DS630(MACHINE LEARNING) FINAL PROJECT

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In [21]:
```
# IMPORT THE NECESSARY LIBRARIES

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

from sklearn.preprocessing import StandardScaler
from sklearn.decomposition import PCA
from sklearn.model_selection import GridSearchCV
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LogisticRegression
from sklearn.neighbors import KNeighborsClassifier
from sklearn.metrics import accuracy_score, confusion_matrix, precision_recall_f
from sklearn.svm import SVC
from sklearn.tree import DecisionTreeClassifier
from sklearn.ensemble import RandomForestClassifier
from sklearn.ensemble import AdaBoostClassifier
```

In [4]:
```
# IMPORT THE DATASET

df = pd.read_excel('CovidDeathUS2021.xlsx')
df.head()
```

Out[4]:

	PEOPLE_POSITIVE_CASES_COUNT	COUNTY_NAME	PROVINCE_STATE_NAME	REPORT_DATE	C
0	9271	Marshall	Alabama	2021-01-01	
1	1517	Barbour	Alabama	2021-01-01	
2	1522	Butler	Alabama	2021-01-01	
3	2418	Clarke	Alabama	2021-01-01	
4	1756	Pickens	Alabama	2021-01-01	

In [5]:
```
# WHOLE INFORMATION OF THE DATASET
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 248083 entries, 0 to 248082
Data columns (total 15 columns):
 #   Column                          Non-Null Count   Dtype
---  ------                          --------------   -----
 0   PEOPLE_POSITIVE_CASES_COUNT     248083 non-null  int64
 1   COUNTY_NAME                     248083 non-null  object
 2   PROVINCE_STATE_NAME             248083 non-null  object
```

```
 3   REPORT_DATE                        248083 non-null  datetime64[ns]
 4   CONTINENT_NAME                     248083 non-null  object
 5   DATA_SOURCE_NAME                   248083 non-null  object
 6   PEOPLE_DEATH_NEW_COUNT             248083 non-null  int64
 7   COUNTY_FIPS_NUMBER                 244654 non-null  float64
 8   COUNTRY_ALPHA_3_CODE               248083 non-null  object
 9   COUNTRY_SHORT_NAME                 248083 non-null  object
 10  COUNTRY_ALPHA_2_CODE               248083 non-null  object
 11  PEOPLE_POSITIVE_NEW_CASES_COUNT    248083 non-null  int64
 12  PEOPLE_DEATH_COUNT                 248083 non-null  int64
 13  IS_COVID_PRESENT                   248083 non-null  bool
 14  ARE_THERE_NEW_COVID_DEATHS         248083 non-null  bool
dtypes: bool(2), datetime64[ns](1), float64(1), int64(4), object(7)
memory usage: 25.1+ MB
```

In [6]:
```
# DROP IRRELEVANT COLUMNS
df_filtered = df.drop(columns=['COUNTY_NAME','PROVINCE_STATE_NAME','REPORT_DATE'
         'COUNTY_FIPS_NUMBER','COUNTRY_ALPHA_3_CODE','COUNTRY_SHORT_NAME','COUNT
```

In [7]:
```
# 5 POINT SUMMARY OF THE DATASET
df_filtered.describe()
```

Out[7]:

	PEOPLE_POSITIVE_CASES_COUNT	PEOPLE_DEATH_NEW_COUNT	PEOPLE_POSITIVE_NEW_C
count	2.480830e+05	248083.000000	2
mean	8.834160e+03	0.562425	
std	3.862826e+04	5.082005	
min	0.000000e+00	-1009.000000	
25%	8.520000e+02	0.000000	
50%	2.062000e+03	0.000000	
75%	5.470000e+03	0.000000	
max	1.235783e+06	930.000000	

In [8]:
```
# NEW AVERAGE DEATH COUNT PER DAY
df_filtered['PEOPLE_DEATH_NEW_COUNT'].mean()
```

Out[8]:
```
0.5624246723878702
```

In [9]:
```
# TOTAL AVERAGE DEATH COUNT
df_filtered['PEOPLE_DEATH_COUNT'].mean()
```

