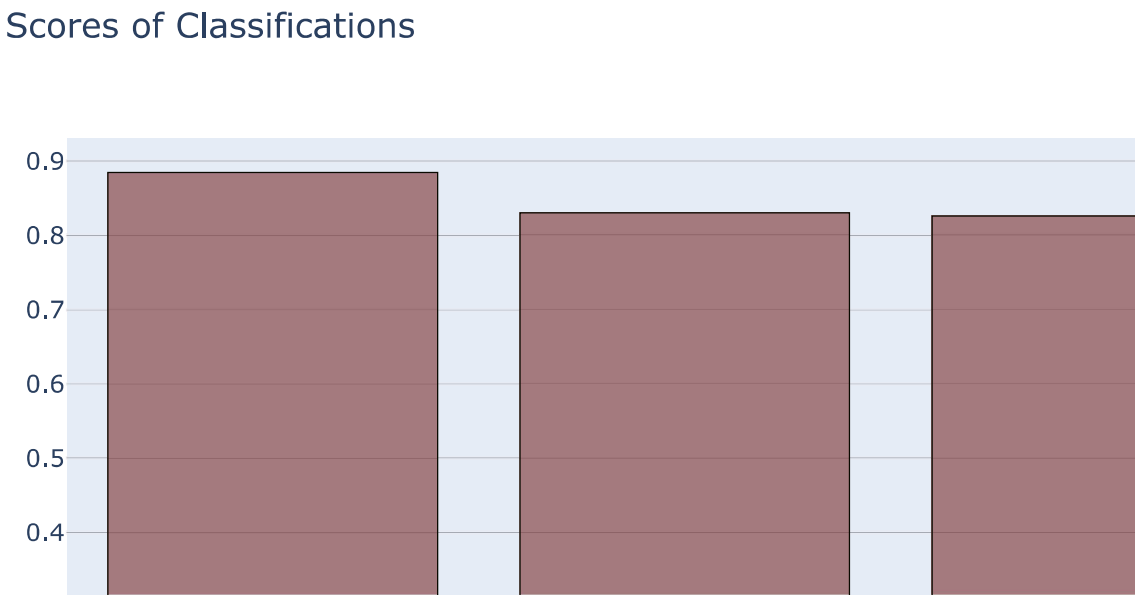
	knn5	knn10	knn20	knn50
Mean_accuracy	0.830781	0.837071	0.840702	0.840742

In [92]:
```
dictionary={"model":["KNN","SVM","DT","RF"],"score":[metrics.accuracy_score(Y_tes
                                                     metrics.accuracy_score(
                                                     metrics.accuracy_score(
                                                     metrics.accuracy_score(

df1=pd.DataFrame(dictionary)
```

In [93]:
```
pip install plotly==4.14.3
```

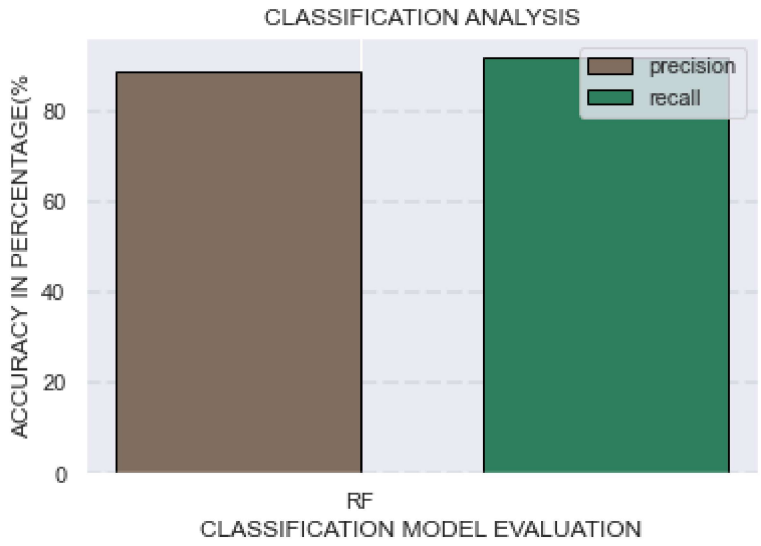
```
Requirement already satisfied: plotly==4.14.3 in c:\users\drashti\anaconda3\lib
\site-packages (4.14.3)
Requirement already satisfied: six in c:\users\drashti\anaconda3\lib\site-packa
ges (from plotly==4.14.3) (1.15.0)
Requirement already satisfied: retrying>=1.3.3 in c:\users\drashti\anaconda3\li
b\site-packages (from plotly==4.14.3) (1.3.3)
Note: you may need to restart the kernel to use updated packages.
```