Out[9]:
```
162.0288290612416
```

In [10]:
```
# CORRELATION BETWEEN THE DIFFERENT FEATURES
df_filtered.corr()
```

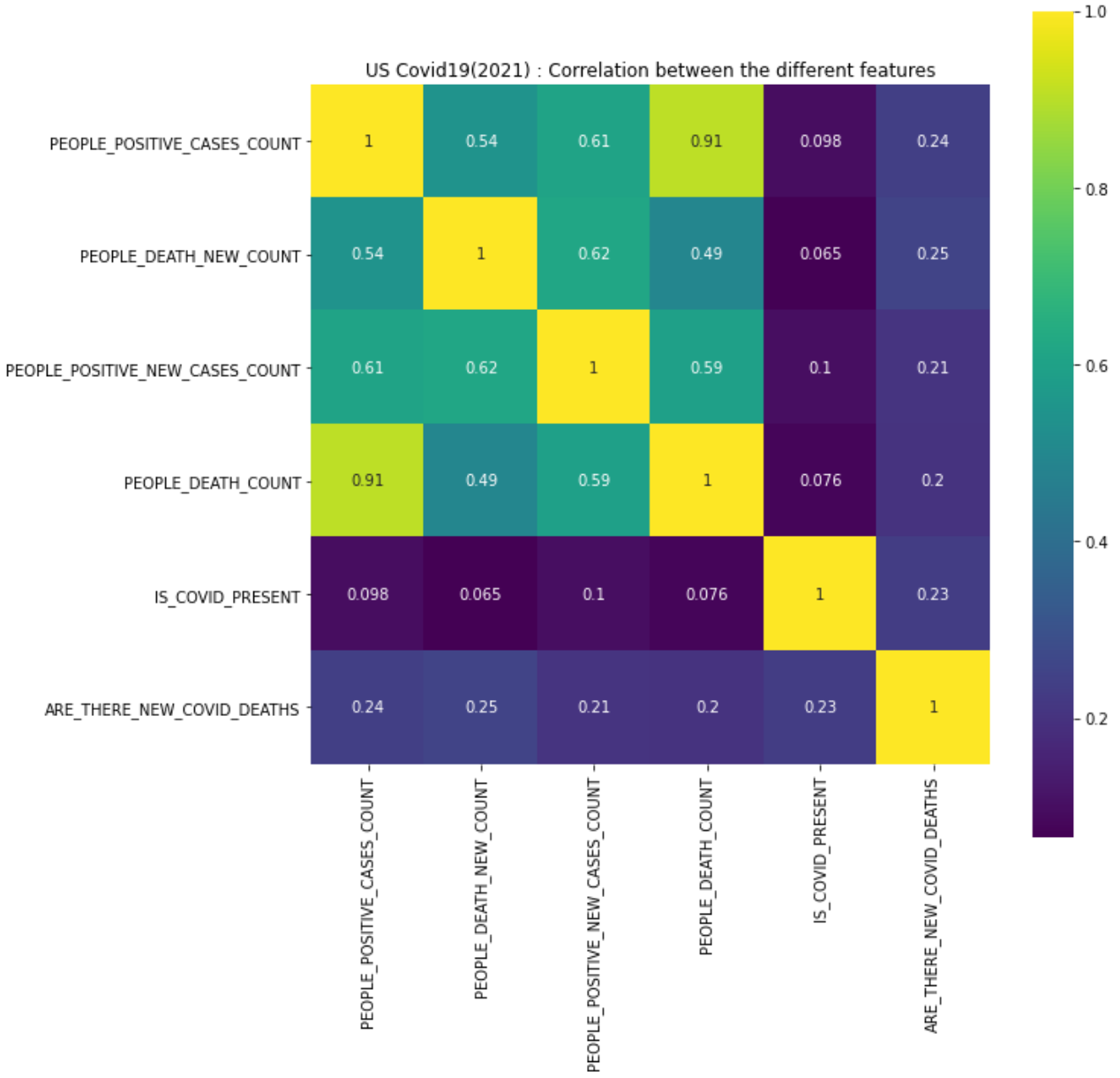
Out[10]:

	PEOPLE_POSITIVE_CASES_COUNT	PEOPLE_DEATH_NEW_C

	PEOPLE_POSITIVE_CASES_COUNT	PEOPLE_DEATH_NEW_C
PEOPLE_POSITIVE_CASES_COUNT	1.000000	0.5
PEOPLE_DEATH_NEW_COUNT	0.544253	1.0
PEOPLE_POSITIVE_NEW_CASES_COUNT	0.607500	0.6
PEOPLE_DEATH_COUNT	0.908214	0.4
IS_COVID_PRESENT	0.097775	0.0
ARE_THERE_NEW_COVID_DEATHS	0.237220	0.2

In [11]:
```
# LOTTING THE FEATURE CORRELATION
correlation = df_filtered.corr()
plt.figure(figsize=(10,10))
sns.heatmap(correlation, vmax=1, square = True, annot=True, cmap = 'viridis')
plt.title("US Covid19(2021) : Correlation between the different features")
```

Out[11]:
```
Text(0.5, 1.0, 'US Covid19(2021) : Correlation between the different features')
```



In [12]:

```
# INFORMATION FOR THE FILTERED DATASET
df_filtered.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 248083 entries, 0 to 248082
Data columns (total 6 columns):
 #   Column                          Non-Null Count   Dtype
---  ------                          --------------   -----
 0   PEOPLE_POSITIVE_CASES_COUNT     248083 non-null  int64
 1   PEOPLE_DEATH_NEW_COUNT          248083 non-null  int64
 2   PEOPLE_POSITIVE_NEW_CASES_COUNT 248083 non-null  int64
 3   PEOPLE_DEATH_COUNT              248083 non-null  int64
 4   IS_COVID_PRESENT                248083 non-null  bool
 5   ARE_THERE_NEW_COVID_DEATHS      248083 non-null  bool
dtypes: bool(2), int64(4)
memory usage: 8.0 MB
```

In [13]:

```
# CONVERT THE CATEGORICAL VARIABLES TO DUMMY VARIABLES
df_filtered['ARE_THERE_NEW_COVID_DEATHS'] = df_filtered['ARE_THERE_NEW_COVID_DEA
```

```
df_filtered['IS_COVID_PRESENT'] = df_filtered['IS_COVID_PRESENT'].astype(int)
print(df_filtered)
```

```
        PEOPLE_POSITIVE_CASES_COUNT  PEOPLE_DEATH_NEW_COUNT  \
0                              9271                       0
1                              1517                       1
2                              1522                       0
3                              2418                       1
4                              1756                       0
...                             ...                     ...
248078                          369                       0
248079                         1405                       0
248080                         4329                       0
248081                         5179                       0
248082                         3157                       0

        PEOPLE_POSITIVE_NEW_CASES_COUNT  PEOPLE_DEATH_COUNT  IS_COVID_PRESENT  \
0                                    82                  86                 1
1                                     3                  33                 1
2                                    14                  45                 1
3                                    28                  26                 1
4                                    22                  26                 1
...                                 ...                 ...               ...
248078                                0                   3                 0
248079                                2                  12                 1
248080                               27                  12                 1
248081                                0                  84                 0
248082                                5                  31                 1

        ARE_THERE_NEW_COVID_DEATHS
0                                0
1                                1
2                                0
3                                1
4                                0
...                            ...
248078                           0
248079                           0
248080                           0
248081                           0
248082                           0

[248083 rows x 6 columns]
```

In [14]:

```
# ASSIGN THE TARGET VARIABLE(y) AND FEATURE VARIABLE(x)
x = df_filtered.iloc[:,0:3]
y = df_filtered.iloc[:, 5]
```