In [94]:
```
import matplotlib.pyplot as plt
import plotly.graph_objs as go

#sort the values of data
import plotly
plotly.offline.init_notebook_mode()

new_index5=df1.score.sort_values(ascending=False).index.values
sorted_data5=df1.reindex(new_index5)

# create trace1
trace1 = go.Bar(
                x = sorted_data5.model,
                y = sorted_data5.score,
                name = "score",
                marker = dict(color = 'rgba(100, 10, 10, 0.5)',
                              line=dict(color='rgb(10,10,0)')),
                text = sorted_data5.model)
dat = [trace1]
layout = go.Layout(barmode = "group",title= 'Scores of Classifications')
fig = go.Figure(data = dat, layout = layout)
plotly.offline.iplot(fig)
```



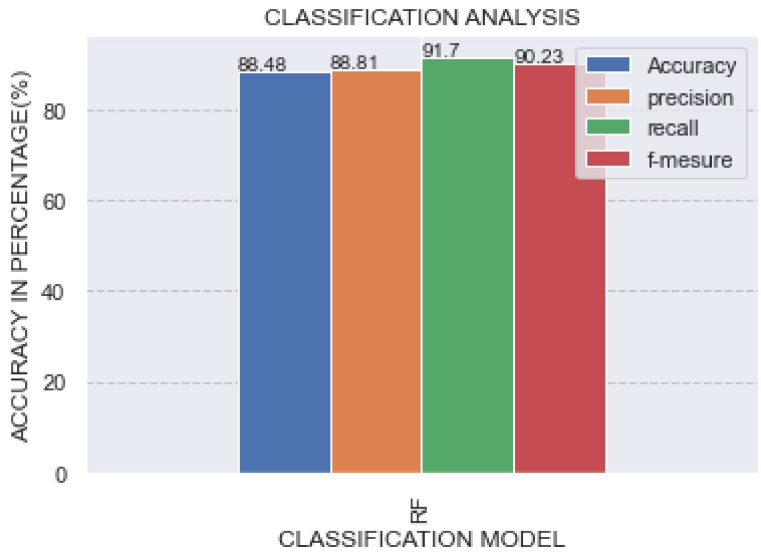
In [95]:

```
import numpy as np
import matplotlib.pyplot as plt

X = ['RF']
Yprecision= [88.81]
Zrecall = [91.70]

X_axis = np.arange(len(X))

plt.bar(X_axis - 0.2, Yprecision, 0.4, label = 'precision', color = '#7f6d5f', ed
plt.bar(X_axis + 0.4, Zrecall, 0.4, label = 'recall', color = '#2d7f5e', edgecolo
plt.grid(color='#95a5a9', linestyle='--', linewidth=2, axis='y', alpha=0.2)



plt.xticks(X_axis, X)
plt.xlabel("CLASSIFICATION MODEL EVALUATION")
plt.ylabel("ACCURACY IN PERCENTAGE(%")
plt.title("CLASSIFICATION ANALYSIS")
plt.legend()
plt.show()
```



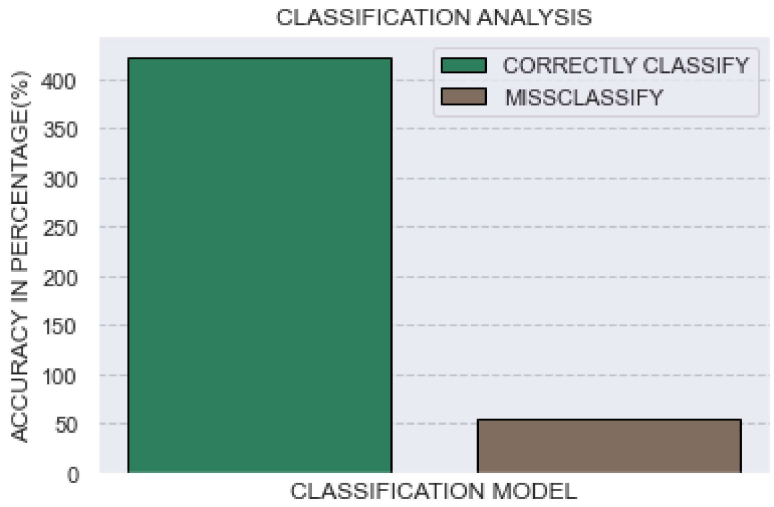
In [96]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt

plotdata = pd.DataFrame({
    "Accuracy": [88.48],
    "precision": [88.81],
    "recall": [91.70],
    "f-mesure": [90.23]
    },
    index=["RF"]
)

ax=plotdata.plot(kind="bar",width=0.6)
plt.grid(color='#95a5a9', linestyle='--', linewidth=1, axis='y', alpha=0.5)

for p in ax.patches:
    ax.annotate(str(p.get_height()), (p.get_x() * 1.005, p.get_height() * 1.005))
plt.xlabel("CLASSIFICATION MODEL")
plt.ylabel("ACCURACY IN PERCENTAGE(%)")
plt.title("CLASSIFICATION ANALYSIS")
```

Out[96]: Text(0.5, 1.0, 'CLASSIFICATION ANALYSIS')



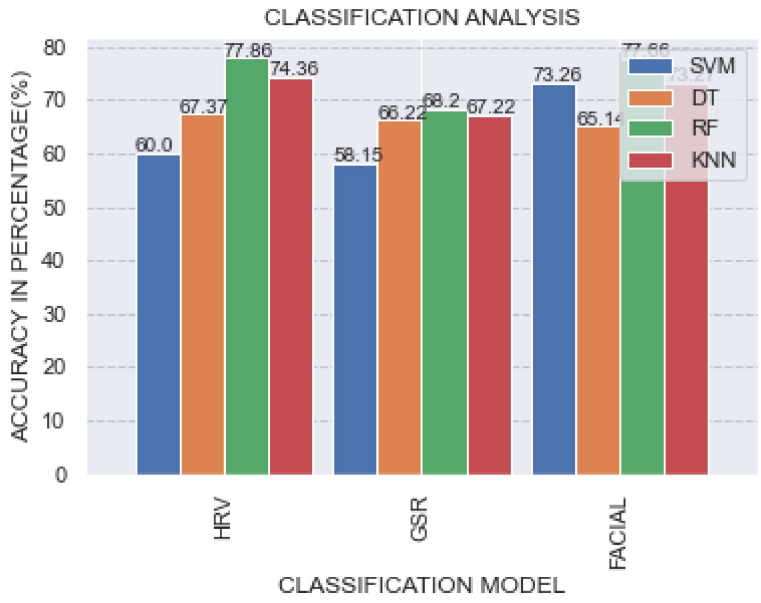
In [97]:

```
import numpy as np
import matplotlib.pyplot as plt

X = ['RANDOM FOREST']
correct= [423]
miss = [55]

X_axis = np.arange(len(X))#2d7f5e

plt.bar(X_axis + 0.2, correct, 0.3, label = 'CORRECTLY CLASSIFY', color = '#2d7f5
plt.bar(X_axis + 0.6, miss, 0.3, label = 'MISSCLASSIFY', color = '#7f6d5f', edgec
plt.grid(color='#95a5a9', linestyle='--', linewidth=1, axis='y', alpha=0.5)

plt.xticks(X_axis, X)
plt.xlabel("CLASSIFICATION MODEL")
plt.ylabel("ACCURACY IN PERCENTAGE(%)")
plt.title("CLASSIFICATION ANALYSIS")
plt.legend()
plt.show()
```



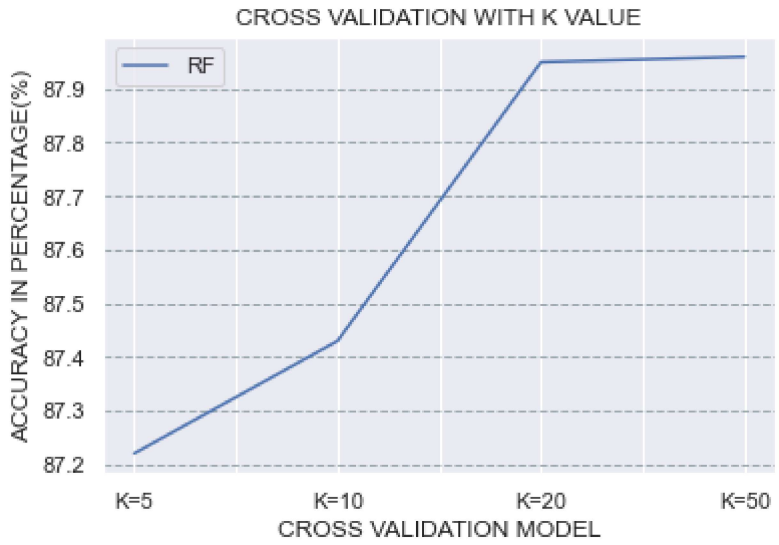
In [98]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt

plotdata = pd.DataFrame({
    "SVM": [60,58.15,73.26],
    "DT": [67.37,66.22,65.14],
    "RF":  [77.86,68.20,77.66],
    "KNN": [74.36,67.22,73.27]
    },
    index=['HRV','GSR','FACIAL']
)

ax=plotdata.plot(kind="bar",width=0.9)
plt.grid(color='#95a5a9', linestyle='--', linewidth=1, axis='y', alpha=0.5)

for p in ax.patches:
    ax.annotate(str(p.get_height()), (p.get_x() * 1.005, p.get_height() * 1.005))
plt.xlabel("CLASSIFICATION MODEL")
plt.ylabel("ACCURACY IN PERCENTAGE(%)")
plt.title("CLASSIFICATION ANALYSIS")
```