In [15]:

```
print(x)
```

```
        PEOPLE_POSITIVE_CASES_COUNT  PEOPLE_DEATH_NEW_COUNT  \
0                              9271                       0
1                              1517                       1
2                              1522                       0
3                              2418                       1
4                              1756                       0
...                             ...                     ...
248078                          369                       0
248079                         1405                       0
248080                         4329                       0
248081                         5179                       0
```

```
248082                              3157                              0

        PEOPLE_POSITIVE_NEW_CASES_COUNT
0                                    82
1                                     3
2                                    14
3                                    28
4                                    22
...                                 ...
248078                                0
248079                                2
248080                               27
248081                                0
248082                                5

[248083 rows x 3 columns]
```

In [16]:
```
print(y)
```

```
0         0
1         1
2         0
3         1
4         0
         ..
248078    0
248079    0
248080    0
248081    0
248082    0
Name: ARE_THERE_NEW_COVID_DEATHS, Length: 248083, dtype: int64
```

In [12]:
```
#SCALE THE DATA BETWEEN 1 AND 0

standardScaler = StandardScaler()
x = standardScaler.fit_transform(x)
x
```

Out[12]:
```
array([[ 0.01130884, -0.11067006,  0.24204903],
       [-0.18942544,  0.08610307, -0.13394795],
       [-0.189296  , -0.11067006, -0.08159394],
       ...,
       [-0.11662884, -0.11067006, -0.01972102],
       [-0.09462418, -0.11067006, -0.14822631],
       [-0.14696939, -0.11067006, -0.12442904]])
```

In [13]:
```
# PERFORM PCA ON THE DATASET
pca = PCA()
pca.fit_transform(x)
```

Out[13]:
```
array([[ 0.08639834,  0.06838149,  0.24253409],
       [-0.13758679, -0.18979688, -0.07927678],
       [-0.21908273, -0.06061766,  0.05537745],
       ...,
       [-0.14119856, -0.01061588,  0.07867233],
       [-0.204776  ,  0.01323029, -0.03262496],
       [-0.22040832, -0.02682995,  0.00554753]])
```

In [17]:
```
# SPLITTING THE DATASET TO TEST AND TRAIN
x_train, x_test, y_train, y_test = train_test_split(x, y, test_size = 0.2, rando
```

In [18]:
```
print('x_train: ', x_train.shape)
print('x_test: ', x_test.shape)
print('y_train: ', y_train.shape)
print('y_test: ', y_test.shape)
```

```
x_train:  (198466, 3)
x_test:  (49617, 3)
y_train:  (198466,)
y_test:  (49617,)
```

In [19]:
```
# FUNCTION TO PRINT ALL THE MODEL ACCURACIES THAT WAS CALCULATED DURING GRID SEA
def print_results(results):
    print('BEST PARAMS: {}\n'.format(results.best_params_))

    means = results.cv_results_['mean_test_score']
    stds = results.cv_results_['std_test_score']
    for mean, std, params in zip(means, stds, results.cv_results_['params']):
        print('{} (+/-{}) for {}'.format(round(mean, 3), round(std * 2, 3), para
```

LOGISTIC REGRESSION CLASSIFIER

In [60]:
```
# RUNNING THE LOGISTIC REGRESSION CLASSIFIER USING GRID SEARCH
lr_classifier = LogisticRegression()
parameters = {
    'C' : [0.001] #Inverse regularization parameter
}
cv = GridSearchCV(lr_classifier, parameters, cv = 5) #cv is for k fold cross val
cv.fit(x_train, y_train)
```

Out[60]:
```
GridSearchCV(cv=5, estimator=LogisticRegression(), param_grid={'C': [0.001]})
```

In [61]:
```
# GIVES US THE HYPERPARAMETER SETTINGS WITH BEST ACCURACY SCORE
cv.best_estimator_
```

Out[61]:
```
LogisticRegression(C=0.001)
```

In [62]:
```
# PREDICT THE TARGET VALUE USING THE FITTED LOGISTIC REGRESSION CLASSIFIER
y_pred = cv.predict(x_test)
print('Logistic Regression: Accuracy Score - ', accuracy_score(y_test, y_pred))
```

```
Logistic Regression: Accuracy Score -  0.8894733659834331
```