Out[98]:
```
Text(0.5, 1.0, 'CLASSIFICATION ANALYSIS')
```



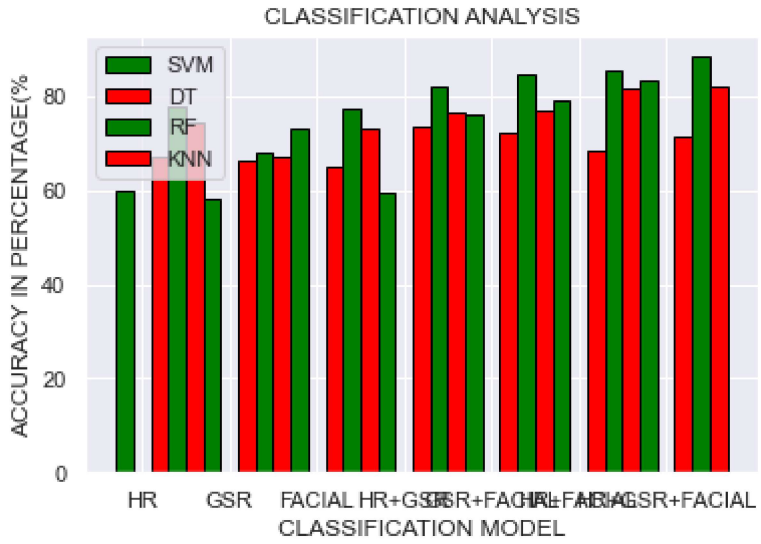
In [100]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
plotdata = pd.DataFrame({

    "RF": [87.22,87.43,87.95,87.96],

    },
    index=['K=5','K=10','K=20','K=50']
)

ax=plotdata.plot(kind="line")
plt.grid(color='#95a5a9', linestyle='--', linewidth=1, axis='y', alpha=0.9)

#for p in ax.patches:
#    ax.annotate(str(p.get_height()), (p.get_x() * 1.005, p.get_height() * 1.005)

plt.xlabel("CROSS VALIDATION MODEL")
plt.ylabel("ACCURACY IN PERCENTAGE(%)")
plt.title("CROSS VALIDATION WITH K VALUE")
```

Out[100]:
```
Text(0.5, 1.0, 'CROSS VALIDATION WITH K VALUE')
```



In [101]:

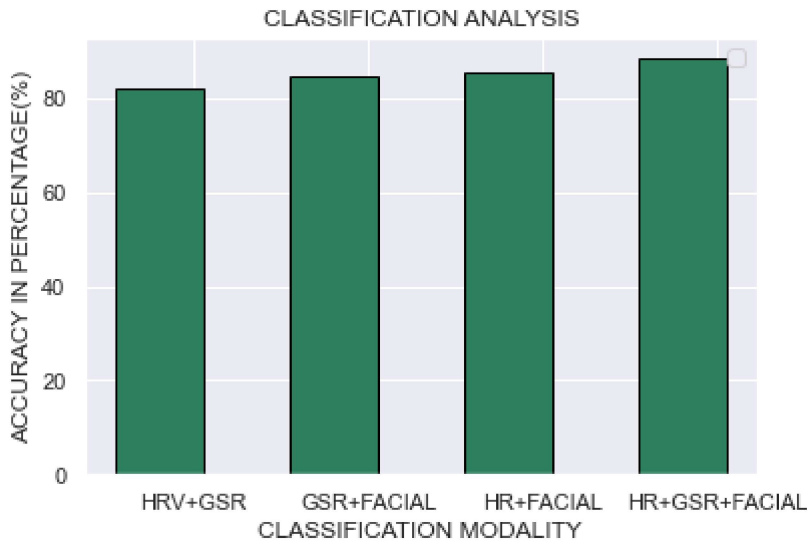
```
import numpy as np
import matplotlib.pyplot as plt