K-NEAREST NEIGHBOR CLASSIFIER

In [49]:
```
# RUN THE K NEAREST NEIGHBOR CLASSIFIER ON THE DATASET
knn_classifier = KNeighborsClassifier()
parameters = {
    'n_neighbors':[5] #no of neighbors
}
```

```
cv_knn = GridSearchCV(knn_classifier, parameters, cv = 5, scoring='accuracy', n_
cv_knn.fit(x_train, y_train)
```

```
Fitting 5 folds for each of 1 candidates, totalling 5 fits
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   2 out of   5 | elapsed:   58.1s remaining:  1.5min
[Parallel(n_jobs=-1)]: Done   5 out of   5 | elapsed:   59.7s finished
```

Out[49]:
```
GridSearchCV(cv=5, estimator=KNeighborsClassifier(), n_jobs=-1,
             param_grid={'n_neighbors': [5]}, scoring='accuracy', verbose=1)
```

In [50]:
```
#PREDICT THE ACCURACY SCORE USING THE FITTED KNN CLASSIFIER
y_pred = cv_knn.predict(x_test)
print('K-Nearest Neighbor: Accuracy Score - ', accuracy_score(y_test, y_pred))
```

```
K-Nearest Neighbor: Accuracy Score -  0.9995364492008787
```

KNN on the non-PCA dataset

In [22]:
```
# RUN THE KNN CLASSIFIER ON NON SCALED DATASET TO CHECK FOR BETTER ACCURACY
knn_classifier = KNeighborsClassifier()
parameters = {
    'n_neighbors':[5]
}
cv_knn = GridSearchCV(knn_classifier, parameters, cv = 5, scoring='accuracy', n_
cv_knn.fit(x_train, y_train)
```

```
Fitting 5 folds for each of 1 candidates, totalling 5 fits
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done   2 out of   5 | elapsed:    5.7s remaining:    8.6s
[Parallel(n_jobs=-1)]: Done   5 out of   5 | elapsed:    5.9s finished
```

Out[22]:
```
GridSearchCV(cv=5, estimator=KNeighborsClassifier(), n_jobs=-1,
             param_grid={'n_neighbors': [5]}, scoring='accuracy', verbose=1)
```

In [28]:
```
print_results(cv_knn)
```

```
BEST PARAMS: {'n_neighbors': 5}

0.852 (+/-0.003) for {'n_neighbors': 5}
```

In [32]:
```
# GENERATE A CLASSIFICATION REPORT TO CHECK FOR PRECISION, ACCURACY AND RECALL V
y_pred = cv_knn.predict(x_test)
print(classification_report(y_test,y_pred))
```

```
              precision    recall  f1-score   support

           0       0.88      0.95      0.92     41118
           1       0.62      0.38      0.47      8499

    accuracy                           0.85     49617
   macro avg       0.75      0.66      0.69     49617
weighted avg       0.84      0.85      0.84     49617
```

In [ ]:
```

```

KERNEL SUPPORT VECTOR MACHINE CLASSIFIER

In [84]:
```
# RUN THE DATASET ON KERNEL(RBF) SUPPORT VECTOR MACHINE
svc_classifier = SVC(kernel = 'rbf', random_state = 0)
parameter = {
    'C' : [0.001, 0.01, 0.1, 1, 10, 100]
}
cv_svc = GridSearchCV(svc_classifier, parameter , cv=5)
cv_svc.fit(x_train,y_train)
```

Out[84]:
```
GridSearchCV(cv=5, estimator=SVC(random_state=0),
             param_grid={'C': [0.001, 0.01, 0.1, 1, 10, 100]})
```

In [87]:
```
y_pred = cv_svc.predict(x_test)
print('SUPPORT VECTOR MACHINE CLASSIFIER: Accuracy Score - ', accuracy_score(y_t
```

```
SUPPORT VECTOR MACHINE CLASSIFIER: Accuracy Score -  0.9998186105568656
```

SVM(kernel) on the non-PCA dataset

In [ ]:
```
from sklearn.svm import SVC

svc_classifier = SVC(random_state = 0)
parameter = {
    'kernel' : ['linear', 'rbf'],
    'C' : [0.001, 0.01, 0.1, 1, 10, 100]
}
cv_svc = GridSearchCV(svc_classifier, parameter , cv=5, scoring='accuracy', verb
cv_svc.fit(x_train,y_train)
```

```
Fitting 5 folds for each of 12 candidates, totalling 60 fits
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
```

In [ ]:
```
print_results(cv_svc)
```

In [ ]:
```
y_pred = cv_svc.predict(x_test)
print(classification_report(y_test,y_pred))
```

In [ ]:
```

```

DECISION TREE CLASSIFIER

In [36]:
```
# RUN THE DECISION TREE CLASSIFIER ON THE TEST AND TRAIN DATASET
parameters = {
    'criterion':["entropy"],
    'splitter':["random"],
    'max_depth':[15],
    'min_samples_split':[4],
    'min_samples_leaf':list(range(1, 5)),
}
```

```
dt_classifier = DecisionTreeClassifier(random_state = 42)
cv_dt = GridSearchCV(dt_classifier, parameters,scoring='accuracy', n_jobs=-1, ve
cv_dt.fit(x_train, y_train)
```

```
Fitting 3 folds for each of 4 candidates, totalling 12 fits
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done  10 out of  12 | elapsed:    0.4s remaining:    0.1s
[Parallel(n_jobs=-1)]: Done  12 out of  12 | elapsed:    0.5s finished
```

Out[36]:
```
GridSearchCV(cv=3, estimator=DecisionTreeClassifier(random_state=42), n_jobs=-1,
             param_grid={'criterion': ['entropy'], 'max_depth': [15],
                         'min_samples_leaf': [1, 2, 3, 4],
                         'min_samples_split': [4], 'splitter': ['random']},
             scoring='accuracy', verbose=1)
```

In [38]:
```
cv_dt.best_estimator_
```

Out[38]:
```
DecisionTreeClassifier(criterion='entropy', max_depth=15, min_samples_leaf=2,
                       min_samples_split=4, random_state=42, splitter='random')
```

In [39]:
```
y_pred = cv_dt.predict(x_test)
print('DECISION TREE CLASSIFIER: Accuracy Score - ', accuracy_score(y_test, y_pr
```

```
DECISION TREE CLASSIFIER: Accuracy Score -  0.941874760666707
```

Decion Tree Classifier on the non-PCA dataset

In [ ]:
```
# RUN THE DECISION TREE CLASSIFIER ON THE TEST AND TRAIN DATASET
parameters = {
    'criterion':["entropy"],
    'splitter':["random"],
    'max_depth':[15],
    'min_samples_split':[4],
    'min_samples_leaf':list(range(1, 5)),
}

dt_classifier = DecisionTreeClassifier(random_state = 42)
cv_dt = GridSearchCV(dt_classifier, parameters,scoring='accuracy', n_jobs=-1, ve
cv_dt.fit(x_train, y_train)
```

In [ ]:
```
print_results(cv_dt)
```

In [ ]:
```
y_pred = cv_dt.predict(x_test)
print(classification_report(y_test,y_pred))
```

RANDOM FOREST CLASSIFER

In [41]:
```
# RUN THE RANDOM FOREST CLASSIFIER ON THE TEST AND TRAIN DATASET
parameters = {
    'n_estimators' : [100,500,1000,2000],
    'max_features' : ['auto', 'sqrt'],
    'max_depth' : [2,3,5],
    'min_samples_split' : [2,5,10],
```

```
    'min_samples_leaf' : [1,2,4,10],
}

rf_classifer = RandomForestClassifier(random_state=42)
cv_rf = GridSearchCV(rf_classifer, parameters, cv=5, verbose =1, n_jobs=-1)
cv_rf.fit(x_train, y_train)
```

```
Fitting 5 folds for each of 288 candidates, totalling 1440 fits
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done  34 tasks      | elapsed:  3.1min
[Parallel(n_jobs=-1)]: Done 184 tasks      | elapsed: 18.2min
[Parallel(n_jobs=-1)]: Done 434 tasks      | elapsed: 45.7min
[Parallel(n_jobs=-1)]: Done 784 tasks      | elapsed: 90.0min
[Parallel(n_jobs=-1)]: Done 1234 tasks      | elapsed: 148.8min
[Parallel(n_jobs=-1)]: Done 1440 out of 1440 | elapsed: 175.9min finished
```