X = ['HR','GSR','FACIAL','HR+GSR','GSR+FACIAL','HR+FACIAL','HR+GSR+FACIAL']
SVM= [60,58.15,73.26,59.53,76.18,78.97,83.26]
DT = [67.37,66.22,65.14,73.67,72.15,68.45,71.54]
RF = [77.86,68.20,77.66,82.21,84.59,85.77,88.49]
KNN = [74.36,67.22,73.27,76.42,77.23,81.86,82]
X_axis = np.arange(len(X))

plt.bar(X_axis - 0.2, SVM, 0.2, label = 'SVM', color = 'green', edgecolor = 'blac
plt.bar(X_axis + 0.2, DT, 0.2, label = 'DT', color = 'red', edgecolor = 'black')
plt.bar(X_axis + 0.4, RF, 0.2, label = 'RF', color = 'green', edgecolor = 'black'
plt.bar(X_axis + 0.6, KNN, 0.2, label = 'KNN', color = 'red', edgecolor = 'black'
plt.xticks(X_axis, X)
plt.xlabel("CLASSIFICATION MODEL")
plt.ylabel("ACCURACY IN PERCENTAGE(%")
plt.title("CLASSIFICATION ANALYSIS")
plt.legend()
plt.show()
```



In [102]:

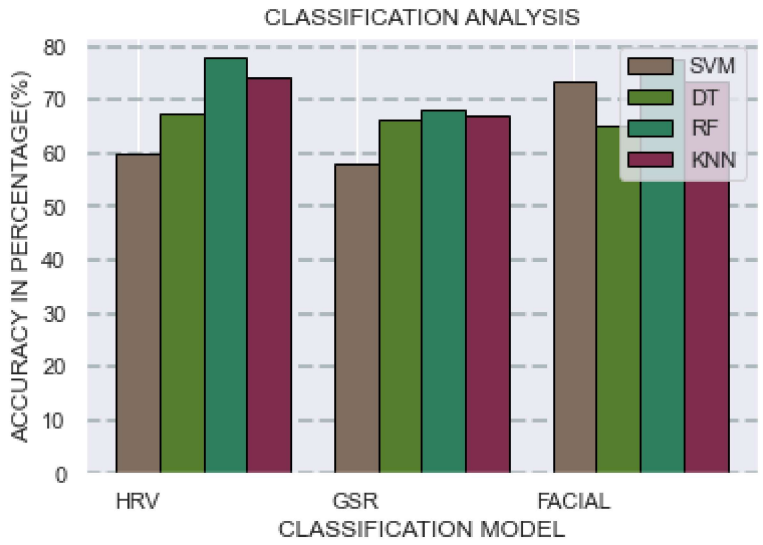
```
import numpy as np
import matplotlib.pyplot as plt

X = ['HRV+GSR','GSR+FACIAL','HR+FACIAL','HR+GSR+FACIAL']

RF = [82.21,84.59,85.77,88.49]

X_axis = np.arange(len(X))


plt.bar(X_axis - 0.2, RF, 0.5, color = '#2d7f5e', edgecolor = 'black')


plt.xticks(X_axis, X)
plt.xlabel("CLASSIFICATION MODALITY")
plt.ylabel("ACCURACY IN PERCENTAGE(%)")
plt.title("CLASSIFICATION ANALYSIS")
plt.legend()
plt.show()
```

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



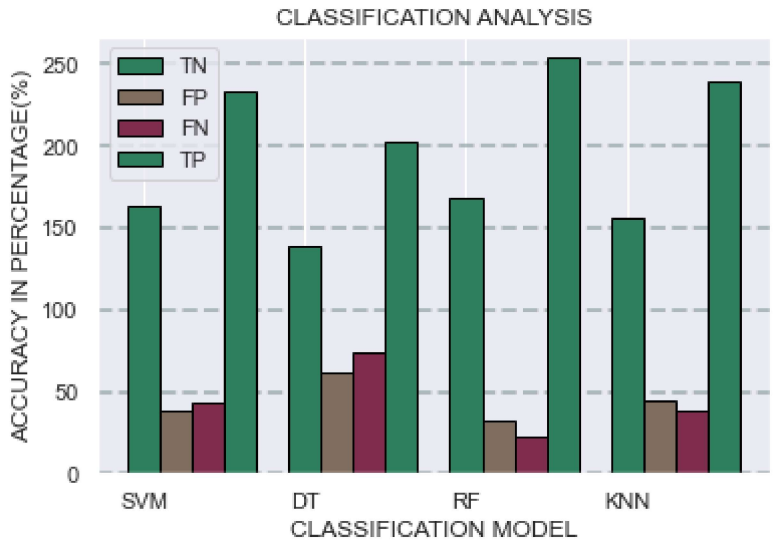
In [103]:

```
import numpy as np
import matplotlib.pyplot as plt

X = ['HRV','GSR','FACIAL']
SVM= [60,58.15,73.26]
DT = [67.37,66.22,65.14]
RF = [77.86,68.20,77.66]
KNN = [74.36,67.22,73.27]
X_axis = np.arange(len(X))

plt.bar(X_axis - 0.0, SVM, 0.2, label = 'SVM', color = '#7f6d5f', edgecolor = 'bl
plt.bar(X_axis + 0.2, DT, 0.2, label = 'DT', color = '#557f2d', edgecolor = 'blac
plt.bar(X_axis + 0.4, RF, 0.2, label = 'RF', color = '#2d7f5e', edgecolor = 'blac
plt.bar(X_axis + 0.6, KNN, 0.2, label = 'KNN', color = '#7f2d4d', edgecolor = 'bl
plt.grid(color='#95a5a6', linestyle='--', linewidth=2, axis='y', alpha=0.7)

plt.xticks(X_axis, X)
plt.xlabel("CLASSIFICATION MODEL")
plt.ylabel("ACCURACY IN PERCENTAGE(%)")
plt.title("CLASSIFICATION ANALYSIS")
plt.legend()
plt.show()
```



In [104]:

```
import numpy as np
import matplotlib.pyplot as plt

X = ['SVM','DT','RF','KNN']
TN= [163,139,169,156]
FP = [38,62,32,45]
FN = [43,74,23,38]
TP = [234,203,254,239]
X_axis = np.arange(len(X))

plt.bar(X_axis - 0.0, TN, 0.2, label = 'TN', color = '#2d7f5e', edgecolor = 'blac
plt.bar(X_axis + 0.2, FP, 0.2, label = 'FP', color = '#7f6d5f', edgecolor = 'blac
plt.bar(X_axis + 0.4, FN, 0.2, label = 'FN', color = '#7f2d4d', edgecolor = 'blac
plt.bar(X_axis + 0.6, TP, 0.2, label = 'TP', color = '#2d7f5e', edgecolor = 'blac
plt.grid(color='#95a5a6', linestyle='--', linewidth=2, axis='y', alpha=0.7)

plt.xticks(X_axis, X)
plt.xlabel("CLASSIFICATION MODEL")
plt.ylabel("ACCURACY IN PERCENTAGE(%)")
plt.title("CLASSIFICATION ANALYSIS")
plt.legend()
plt.show()
```



In [105]:
```
from sklearn import metrics

print('Mean Absolute Error:', metrics.mean_absolute_error(Y_test, rf_prediction))
print('Mean Squared Error:', metrics.mean_squared_error(Y_test, rf_prediction))
print('Root Mean Squared Error:', np.sqrt(metrics.mean_squared_error(Y_test, rf_p
```

```
Mean Absolute Error: 0.11506276150627615
Mean Squared Error: 0.11506276150627615
Root Mean Squared Error: 0.3392090233267331
```

In [110]:
```
from sklearn.model_selection import cross_val_score
from sklearn.metrics import classification_report, confusion_matrix
print("=== Confusion Matrix ===")
print(confusion_matrix(Y_test, rf_prediction))
print('\n')
print("=== Classification Report ===")
print(classification_report(Y_test, rf_prediction))
print('\n')
```

```
=== Confusion Matrix ===
[[169  32]
 [ 23 254]]


=== Classification Report ===
              precision    recall  f1-score   support

         0.0       0.88      0.84      0.86       201
         1.0       0.89      0.92      0.90       277

    accuracy                           0.88       478
   macro avg       0.88      0.88      0.88       478
weighted avg       0.88      0.88      0.88       478
```