Out[41]:
```
GridSearchCV(cv=5, estimator=RandomForestClassifier(random_state=42), n_jobs=-1,
             param_grid={'max_depth': [2, 3, 5],
                         'max_features': ['auto', 'sqrt'],
                         'min_samples_leaf': [1, 2, 4, 10],
                         'min_samples_split': [2, 5, 10],
                         'n_estimators': [100, 500, 1000, 2000]},
             verbose=1)
```

In [43]:
```
y_pred = cv_rf.predict(x_test)
print('DECISION TREE CLASSIFIER: Accuracy Score - ', accuracy_score(y_test, y_pr
```

```
DECISION TREE CLASSIFIER: Accuracy Score -  1.0
```

In [ ]:
```
# Random Forest Classifier on a non-PCA dataset
```

In [ ]:
```
# RUN THE RANDOM FOREST CLASSIFIER ON THE NON-SCALED DATASET
parameters = {
    'n_estimators' : [100,500,1000,2000],
    'max_features' : ['auto', 'sqrt'],
    'max_depth' : [2,3,5],
    'min_samples_split' : [2,5,10],
    'min_samples_leaf' : [1,2,4,10],
}

rf_classifer = RandomForestClassifier(random_state=42)
cv_rf = GridSearchCV(rf_classifer, parameters, cv=5, verbose =1, n_jobs=-1)
cv_rf.fit(x_train, y_train)
```

In [ ]:
```
print_result(cv_rf)
```

In [ ]:
```
y_pred = cv_rf.predict(x_test)
print(classification_report(y_test,y_pred))
```

ENSEMBLING METHOD: ADABOOST ALGORITHM

In [77]:
```
# USE THE ENSEMBLING TECHNIQUES TO BOOST THE ACCURACY SCORE
adaboost_clf = AdaBoostClassifier(random_state=42)
```

```
parameters = {
    'learning_rate' : [0.1,1,0.01,0.5],
    'n_estimators' : [100,120,140,160,180, 200]
}
cv_adaboost = GridSearchCV(adaboost_clf, parameters, cv = 5, n_jobs=-1, verbose=
cv_adaboost.fit(x_train, y_train)
```

```
Fitting 5 folds for each of 24 candidates, totalling 120 fits
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done  34 tasks      | elapsed:    3.0s
[Parallel(n_jobs=-1)]: Done 120 out of 120 | elapsed:    5.7s finished
```

Out[77]:
```
GridSearchCV(cv=5, estimator=AdaBoostClassifier(random_state=42), n_jobs=-1,
             param_grid={'learning_rate': [0.1, 1, 0.01, 0.5],
                         'n_estimators': [100, 120, 140, 160, 180, 200]},
             verbose=1)
```

In [78]:
```
y_pred = cv_adaboost.predict(x_test)
print('ADABOOST CLASSIFIER: Accuracy Score - ', accuracy_score(y_test, y_pred))
```

```
ADABOOST CLASSIFIER: Accuracy Score -  1.0
```

In [ ]:
```
# Adaboost on a non-PCA dataset
```

In [ ]:
```
# USING THE ADABOOST ENSEMBLE TECHNIQUE TO BOOST THE ACCURACY SCORE USING THE NO
adaboost_clf = AdaBoostClassifier(random_state=42)
parameters = {
    'learning_rate' : [0.1,1,0.01,0.5],
    'n_estimators' : [100,120,140,160,180, 200]
}
cv_adaboost = GridSearchCV(adaboost_clf, parameters, cv = 5, n_jobs=-1, verbose=
cv_adaboost.fit(x_train, y_train)
```

In [ ]:
```
print_result(cv_adaboost)
```

In [ ]:
```
y_pred = cv_adaboost.predict(x_test)
print(classification_report(y_test,y_pred))
```

In [ ]:

In [ ]: